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Living on the Edge: Navigating Resource Management Challenges in the Villages of Ajodhya Hill, West Bengal

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Abstract

The Ajodhya Hill region, part of the Chhotanagpur plateau in West Bengal, features a rugged landscape and a subsistence economy reliant on forest resources. This study employs primary data gathered through household surveys, interviews, and focus group discussions with local villagers and officials to analyze resource management challenges in Ajodhya Hill. The area, home to Scheduled Tribe communities such as the Santal and Munda, contains significant natural resources that provide essential ecosystem services for tribal livelihoods. Due to seasonal rainfall and dry spells, rainwater collection is crucial for water security, as the region experiences rapid runoff and limited water retention. Traditional water purification methods are vital, and indigenous tools support local agriculture. Groundwater extraction has become problematic as surface water sources decline due to unpredictable rainfall and deforestation, a trend exacerbated by development initiatives. Soil erosion poses a significant environmental challenge, especially where unsustainable agricultural practices impact the delicate landscape. The research suggests sustainable pathways, including integrated watershed development, participatory forest management, livelihood diversification, and eco-tourism initiatives.

Keywords

Sustainability, Resilience, Livelihoods, Scarcity, Adaptation, Governance

1. Introduction

The mountainous and plateau fringe region of India reflects a distinct ecological and socio-economic landscape in which habitation is closely integrated with nature and the environment and is sustained by limited endowments (Rani et al., 2022; Singh et al., 2021). The Ajodhya hill region developed from the Chhotanagpur plateau region. This region is typified by a rugged landscape, a skeletal soil profile, seasonal water deficit, and a forest-based subsistence economy (Ghosh et al., 2023; Sarkar, 2025). Local communities have been shaped by prevailing environmental stressors, even as they follow traditional practices of natural resource use, land transformation, and decentralized water storage systems. Villagers are substantially reliant on rainwater harvesting, natural resources, non-timber forest resources, and traditional knowledge. Resource management in these hilly villages is influenced by the interlinked effects of multiple physical limitations and socio-economic vulnerabilities. Rainwater harvesting predominates in the local economy of villagers, making their livelihoods highly vulnerable during both monsoons and prolonged dry seasons (Ruj et al., 2025). Forest resources functioned as a livelihood buffer by providing fuel, fodder, fruits, and herbal medicines for the local indigenous tribal community, including the Santhal, Bhumij, and Munda (Paul, 2021; Mandal et al., 2023). Due to accelerating human pressure like deforestation, unregulated tourism, infrastructure expansion, shifting cultivation, over consumption of forest resources, etc., the total forest cover area is declining, losing biodiversity, increasing soil erosion, and changing the land, which undermines the resilience of the community-based economic system (Ghosh et al., 2021a, 2021b). Alongside this, exogenously led developmental initiatives, such as watershed projects and tourism-related infrastructure development, often proceed without adequate regulatory oversight of local communities, thereby exacerbating natural resource depletion and the socio-economic vulnerability of livelihoods (Banik & Mukhopadhyay, 2022).

The primary research question of the present study is: How do rural households in Ajodhya Hill negotiate and adapt to interlinked resource stress (water-forest-land) within the context of environmental fragility and socio-economic constraints? The specific research questions guiding this investigation include: What are the spatial and seasonal patterns of water availability across villages in Ajodhya Hill? How does dependency on forests influence livelihood strategies and resource extraction behaviours? What is the relationship between land degradation (such as lateritic soil and badland formation) and agricultural productivity? In what ways do households diversify their livelihoods under conditions of resource stress (e.g., migration, forest collection, wage labour)? What role do indigenous knowledge systems (IKS) play in the management of water, forest, and land resources? How do gender roles and social structures affect access to and control over natural resources? What are the effects of state interventions (including afforestation, watershed programs, and rural schemes) on the sustainability of local resources? Additionally, how does climate variability (such as erratic rainfall and drought) in-

tensify resource insecurity?

The primary Goal of the study is to critically analyse the nexus between water, forest, and livelihood systems in Ajodhya Hill villages under ecological stress. Secondary objectives include assessing water resource availability, access, and seasonal stress patterns; Analysing Forest resource dependence and extraction dynamics; documenting livelihood diversification strategies and coping mechanisms; investigating the role of indigenous knowledge systems in resource management; examining institutional interventions and governance structures; and developing a spatial understanding of vulnerability and resilience using field and geospatial data.

The specific contribution of the paper, as well as the novelty statement of the study, can be elucidated in various ways. For instance, from a conceptual perspective, it establishes a triangular nexus framework (Water-Forest-Livelihood) specific to lateritic upland ecosystems, thereby advancing beyond single-resource analysis and integrating political ecology alongside micro-level resource geography within the context of Ajodhya Hill. From an empirical standpoint, it provides novel village-level evidence concerning seasonal water scarcity patterns (spring depletion, groundwater stress), forest extraction gradients (fuelwood, NTFPs, sal leaf economy), and the correlations between badland geomorphology and agricultural decline. Furthermore, it generates primary household-level data from Ajodhya Hill, an area underrepresented in existing studies on Purulia. Methodologically, it combines field surveys (including household questionnaires and Participatory Rural Appraisal methods), geospatial analysis (covering land use, terrain, and degradation mapping), and the integration of perception-based and observational data. This demonstrates a versatile mixed-method framework applicable to other semi-arid tribal upland regions. The regional (Ajodhya-specific) contribution extends beyond previous studies that primarily focus on geomorphology (such as laterite and Badlands) or treat forests and tribal livelihoods separately. It provides a comprehensive, system-based understanding of resource stress, human adaptation, and landscape transformation. The contribution highlights micro-scale heterogeneity among villages, which is often overlooked in district-level analyses. In terms of policy relevance, it identifies critical gaps in water governance and forest management, emphasising the need for decentralised water harvesting systems, community-based forest governance, and livelihood diversification planning. Additionally, it offers evidence-based inputs for sustainable rural development, climate adaptation strategies, and tribal livelihood enhancement programs. Theoretically, it advances the discourse on resource stress and adaptation, human-environment interaction models in marginal landscapes, and proposes Ajodhya Hill as a "micro-laboratory" for studying coupled socio-ecological systems under stress. By integrating field-based evidence with geospatial insights, this study fosters a nuanced understanding of the water-forest-livelihood nexus in Ajodhya Hill, providing both theoretical refinement and practical pathways for sustainable resource governance in lateritic upland ecosystems.

2. Data and Methods

The study utilises both primary and secondary data to assess resource management challenges in the villages of Ajodhya Hill, West Bengal. Primary data were collected through household surveys, key informant interviews, and focus group discussions with local villagers, community leaders, and forest officials. Field observations were conducted to document land-use patterns, water sources, agricultural practices, and forest dependence. GPS-based mapping and photographic documentation were used to capture the spatial distribution of resources and infrastructure. Secondary data were obtained from government reports, census data, forest department records, and satellite imagery (Table 1) to analyse long-term changes in land cover and rainfall variability. A mixed-method approach was adopted, integrating quantitative and qualitative analyses. Quantitative data were analysed using GIS-based spatial analysis to identify patterns in resource use and degradation. Qualitative data from interviews and discussions were coded thematically to understand community perceptions, traditional knowledge, and adaptive strategies. Remote sensing and GIS tools were applied to map land-use changes and temporal changes in water resource availability. A comparative analysis was conducted across villages to highlight spatial disparities and levels of vulnerability. The integrated methodology offers a comprehensive understanding of human–environment interactions and sustainability challenges within the Ajodhya Hill ecosystem.

Table 1. Details of satellite data, date of acquisition, and resolution.

Satellite and Sensor	Date of acquisition	Path/Row	The band used Spatial resolution
Landsat 8 "OLI_TIRS"	04/04/2014	140/44	30 m
	29/04/2014	139/44	
	22/01/2017	140/44	
	31/01/2017	139/44	

Source: The table has been prepared by the author.

The primary data design of this study constitutes a fundamental component of the research. A total of 10 villages across Ajodhya Hill were surveyed, selected to represent upland, mid-slope, and foothill environments. The survey included 100 households, averaging 10 per village, to ensure variability across villages. A multi-stage sampling methodology was employed for this investigation. In the first stage, villages were purposively selected based on resource stress indicators such as water scarcity, dependence on forest resources, and land degradation. In the second stage, systematic random sampling was utilised to select households within each village. This approach ensured the inclusion of marginal farmers, landless households, and families dependent on forest resources. The field survey was conducted during the pre-monsoon and early monsoon periods (April-July), a timeframe that captures peak water stress conditions and associated livelihood adaptations.

The Household Survey Method employs a structured questionnaire that addresses various topics, including water access and seasonal availability, forest use (fuelwood and Non-Timber Forest Products), agriculture and land conditions, livelihood diversification, and migration. A total of 10 Focus Group Discussions (FGDs) were conducted, with one FGD per village. Each discussion involved five participants. Participants for the FGDS were purposively selected to ensure representation of elderly residents with local ecological knowledge, women involved in water collection and fuelwood dependence, small and marginal farmers, and households dependent on forests. Efforts were made to include socially diverse groups, comprising both tribal and non-tribal communities. Key informant interviews were conducted with village leaders, forest guards, and local officials to gain insights into institutional interventions and governance. Data reliability was ensured through cross-verification via triangulation-integrating household surveys, FGDS, and field observations- and through repeated questioning to confirm seasonal consistency of responses.

3. Study Area

3.1. Localization

The Ajodhya Hill region, located in western West Bengal, lies within the Purulia district and constitutes the easternmost extension of the Chota Nagpur Plateau. Geographically, it lies between 22˚58'N to 23˚05'N latitude and 83˚35'E to 86˚15'E longitude. Covering blocks such as Baghmundi, Balarampur, Jhalda I & II and Arsha (**Figure 1(a)**). Ranging from 500 m to peaks like Bagabanipur and Chamtaburu, the terrain includes L-shaped hill ridges and residual monadnocks, which are typical of plateau–valley fringe (Ghosh et al., 2023). There are many multi-cyclic and polygenic landforms due to a complicated evolutionary history. Geotourists are drawn to its valuable geosites, which include residual hills, escarpments, river valleys, waterfalls, lakes, springs, and other notable features. The hill is popular for rock climbing and easy to moderate trekking. Several organizations and mountaineering schools conduct training courses every year in this region.

3.2. Regional Geology

Ajodhya Hill is located near the eastern edge of the Eastern Ghats and the western edge of the Ganga-Brahmaputra delta. It is part of the Chhotanagpur Plateau, an erosional plateau that forms the essential part of the Precambrian continental shield of Indian India. The Chhotanagpur Gneissic Complex, which spans 300 km of West Bengal, is composed of Archean gneissic rocks with a small extension of Quaternary semi-consolidated sediments, Permo-Carboniferous sandstone and shale, Precambrian massive granite, and recent alluvial sediment deposition (Dolui et al., 2016) (**Figure 1(b)**). Steep slopes and rock outcrops characterise the hilly tracts, impeding intensive cultivation while encouraging localised water retention in natural depressions that sustain small-scale subsistence farming.

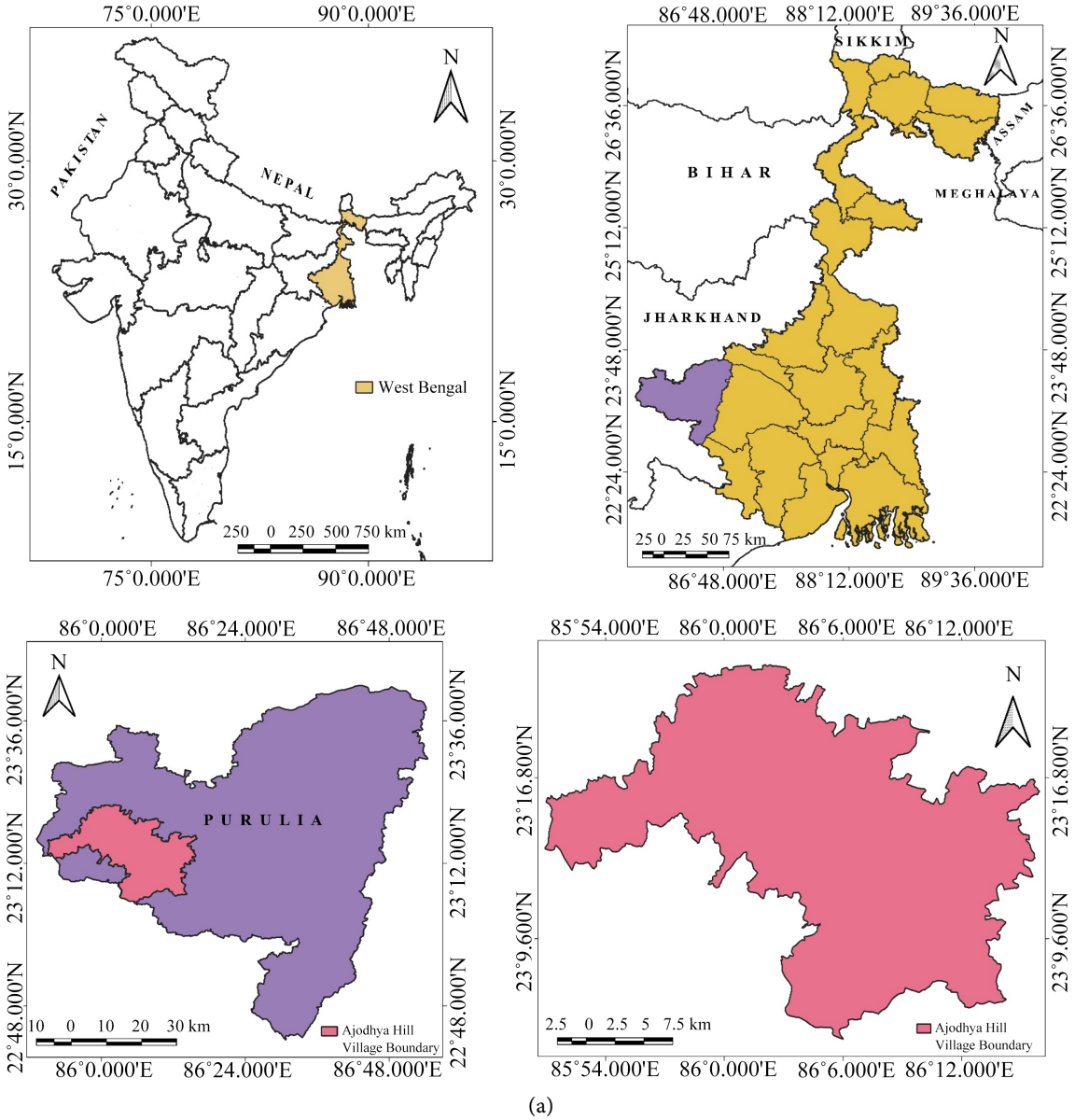

Figure 1. (a): Location Map of Ajodhya Hill which is located in Purulia district, the Southwestern part West Bengal; (b): In this image exposed metamorphic rock outcrop illustrates prominent banding and foliation typical of the region's geological features on the Ajodhya area.

3.3. Soil Geomorphology

The Ajodhya Hill is considered the most weathered uplifted part of the Purulia district and is characterized by weathering and overland flow from the past. Sand and clay are formed from the breakdown and disintegration of bedrock through weathering and foundation processes. Quartz-biotite gneiss is most vulnerable to weathering in Ajodhya Hill (Sarkar, 2025). The surface soil was formed from erosional, complicated crystalline rock. Because of the downslope migration of soil-forming deposits, the soil depth is thinner on top of a hill than in the escarpment area. It develops and gathers more in the foothill pediment area because of its lowest height and slope. Bedrock, Conglomeratic granite, and gneiss have all had a major impact on the development of the soil profile, resulting in a sandy-loam soil texture (Sarkar, 2024).

3.4. Climate and Vegetation

The Ajodhya region, forming the eastern fringe of the Chota Nagpur Plateau in West Bengal, experiences a tropical deciduous climate characterized by three distinct seasons. The area receives an annual rainfall of 1100 - 1500 mm, with most falling during the southwest monsoon, which accounts for over 80% of annual precipitation. Summers are hot, with temperatures often exceeding 42˚C, whereas winters are relatively mild, with minimum temperatures below 8˚C in January. Humidity varies substantially, ranging from 75% - 85% during the monsoon to as low as 20% - 30% in summer, thereby influencing evapotranspiration and variability in soil moisture (Paul & Das, 2022). Vegetation in Ajodhya Hill is primarily composed of Northern Tropical Dry Deciduous (**Figure 3**). Forests, along with undergrowth shrubs, grasses, and climbers (Mandal et al., 2023). Due to increasing anthropogenic pressures, particularly shifting cultivation and firewood collection (Mandal & Mukherjee, 2024), large areas of primary forest have been degraded into scrubland or secondary forest (**Figure 2** and **Figure 3**).

3.5. Local Climatological Indicators of Ajodhya Hill

The thermal regime of the Ajodhya Hill regions is characterised by a mean annual temperature of 24˚C - 26˚C. The maximum temperature during summer (April to June) ranges from 40˚C to 45˚C, while the minimum temperature during winter (December to January) ranges from 8˚C to 12˚C. The diurnal temperature variation is high, with a range of 10˚C - 18˚C. The mean annual rainfall ranges from 1100 mm to 1400 mm, with 80% - 85% of rainfall occurring during the Southwest monsoon from June to September. The peak rainfall months are July and August. Pre-monsoon convectional showers occur sporadically from March to May. Winter rainfall in this area is minimal to negligible. The inter-annual variability of rainfall in the Ajodhya Hills is moderate to high, with a coefficient of variation of approximately 20% - 30%. Dry spells during the monsoon season typically last 2 to 4 weeks. Occasionally, drought years occur approximately every 3 to 5 years, characterised by a rainfall deficit. The onset and withdrawal of the monsoon are often erratic and unpredictable.

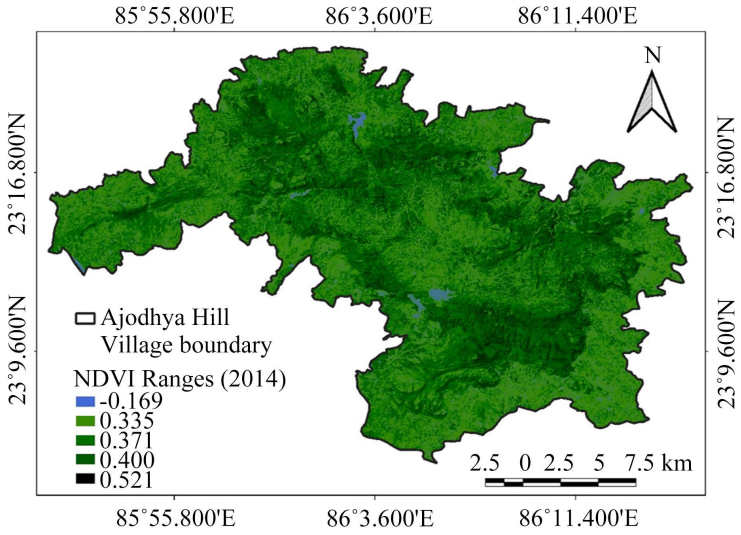

Figure 2. NDVI of 2014 represents the different vegetation cover in Ajodhya region in 2014 where the dense and highly dense vegetation cover are seen in large number and the non-vegetation area represents waterbodies such as lakes.

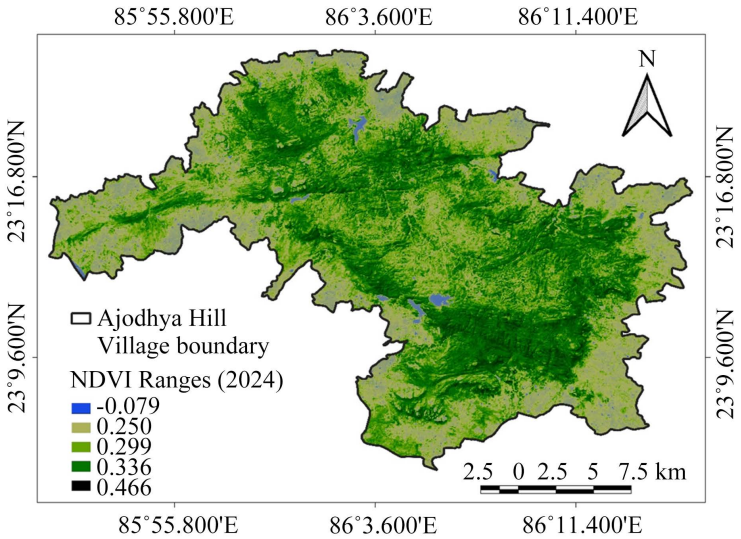

Figure 3. NDVI of 2024 represents the different vegetation cover in Ajodhya region in 2024 where the dense and highly dense vegetation cover are decreased as compared to 2014 and the moderate vegetation cover increased in a large number. The non-vegetation area represents lakes and other waterbodies.

The relative humidity in the Ajodhya hill area during the monsoon season ranges from 70% to 85%, whereas in the pre-monsoon summer period, it ranges from 30% to 45%. The annual potential evapotranspiration exceeds 1400 - 1600 mm, peaking between April and June. The seasonality of this region is characterised by distinct climatic phases. The pre-monsoon period (March-June) is marked by hot and dry conditions; the monsoon season (June-September) is humid and wet; the post-monsoon phase is transitional and occurs during October and November; and winter (December-February) is notably cool and dry. The annual

water deficit is significant because potential evapotranspiration exceeds rainfall during the dry months. Soil moisture availability is seasonally constrained due to rapid depletion following the monsoon. Surface water persistence is limited to ephemeral streams and seasonal tanks or ponds. The dominant winds during the monsoon are south-westerly. Pre-monsoon winds are dry, gusty, and can be locally strong. Thunderstorm activity includes *Kalbaisakhi* (*nor-wester*)-type events occurring in April and May. Additionally, heatwaves are frequent during May and June.

The Vegetation-Climate Link has been identified through various factors, such as the Natural vegetation type: Tropical dry deciduous forest; the Leaf fall period: Late winter-early summer (indicating a response to moisture stress); and the Growing season length: approximately 120 - 150 days, which is dependent on the monsoon. Agro-Climatic Indicators have also been established. The cropping dependency is predominantly rainfed, with Kharif being the primary agricultural season. Rabi cropping is limited due to moisture and irrigation constraints. The risk of crop failure is associated with monsoon variability and dry spells. The climate of Ajodhya Hill can be classified according to the Consistent Framing system. The *Köppen* climate type is *Aw*, indicating a Tropical savanna with a dry winter, characteristic of a dry sub-humid monsoonal climate region. It is not a desert climate, as there is a seasonal moisture surplus during the monsoon period, and water stress occurs during the dry season. A key integrated indicator is the hydro-climatic condition, which is seasonally water-abundant during the monsoon and becomes water-scarce during the pre-monsoon transition.

3.6. Population and Society

The Ajodhya Hill region in Purulia District, West Bengal, is predominantly inhabited by Scheduled Tribe communities, including the Santal, Bhumij, Munda, Birhor, and Hill Kharia, many of whom have lived in this region for generations. The tribal population in the area constitutes a significant proportion of the local population, with villages distributed across scattered forested and hilly terrain, often lacking basic infrastructure services such as road connectivity, electricity, and potable water. Santal, the largest tribal group, maintains strong cultural ties to the land expressed through festivals, dance, music, and sacred groves, which play a vital environmental conservation and spiritual role (Mandal et al., 2023). Livelihoods are primarily dependent on subsistence agriculture, shifting cultivation, minor forest produce collection, and seasonal migration to nearby towns for labour. Despite development challenges, local society demonstrates strong communitarian values, rich traditions, and a high degree of traditional ecological knowledge, including herbal medicine and sustainable foraging practices (Ghosh et al., 2021a). These factors collectively shape the socio-cultural landscape of the Ajodhya Hill, where indigenous identities are tightly interwoven with the environment and ongoing struggles over land, rights, and development.

4. Results and Evaluation

4.1. Rich of Resource: Nature and Type

The natural resources of Ajodhya Hill are diverse and ecologically significant. The area supports dry-deciduous and mixed forests dominated by Sal (Shorea robusta), Mahua, Palash, and Kusum, which provide fuel, fodder, timber, and NTFPs (non-timber forest products) such as lac, honey, and medicinal plants. These forests are not only ecologically vital but also culturally and economically important to the tribal communities, especially the Santhals and *Birhors*. The hill region is also rich in water resources, with perennial streams and springs feeding small reservoirs, supporting agriculture and local livelihoods. Additionally, the presence of waterfalls, rock formations, and tribal villages makes Ajodhya Hill a potential site for eco-tourism. Overall, Ajodhya Hill exhibits a unique blend of geological, ecological, and anthropological richness. In the villages of Ajodhya, the hills are surrounded by the dry deciduous trees dominated by Sal, Mahua, Palash, and scattered bamboo and *Tendua* trees. They provide a huge variety of timber, fuelwood, and bamboo for making fences and mats. Mahua flowers, honey, medicinal plants, and fodder for livestock are important components for rural subsistence farming (Dutta et al., 2024). This is a striking example of how the rural communities rely on forests for their daily livelihoods yet are under huge ecological pressure. These forests serve as the lifeline of the locals.

These forests face a pressure of overharvesting of fuelwood and timber, shifting cultivation, and overgrazing, which has led to soil erosion, reduced forest cover, and a decline in biodiversity. The depletion of the forest has also increased significantly due to the construction of dams, Bridges, and hotels, as well as the growth of the tourism industry, which has led to a substantial portion of the Ajodhya hill being developed, thereby impacting forest resources to some extent. The livelihoods of people living in Ajodhya Hill are still heavily dependent on the monsoon's rhythm, the fertility of isolated soil patches, and the quantity of nearby forests, despite recent community-based afforestation initiatives, watershed projects, and small-scale irrigation schemes that seek to restore degraded forests, conserve soil, and diversify livelihoods.

4.2. Ecosystem Services

Ecosystem services are essential benefits that humans derive from nature. These services form the backbone of both ecological stability and tribal livelihood. The services such as fuelwood, fruits, medicinal plants, and freshwater from springs directly support the daily needs of tribal communities like Santals and *Bhumijis* (Hazari et al., 2025; Paul, 2021). Regulating services include slope stabilization, microclimate regulation, and water purification, all crucial in the erosion-prone lateritic landscape. Cultural ecosystem services rooted in animistic beliefs and festivals like *Sohrai* reveal the spiritual and identity-based bonds between the people and their environment. However, increasing deforestation, unregulated tourism, and erosion of indigenous knowledge threaten these services, highlighting the

need for integrated conservation efforts that prioritize both environmental sustainability and community well-being. Small streams, seasonal rivulets, and natural depressions create transient water bodies during the monsoon season in this lateritic, mountainous environment. For irrigation, household use, and livestock watering, villagers mostly depend on these small water sources, as well as ponds, check dams, and wells that have been dug. While the upland plots rely on soil moisture retention and sporadic tank irrigation to cultivate millets, pulses, and oilseeds, the low-lying paddy fields in the valley bottoms close to Baghmundi are nourished by seasonal streams, which support the growth of Aman rice during the monsoon. This hydrological regulation is a key ecosystem service, ensuring that the small streams and ponds retain water long enough to support farming and livestock during the dry months.

In order to preserve biodiversity and microclimatic stability, local communities, especially those in Santhal, Munda, and Bhumij, practice small-scale water collecting and protect sacred groves and forest areas. Deforestation, overgrazing, and unpredictable rainfall, however, are putting increasing strain on these ecosystem services by lowering water availability, aggravating soil erosion, and endangering the productivity of both forests and agriculture. Ajodhya Hill region livelihoods depend on integrated natural resource management, which is demonstrated by initiatives like community watershed management, afforestation, and small-scale irrigation structures that seek to improve water security and rehabilitate damaged ecosystems. The locals mainly use the tap water facilities installed by the government, which provide water throughout the year, except during extreme drought conditions. And for household purposes, they use the nearby ponds or some low-lying waterbody.

4.3. Utilization of Land: Type Pattern and Challenges

The term *utilization of land* pertains to the optimal use of land resources to attain the most beneficial outcomes. Proper land use can significantly enhance solutions to research management challenges faced by marginalized populations of the Ajodhya hill. Consequently, land utilization is critically important for regions lacking developmental progress. In the foothill of Ajodhya, villagers encounter similar issues. The land use and land cover patterns in this region generally mirror those of neighbouring villages. However, distinctive features are evident, as the foothill pediment areas are predominantly covered by deciduous forests interspersed with vegetation. This includes deciduous leaves from species such as they shall polish Krishna Chura, mohua, kusumkhed, Simul, various bamboo species, and pines like Shagun and Shirish Piyaar (Podder & Bhui, 2025). Additionally, certain shrubs, bushes, and grasses are present in moderate quantities. The primary land use here consists of agricultural fields, which are often left fallow to restore soil fertility and nutrients. Intensive to seasonal agricultural practices is totally concentrated in and around the foothill of Ajodhya. The predominant cultivated crop is paddy, with other crops including barley, oilseeds, and vegetables

such as brinjal and tomato, locally referred to as *bilati.* In some areas, wheat is also cultivated.

As one of the driest regions, water scarcity presents a significant challenge. During summer, groundwater levels decline, and villagers struggle to access sufficient water for domestic and agricultural needs. To address these issues, various government initiatives have been implemented. Projects such as the Usharmukhi Micro Watershed Scheme, *Jal Dahro Jal Bharo* Scheme, and *Jalatirths* Scheme have been introduced, utilizing rainwater harvesting techniques and creating reservoir ponds to store water for use during shortages. Furthermore, managing surface runoff from excess rainfall is critical; consequently, several check dams have been constructed within the villages to mitigate runoff (Mukherjee & Das, 1989). Although canals exist, they are seldom functional, with water being released only once or twice from the dams. The land use pattern also encompasses settlements of indigenous populations, village markets, arts and crafts markets, temples, and key project centers. The settlements are scattered and typically connected by unpaved (Kuchcha) roads.

4.4. Challenges in Livelihood

The residents of Ajodhya Hill villages in West Bengal are mostly tribal communities like Santhals, Bhumij, and Mundas, who have a strong dependence on forest resources for their livelihood. Notwithstanding the rich cultural and ecological history of the region, these extremely rich inhabitants are confronted with multiple challenges related to their livelihoods, which are deeply connected with environmental degradation, socio-economic marginalization, and geographical constraints (Palit & Saren, 2021).

4.4.1. Scarcity of Resources

The major problem in Ajodhya Hill is the availability of basic natural resources. Earlier, a very dense forest was depleting naturally due to illegal tree felling, jhum cultivation, and tourism without proper regulation. Fuelwood, minor forest products, and medicinal plants that are important for tribal livelihoods are threatened (Dey & De, 2010). Further, in the context of scanty irrigation facilities, the agricultural system still continues to be dependent on rainfed weather, which is uncertain, causing low yield and food insecurity. Agricultural productivity specially in the villages located on the hill has been declined and availability of medicinal plants is also indigenous.

4.4.2. Challenges in Living Conditions and Environment

The living conditions in these villages still leave much to be desired: poor access to safe drinking water, electricity, healthcare, and sanitation. Accessibility is further limited due to hilly topography and inadequate infrastructure, which worsens during the monsoon, when landslides and floods are common (**Figure 4** and **Figure 5**). Malnutrition, diarrheal diseases, and illiteracy further compound the vulnerability of the tribal people, thwarting them from escaping the poverty cycle.

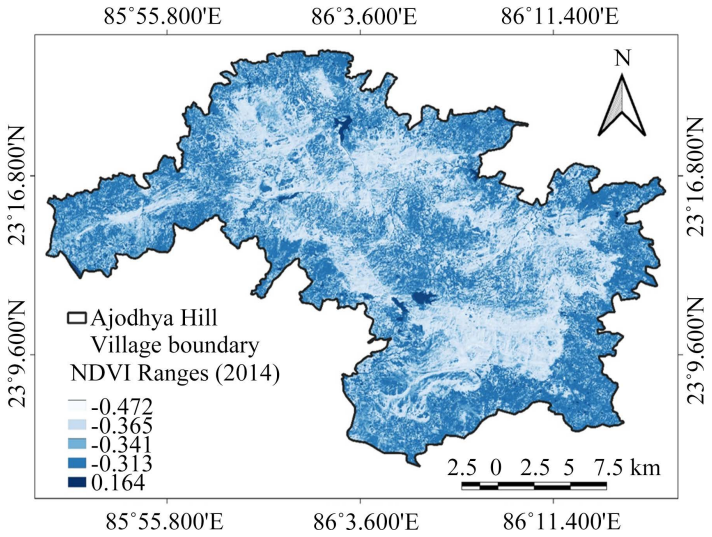

Figure 4. NDWI of 2014 shows the different water index in Ajodhya region in 2014; where different water content is represented and the waterbodies such as lakes are shown.

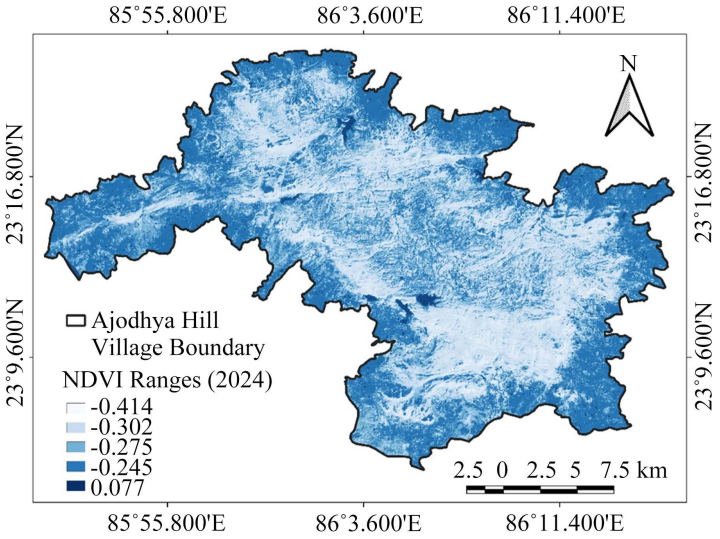

Figure 5. NDWI of 2024 shows the different water index in Ajodhya region in 2024; where different water content is represented and the lakes are seen near the hilly region. The water content of the overall Ajodhya region is quite high as compared to 2014.

4.4.3. Challenges Regarding How They Interact with the Environment

Co-existential relation with nature is the hallmark of the primitive tribal community pertaining to the traditional way of living. However, they are under pressure from both native (population pressures) and introduced (state forestry laws, outside market demands) factors, which have hindered their sustainable practices. Historically, this was managed through community-level norms and knowledge systems, but in recent years, over-extraction has been observed, particularly in the case of the collection of *sal* leaves, honey, and bamboo. Government controls and community participation in forest management are also a source of tension between authorities and local people.

4.4.4. Spatio-Temporal and Geographical Condition

The position of Ajodhya Hill in the western plateau fringe of West Bengal has distinct geographic and climatic obstructions. The region has a harsh desert climate with erratic distribution of rainfall. Timewise monoculture dependence on the monsoon season for agriculture diminishes 365 days of productivity. Seasonal migration for work, to cities of Jharkhand and other regions of West Bengal, is also prevalent, calling for livelihood diversification.

4.5. Livelihood and Agriculture

In most villages in Ajodhya, males are predominantly engaged in various professions, including shopkeeping, transportation, and farming. Females, on the other hand, are mainly dependent on livestock farming and household management. In most families, both the male and the female work together, either in the field or in different professions. They engaged themselves from morning till dusk in order to run the family. However, in certain scenarios or households, it is evident that females are primarily responsible for maintaining the livestock and caring for the children. In a village like Murguma, females are not engaged in farming; instead, they are involved in family issues and tasks such as fetching water and collecting firewood (Figure 6). The scenario in the case of agricultural practice mostly takes place in the monsoon and post-monsoon season, where the availability of water is maximum. And they mainly practice subsistence farming (Figure 7). Aman paddy is the main staple crop for the Ajodhya villages. In the villages near *Turga*, they cultivate drought-prone staples like millet, black gram, and mustard often in small patches. Around the homestead's trees, such as mango, guava, and papaya, and in a few families' gardens, there are also tiny vegetable gardens irrigated by hand-dug wells. Farming is often characterized by the wooden ploughs drawn by cattle, and Santhals, Mundas, and Bhumjis' households maintain old local seed varieties and age-old planting techniques. The women are mainly engaged in the weeding and post-harvesting scenario. The types of crops that are mainly harvested in and around the Ajodhya village are potato, Brinjal, Corn, Rice, and Tomato in the monsoonal season.

Figure 6. A temporary shed where stored fuelwood, reflects the dependence of local communities on forest resources for daily livelihood.

Figure 7. A view of agricultural fields. It reflects seasonal paddy cultivation and natural vegetation in the study area.

5. Discussion

5.1. Scarcity and Survival-Natural Resource Management and Practices-Community Resilience in Crisis

5.1.1. Water Conservation and Management

1) Rainwater harvesting

In the Ajodhya Hill region, with its pronounced seasonal rainfall and protracted dry spells, rainwater collection is a crucial strategy for ensuring water security. The area receives very little rainfall throughout the year, resulting in rapid runoff from the lateritic, mountainous terrain, which cannot retain sufficient water. To collect this water, traditional and community-based rainwater harvesting facilities are constructed at key points across hill slopes and valleys, including percolation tanks, agricultural ponds, and surface runoff collection pits. Using clay on cement-lined storage tanks, bamboo gutters, and tin on asbestos roofs, tribal households also engage in rooftop rainwater gathering. On hot summer days when most ponds are dried up, the people of this dry region have come up with a different method of storing water in "*Happa*". In the center of the pond, a large hole is observed, where water from unexpected down processes or trapped in rocks and dirt fills it in almost all blocks. People get through the dry season by using this stored water. Rainwater collection not only augments water supply but also facilitates groundwater recharge, improves soil moisture for agricultural fields, and mitigates surface erosion, rendering it an ecologically friendly alternative.

2) Construction of Check Dam

One of the most effective small-scale engineering solutions used in the Ajodhya Hill region to address water constraints and stop erosion is the check dam. By reducing runoff during the monsoon, these low-lying, semi-permanent barriers constructed across seasonal streams and gullies aid in moisture retention, infiltration, and groundwater recharge. These tiny check dams are able to contain the monsoonal rains because of the region's lateritic and rocky terrain, which has poor

water retention (Ruj et al., 2025). Many schemes, such as MGNREGA and IWMP, have supported the construction of multiple check dams around the Ajodhya Hill region. Villages with operational check dams have demonstrated higher soil fertility and noticeably enhanced agricultural intensity (**Figure 8**). Due to their difficult circumstances during the dry season, farmers have opted for check dams, which provide adequate water to support agricultural and daily household operations all year round.

Figure 8. Water flow over a check dam in the Ajodhya region, examine the role of small-scale hydrological structures in water management within a hilly forested landscape. It helps in groundwater recharge, irrigation support, and sustaining local biodiversity. This image also reflects human interventions in modifying natural hydrological systems for livelihood and ecological balance.

3) Pond and Reservoirs

In the Ajodhya Hill area, ponds and reservoirs function as lifelines for communities, livestock, and ecosystems. Unlike the quick runoff that characterizes the region's monsoonal landscape, these man-made or expanded natural depressions store water year-round and are crucial during the dry months, in contrast to the rapid runoff that defines the area's monsoonal environment. One of the most important sources of water in the area is the Murguma Reservoir, which is close to the northwest base of Ajodhya Hill and provides water for residential use, aquaculture, and irrigation. Rainwater and seasonal flows are collected by a number of reservoirs, including Bamni, PPSP storage tanks, wells and several ponds constructed by Panchayats (**Figure 9**). Fish farming, a new method of subsistence, was also practiced in these multipurpose waterbodies. However, there are still numerous problems with siltation, encroachment, and inadequate upkeep. Community-managed ponds and reservoirs are crucial in this drought-prone region not only for supply but also for ecological restoration, livelihood diversification, and climate adaptation.

Figure 9. Traditional open well located in the Ajodhya region which is use as a community-based groundwater source, domestic and agricultural purposes. The structure reflects local resilience on shallow aquifers for daily sustenance. They also face sustainability concerns such as groundwater depletion, contamination, and reduced recharge due to changing land-use patterns.

4) Traditional water purification

Traditional methods of water purification and storage play a vital role in the daily lives of tribal communities. One widely practiced technique is to store drinking water in earthen pots, which are placed on beds of wet sand under a tree's shade to maintain a cool temperature and natural filtration. The porous nature of the clay allows slow evaporation, which helps cool the water and slightly filters out large impurities. Additionally, in some households, water is filtered through a cotton cloth or charcoal, or ash added for a basic purification, a method supported by traditional ecological knowledge systems. In recent years, public health campaigns by NGOs and local self-help groups have been introduced to improve these methods, such as using covered pots to avoid mosquito breeding, training on post-cleaning with mild herbal disinfectant, and demonstrating low-cost solar disinfection (SODIs). These blended traditional-modern water safety practices are not only cost-effective and culturally accepted but also sustainable, making them especially relevant for remote forest edge communities in the Ajodhya Hills.

5.1.2. Traditional Agricultural Practices

1) Indigenous tools

A range of indigenous tools made from locally accessible materials are essential to traditional agricultural techniques in the Ajodhya region. The region's reliance on animal-driven agriculture is reflected in the Desi Hal or Langle (Figure 10) which is mainly used for initial tillage and pulled by two bullocks. By levelling fields and breaking up clods, the wooden Planer or Moi enhances soil structure and gets it ready for planting. The pickaxe (Gaiti) helps farmers break hardpan soil, enabling cultivation even on difficult terrains, while the spade (Kodal) is used for digging, breaking clods, and creating furrows. For chopping logs and shaping plants, especially when clearing wooded regions and caring for orchards, the axe, also known as the Kurhar, is indispensable.

Figure 10. In this image a farmer carrying a traditional wooden which highlighting indigenous agricultural practices plough on the hill area.

Tools for harvesting and processing include the Hausa-I sickle, which is used to cut paddy and remove grasses, and the Kula scoop, which is used in traditional winnowing techniques to separate grain from chaff. The creative use of human energy in agricultural processing is demonstrated by the employment of traditional processing tools such as the Sil Nora (Shil Noda) for grinding spices and herbs and the Dheki, a wooden lever-based device used for husking grain. A wooden Ghani is used to extract oil from Mahua and mustard seeds, maintaining traditional methods that yield premium oil. For transportation, the bullock cart (Karagari) continues to play a key role in moving crops from fields to homes or markets. Collectively, these tools highlight the deep knowledge of local farmers in integrating natural resources, human labour, and animal power to sustain traditional agriculture while maintaining ecological balance.

2) Crop Calendar

The crop calendar delineates the quantity of crops cultivated on specific land within a yearly cycle. The cropping pattern of a given region is wholly contingent upon its climate and soil composition. The soil in this area is shallow with a moderately coarse texture, leading to a limited capacity for water retention. During the Kharif season, crops such as paddy (Figure 11) (including both house paddy and Aman paddy), maize, groundnut, among others, are cultivated. In the Rabi season, wheat and lentils are predominantly reanimated.

Figure 11. Bundles of paddy seedlings prepared for transplantation in the Ajodhya region. This image illustrates the predominance of paddy cultivation in local agricultural practices.

3) Water for crop

In the villages, the net irrigated area is 3925 hectares, partially irrigated land is 414 hectares, and the total rainfed area is about 4836 hectares. Various sources of water are available for irrigation, such as rivers, namely Kankshabati, Subarnarekha, and Kumari. Apart from these, other sources include canal diversion and groundwater, but during the dry period, the problem of water scarcity occurs.

4) Cropping pattern and rotation

Like other regions, the Purulia district villages also follow the same kind of cropping pattern. They show seeds mainly in the kharif season and in winter, potatoes, master tomato, or show during summer, bitter goat and sweet pumpkin. Nowadays, sugarcane is also cultivated in the lower foothill areas.

5) Crisis: Local and global

a) Local Crisis:

The villages of Ajodhya Hill face acute resource management issues due to deforestation, soil erosion, water scarcity, and declining forest productivity. Overdependence on forest products, shifting cultivation, and lack of alternative livelihoods have intensified pressure on natural resources. Seasonal unemployment, poor infrastructure, and limited access to health and education services further marginalize these tribal communities.

b) Global Crisis:

These local challenges reflect broader global concerns of environmental degradation, climate change, and the unsustainable use of natural resources. The loss of biodiversity, increasing carbon emissions from deforestation, and vulnerability to extreme weather events link Ajodhya Hill's plight to global ecological crises. Moreover, the erosion of Indigenous Knowledge Systems due to modernization mirrors the worldwide threat to cultural diversity and traditional ecological wisdom. This dual crisis highlights the urgent need for integrated, participatory, and sustainable resource management practices that bridge local livelihoods with global environmental responsibilities.

5.1.3. Forest Management

1) Joint Forest Management

The forest, including the northern tropical dry deciduous forest, is part of the ecological landscape. Ajanta encompasses 13719.76 sector forest land. The tribal population in this region relies heavily on the forest for their livelihood. To prevent the loss of biodiversity while focusing on sustainable rural development, RKMLSP actively engages in promoting JSM in the Ayodhya Hill area. RKMLSP has established green colleges in this region to provide skill training to rural youth and to raise awareness about the sustainable utilization of natural resources, thereby enabling the local tribal communities to derive economic benefits and improve their livelihoods. The Joint Forest Management (JFM) approach aids in conserving the rich biodiversity of these hills by involving local communities in conservation efforts (Figure 12). Additionally, JFM grants a stake in forest resources to local communities, which leads to a reduction in the transaction burden

on local populations and forest authorities. In the villages of Ajodhya hills are surrounded by the dry deciduous tresses dominated by Sal, Mahua, Palash, and scattered bamboo and Tendua trees. They provide a huge variety of timber, fuelwood, bamboo for making of fences and mats. Mahua flowers, honey medicinal plants and fodder for livestock which is an important component for rural subsistence farming. This is a striking example of how the rural communities rely on forests for their daily livelihoods yet of huge ecological pressure. These forests serve as the lifeline of the locals.

Figure 12. Stunning beauty of Pakhi Pahar which is located in the dense forest of Ajodhya Hill in West Bengal which is symbolizing the interconnected between natural landscapes and resource management by the local community.

2) Non-Timber Forest Product

Non-Timber Forest products encompass medicinal and aromatic plants, honey produced by bees, and a diverse array of other products. In the Ayodhya hills, local inhabitants harvest large Shal leaves for the production of disposable plates. The bark of certain trees is used to produce edible oil and shawls, while the resin obtained from crept bark is burnt as incense. The local Hindu community, known as Kend, collects leaves which are used by tribal women to wrap beedis, supporting a traditional cottage industry. Villagers also extract oil from Kusum seeds for culinary purposes and as lamp fuel. Additionally, Koroi, a locally known tribal craft, involves cutting the Karo stem to weave mats, baskets, and various other handicrafts.

5.1.4. Indigenous Knowledge System (IKS)

1) Ethno-botanical Knowledge

This region is predominantly inhabited by various tribal communities that possess knowledge of ethno-botanicals and have access to a range of medicinal plants. In many reports, it is claimed that a total of 56 plant species of 35 plant families were found to be used by different ethnic groups present in Ayodhya Hill and its

adjoining villages. Depending on the disorder, plants were used alone or in combination with other plants. For example, Polygonum plebeian, when mixed with the adventitious root of Ficus benghalensis and bark of Butea superba, was found to cure dysentery. To alleviate stomach aches, colds, and coughs, especially in babies, the root of Cissampelos pareia is crushed with the root of Ocimum basilicum. Haritaki (Terminalia chebula) fruits (**Figure 13(a)**) are valued as a mild laxative and for treating digestive problems and sore throats. *Boira* fruits (**Figure 13(b)**) traditional medicine uses a variety of parts (bark, roots, and leaves) to treat conditions like wounds, toothaches, and stomach issues. These treatments show how indigenous botanical knowledge provides easily accessible, affordable healthcare and emphasize the close relationship between biodiversity and community well-being.

(a) (b)

Figure 13. (a) Haritoki growing in the forests near Ajodhya Hill, West Bengal. They use it as digestive remedies which reflects their indigenous healthcare practices. (b) Fruit branch of Boira which is found in the Ajodhya Hill region, West Bengal. It is a non-timber forest resource which supports the traditional ecological knowledge of the local communities.

2) Cultural practices: Rituals and festivals

Because of their strong ties to the land and farming cycles, the people of the Ajodhya region celebrate a wide variety of seasonal and agricultural celebrations. Disum Sendra is a hunting celebration observed by the Santhal community, while Bataula signifies the planting of Asarh seeds. Cultivators also celebrate Rohinutsav, a holiday associated to sowing, to bless the recently planted seeds. The Karam Parabs are celebrated when paddy cultivation is finished, with a focus on communal joy and thankfulness. While Bandha Parab, which is celebrated after Kali Puja and is well-liked by the Kurmi, Bhumig, Korsha, and Lodha people, is known to the Santhal and Munda communities as Sohray, the Bhadu festival honours the harvest of Aus paddy in the month of Bhadra. Additionally, the Baha festival, a spring celebration, highlights the seasonal renewal and prosperity. Collectively,

these rituals and festivals underscore the cultural heritage of the region, intertwining agricultural practices with social cohesion, spiritual observances, and communal joy.

3) Cultural and Indigenous knowledge

The locals are actually accustomed to the cultural significance and benefit of the indigenous knowledge. They mainly followed the culture related to respecting wildlife, forests, and water sources during festivals, reaffirming the moral precepts of resource management. Storytelling, dance, and music all contain ecological information and transmit it to future generations in captivating and unforgettable ways. Festivals such as Disom Sendra, celebrated in the post-harvest season, promote harmony with nature and transmit agricultural and forest knowledge. It is associated with rituals honouring trees and water bodies, as well as with music, dance, and storytelling. Mainly, they practice cultural events around the harvesting season to inculcate agricultural rituals and practices. However, the next generation is less engaged in transmitting the traditions they have learned from their elders. Communities use local plants to cure wounds, fevers, respiratory conditions, and stomach issues. All local people, including children, are well aware of the remedies that forest trees provide, and to some extent, they rely on forest products and their benefits.

5.2. Sustaining Livelihood

People in tribal communities living in the Ajodhya Hill vicinity are primarily dependent on eco-based livelihoods and ecotourism (Figure 14). However, environmental degradation and economic deprivation have compelled them to modify traditional practices and adopt new, eco-friendly measures. Sustainable livelihoods within this landscape now include forest-based resource utilisation and highland agricultural technologies and practices that are more productive when local people are involved.

Figure 14. Scenic view of Ukamburu in the Ajodhya region which is surrounded by forested hills.

5.2.1. Forest-Based Livelihood

Forest-based livelihoods remain the lifeline for the survival of tribal families in Ajodhya Hill. Non-Timber Forest Products, including sal leaves, mahua flowers, tamarind, lac, honey, and bamboo, are collected and marketed in local markets, sometimes constituting the major source of cash income for most households (Figure 15 and Figure 16). Women are significantly involved in sal-leaf plate making, a traditional green practice that assures household income during non-agricultural seasons. The Ajodhya region is known for its use of ethnomedicinal plants, an ancient practice among the Santhal and Bhumij tribes. Typical indigenous plants and traditional phytomedicines such as Andrographis paniculata (kalmegh), Terminalia chebula (haritaki), and Aegle marmelos (bael) are commonly used to cure common ailments, including fever and gastrointestinal disorders. Community-based conservation programs, such as village herbal gardens and ethno-medicinal plant nurseries, are being propagated to preserve this valuable indigenous knowledge and biodiversity for future generations (Mame et al. 2025).

Figure 15. Mud houses with tiled roofs reflect the adaptation of local community, ecological conditions and insufficient resource of their everyday livelihood and management challenges.

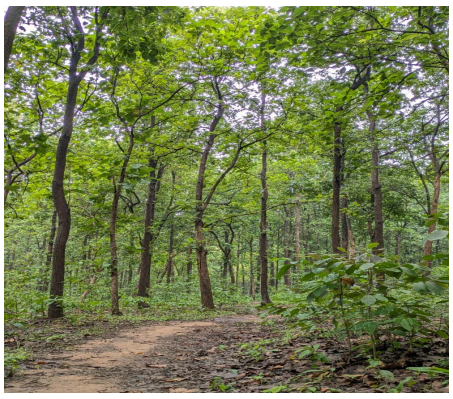

Figure 16. Dense tropical deciduous forest vegetation, showcasing the dominance of tall tree canopy and understory growth. Villagers collect forest resources like sal leaves, mahua, kendu leaves, medicinal herbs etc for consumed themselves or sold in local markets which helps in their economic growth.

5.2.2. Shift towards Agriculture

Recognizing the limits to livelihoods solely dependent on forests, many communities began to turn towards farming. Organizations like PRADAN (Professional Assistance for Development Action) have been instrumental in setting up initiatives such as Self-Help Groups (SHGs), particularly among tribal women, to promote sustainable development. Another great example of its benefits is the System of Rice Intensification (SRI). This method reduces water use and increases yield per hectare, thereby enhancing climate resilience and, economically, making it fully viable. In order to enhance food and income security, farmers are increasingly shifting from monocropping to diversified cropping systems. Crops like millets, pulses, as well as oilseeds are being taken up in conjunction with rice planting too. Finger millet (Eleusine coracana) and pigeon pea (Cajanus Cajan), for instance, are drought-resistant and can help increase soil organic content. They therefore suit nicely in the sloping uplands of Ajodhya Hills. In order to deal with the issue of the depletion of soil nutrients and decrease reliance on chemicals, villagers have started utilizing their nightsoil be vermicompost. This has brought better productivity in crops but has at the same time created a source of revenue through sales of fertilizer. On compost pit construction and maintenance, PRADAN and local panchayats provide training programs, making it readily scalable across tribal hamlets.

5.2.3. Reduced Socio-Economic Pressure

Over the past few years, specific developmental programs and community-based interventions in Ajodhya Hill villages have been successful to a great extent in lowering the social and economic stress on the tribal population. Other income generation possibilities, apart from the dependence on the forest, were generated through programs such as SHGs, induction in skill development training, and access to government welfare schemes. These have slowly risen household incomes, decreased seasonal migration, and enabled local communities to better utilize their resources.

5.2.4. Development of Cultural Tourism and Risk from Tourism

Ajodhya Hill, situated in the Purulia district of West Bengal, is ecologically and culturally rich. Over the past few years, cultural tourism has become a new source of income for the local tribal and artisan communities. The area's local festivals, folk art, and distinctive craft practices are drawing in an increasing number of visitors (**Figure 17**). Yet, in addition with the advantages, tourism is still a menace to the environment and the cultural identity of the region (Ghosh & Mukhopadhyay, 2022).

1) Festival Tourism

Festival tourism is the prominent magnet of Ajodhya Hill. Traditional tribal festivals like Tusu Parab, Bandna Parab, and Chhau Dance festivals are celebrated with great splendor and people's participation. These occasions, granted by the local governing and tourism departments, not only attract domestic and foreign

Figure 17. Pakhi Pahar in Ajodhya Hill attracts many tourists with its different types of bird rock art and trekking paths. This place is very unique for the guiding of local, creativity and communal engagement.

tourists but also provide seasonal jobs for rural youth and help local food, music, and dance get promoted. Festival tourism not only supports the cultural traditions but also provides financial benefits to the rural economy, which is often very marginalized.

2) Handicrafts and Mask Making

Handicrafts, mainly the complicated Chhau masks, are the major elements of Ajodhya's cultural economy. The vividly colored masks are intended for Chhau dance, and additionally, they can be used as decorative items. The local craftsmen are usually blending traditional skills with new designs to satisfy the market through their intensive crafting skill.

3) Charida Village, Chhau Mask Artisans

Charida village, situated near Baghmundi, is known worldwide as the hub of Chhau mask production. The principal occupation of the region is Chhau mask making, which is now registered as a Geographical Indication (GI) of India. More than three hundred families are solely engaged in this craft. Tourists flock to Charida mainly to see masks being made, to talk to the craftsmen, and to buy from them directly (Figure 18). This kind of artisanal tourism has uplifted income levels, especially amongst women and youth. Though the commercialization of the craft clearly has positive aspects, it also leads to the dilution of the culture and the symbolic loss of the masks.

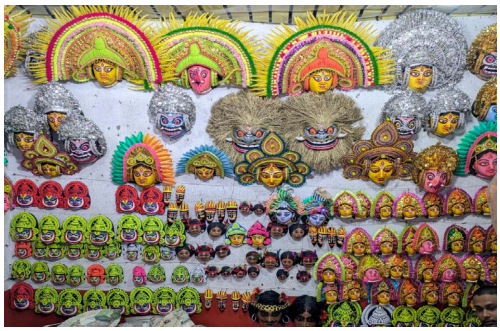

Figure 18. Traditional Mask making which reflects the cultural artifacts, craftmanship of ***Mukosh Gram*** in Ajodhya, West Bengal.

4) Pakhi Pahar

Pakhipahar, a hill offering a beautiful view near Ajodhya, has been named the district's eco-cultural tourism centerpiece (Mandal et al., 2024). Local youth groups have been empowered through various trainings as guides, performers, and hospitality providers. They not only organize cultural programs, trekking routes, and birdwatching tours but also contribute to this green cause, earning a sustainable income in the process. The participation of young people in tourism activities has resulted in pride being felt for local heritage and has also resulted in reduced migration through the offering of sustainable livelihood options.

5) Risk from Tourism

Though tourism contributes significantly to the economy, it likewise brings along some negative impacts. Unchecked tourists coming in large numbers during peak seasons result in not only littering but also deforestation, and overuse of water and sanitation facilities. The concept of "cultural commodification," that is, the process of the traditional cultures being changed for the sake of tourism needs, has become the major cause of the disappearance of the tribal customs and dance performances' authenticity. Besides, such negative consequences of the unregulated growth of roadside markets and commercial lodges as social tension and exploitation appear when the local population is not included in profit-sharing (**Figure 19**).

Figure 19. Temporary shop near the tourist spots of Ajodhya region which depicting makeshift shelters and associated environmental impacts such as plastic accumulation along the forest edge.

5.2.5. Water Resource Development and Hydropower Generation Project

Water is an important natural resource, essential to the livelihoods of the villagers

of Ajodhya Hill. Yet water remains vulnerable due to erratic rainfall, seasonal streams, and hilly terrain. The exploitation of water resources, through the construction of irrigation works and medium- and small-scale hydroelectric plants, is a key factor in reducing water stress and increasing the resilience of agriculture and domestic uses.

1) Irrigation

Rice farms in the Ajodhya Hill region are predominantly rain-fed and subject to precarious agriculture. Recognising this, the government and NGOs have encouraged small-scale irrigation facilities such as check dams, shallow tube wells, and lift irrigation. These are interventions that have enabled farmers to expand cultivation into the dry season and increase yields. For example, NGOs such as PRADAN and local Panchayats have collaborated to install low-lift irrigation pumps along bridle paths (associated with small streams), benefiting marginal farmers in tribal hamlets. Among the cultivated crops, paddy is the most dominant, supporting subsistence and livelihoods in this region. They primarily use rainfed water for irrigation. This practice reflects the community's dependency on the rainfall water and small water bodies like ponds. Most farmers use wooden ploughs, drawn by cattle, for tilling, weeding, and harvesting. These indigenous tools are crafted from locally available resources such as wood and iron. These tools are mainly used in farming systems due to cost-effectiveness, ease of repair, and sustainability for small agricultural areas.

2) Pre-System Water Stress

Villagers in Ajodhya Hill experienced acute water stress before the introduction of water management systems. During the summer, women and children had to walk many kilometres each day to fetch drinking water because there were few water sources. This has limited agriculture to a single season, resulting in food insecurity and income instability. Livestock became dehydrated and contracted diseases, including those that lowered the yield of dairy and meat products. These deteriorating health conditions led to increased migration to access other employment opportunities.

3) Water Harvesting

Due to the uneven distribution of rainfall, water-harvesting structures have become necessary. The government has constructed *jhola bunds* (small earthen dams), *dobas* (small farm ponds), and a rooftop rainwater-harvesting system to conserve water for both irrigation and domestic use. These structures not only reduce runoff and soil erosion but also recharge groundwater, providing water during dry months.

4) Livestock Integrated Farming

Along with better access to water, integrated systems have begun to develop. Farmers are practising integrated farming by combining their agricultural activities with animal (dairy, goat, and pig or poultry rearing) and mushroom cultivation to earn a diversified income. There is also an increasing trend toward women and women's SHGs taking up the operation of caged and backyard poul-

try, goats, and pigs because it requires less space and water. Furthermore, access to water has enabled the favourable development of oyster mushroom cultivation, which is both profitable and sustainable. Such an integrated model not only enhances nutrition and food security but also helps decrease dependence on forests.

5) Threat from Hydropower Project

The environment and nearby tribal communities are seriously threatened by the proposed hydropower projects in the Ajodhya Hill region. Even though the goal of these projects is to produce clean energy, they frequently call for the purchase of land, deforestation, and modification of natural water flows. Tribal families may be uprooted, agricultural land may be lost, and livelihoods dependent on forests may be disrupted as a result. Additionally, the delicate hill terrain's ecological balance is in jeopardy due to increased landslip vulnerability and stream drying up. Hydropower development could exacerbate already-existing resource conflicts and marginalization if community consultation and environmental protections are not properly implemented.

5.3. Living with Limits: Crisis of Survival

Villages like *Bamni*, Baghmundi, and *Turga* in the Ajodhya Hill region show how livelihoods, natural resources, and tourism interact. While the nearby Sal and Mahua forests supply fuelwood, feed, and non-timber forest products, farmers depend on rainfed paddy, millets, pulses, and domestic gardens. Water management, cropping, and seed selection are guided by traditional practices, while livestock and irrigation are supported by small streams, ponds, and check dams. With tourists concentrated on hilltops, woods, waterfalls, and cultural events, tourism has grown to be a significant source of revenue. This has created chances for homestays, local handicrafts, and guided hikes. Agriculture, forest resources, and community income are still at risk due to irregular rainfall, soil erosion, deforestation, overgrazing, and seasonal migration. However, recent efforts, such as watershed projects, afforestation, and horticulture promotion, have improved water retention and livelihoods. The reality of the area is one of subsistence living combined with delicate ecosystems and expanding tourism, where local knowledge and modest development initiatives coexist to support both people and the environment.

5.3.1. Environmental Degradation

1) Drivers and Mechanisms of Deforestation

The pumped storage project in Ayodhya Hill capitalizes on the region's advantageous local topography, situated on a tributary of the Subarnarekha. This development is impacting the ecosystem and the natural bio-geomorphology of the area. An additional concern associated with this project is the region's increasing soil erosion, rendering it susceptible to soil erosive processes. Consequently, the construction of pumped storage plants contributes to environmental degradation,

further exacerbated by other development initiatives that alter forest cover, convert agricultural land, and expand settlements. Traditional practices such as shifting cultivation among the tribal populations have also led to forest land degradation. Furthermore, exposing bare rock surfaces for tourism purposes is another factor contributing to the environmental challenges faced by the region.

2) Deforestation

Frequent forest fires during the dry season, the expansion of settlements and related infrastructure, and agricultural development have led to a decline in dense forests. Forest cover controls the climate of a region, and deforestation leads to a decrease in the amount of rainfall, which directly affects agriculture, as it largely depends on natural conditions.

3) Scarcity of water: Agriculture and household

Water scarcity is the insufficient availability of water resources to meet the demand for water use within a region. It already affects every continent, with at least 2.8 billion people worldwide experiencing at least one month of water shortage each year (International Decade for Action on Water and Life, 2005 to 2015). Identifying the causes of water scarcity in the villages around Ajodhya is crucial, as rural development plays a key role in economic and human progress. Water scarcity, both in this village and throughout Purulia, has a long history, which is also reflected in numerous folklores of Purulia. Both physical and economic water scarcity have been reported in this area. Ajodhya covers parts of Jhalda, Baghmundi, Balarampur, and Arsha, areas characterized by very low to low groundwater utilization. Rapid deforestation, soil erosion, and grazing contribute to water loss and ultimately lead to water scarcity.

5.3.2. Socio-Economic Challenges

The villages of Ayodhya Hill are underdeveloped and backward. Land remains underutilised, which often leads to poor resource management. Many related problems are faced by the marginal people of the foothill villages.

1) Agriculture challenges

The region is dry, and the soil pH is primarily neutral (Sarkar, 2025). This makes agricultural practices somewhat difficult in these areas. Water scarcity and irrigation problems are major issues in these villages. However, these problems have decreased significantly since the implementation of ponds and rainwater harvesting methods.

2) Water Challenges

Water-related, the Ayodhya hill region has extreme weather conditions. In summer, extreme heat damages crops and vegetables. On the other hand, heavy rainfall also damages these. During the monsoon months, due to heavy rainfall and the release of excess water from dams and barrages, floods often occur. That damages villagers' livelihood patterns and worsens their condition.

3) Transport Challenges

Transportation systems in the Ajodhya hill are well constructed. Still, some issues are faced by marginal people. Main roads, or high roads, are located at dis-

tances of approximately 500 - 750 m to 2 km, or sometimes more, from the villages. The fairy hospitals, health centres, and schools are major issues here. Sometimes cattle congregate along narrow, hilly roads surrounding tourist sites, creating traffic congestion, especially during peak tourist seasons, and disrupting vehicular movement (Figure 20).

Figure 20. Cattle congregation on the Ajodhya tourist spot which illustrating human-animal interactions and land-use practices in the riparian landscape.

4) Environmental challenges

Environment-related problems, such as deforestation due to improper land use management, lead to environmental damage, thereby disturbing the ecological balance of biodiversity. The land in these villages has the potential to reduce backwardness, but improper usage and neighbouring resource management hinder development. Purulia, one of the backward districts of West Bengal, faces many social and economic issues caused by poverty, unemployment, underdeveloped infrastructure, poor health and sanitation, food insecurity, and lack of education, among others. These problems create disparities among marginalised groups. In the Ayodhya Hills area, most residents belong to tribal communities, and their livelihoods are severely disadvantaged. Most depend on agriculture as their primary source of food and income. Dependence on agricultural and forest resources is high; some work as agricultural labourers on other lands. Only a few have small businesses, such as grocery, meat, vegetable, and electronic shops in the village market. Many people migrate to other districts or states as migrant workers due to high unemployment, and in 2020, their situation worsened. Some villagers engage in craft activities such as mass making, which has gained popularity recently, and folk dance charunach, which is now internationally recognised. People also perform these arts for earnings. Despite these economic activities, the community's dependence on agriculture for food and the persistence of food insecurity

remain issues. Basic amenities such as mobile phones, refrigerators, and radios are scarce, and overall quality of life is low. Most people live in kutcha houses, and some still use coal or kerosene for fuel. Public sanitation facilities are available, and many have private toilets. Most people own bicycles and travel locally by them. A significant number of residents are educated, having cleared high secondary exams or pursued further studies. Overall, family incomes are generally moderate to low.

Purulia is a district located along the street, and in the Ayodhya hill region, the situation can sometimes be worse. The scarcity of water and dependence on agriculture during the rainy season create ongoing problems. In recent years, efforts like rainwater harvesting under government schemes and the construction of ponds and reservoirs have helped store water for use in the summer months. Additionally, several check dams have been built to reduce surface runoff from excess rainwater. These measures have mitigated water-related challenges, but during the monsoon, heavy rains and the release of excess water from dams often cause problems, sometimes making conditions terrible for poor and marginalized people. Flash floods can also occur due to heavy rainfall. There are very few schools in remote villages, and no colleges are nearby. Residents in other parts of the district must travel long distances to pursue higher education. Although education is spreading, many children still drop out of school and college to work or engage in activities that generate income. Poverty remains a major issue. Hospitals and healthcare centers are scarce in villages; the condition of these facilities is often poor, with limited infrastructure, shortages of medicines, and lacking proper facilities. While main roads and highways are well-constructed and connected, many are far from the core villages.

Dispur and backward villages need development, but in some cases, development efforts carry negative feedback. Building dams or large-scale projects, such as the Purulia pump storage project, cause environmental degradation like deforestation and depletion of water resources. Additionally, ecological balance is disturbed. Not only the environment but also tribal marginalized communities are affected. The displacement of these communities and the acquisition of agricultural land for large projects create difficult situations. Such problems faced by poor people are considerable. The hill area has limited resources, including forests and water. Constructing dams and other projects often hamstring these resources, leading to deforestation and environmental challenges in the region. Tourism is a major income source in these villages, but the COVID-19 pandemic has caused a rapid decline in tourism, creating many economic challenges for locals (Banik & Mukhopadhyay, 2022). Furthermore, environmental damage often occurs, and tribal people have lost many of their cultural rituals, facing difficulty in practicing them. With modern conservation efforts and intervention by urban elites, the Santhal tribe has abandoned many of their traditional rituals. This is morally wrong, as they lose their cultural norms. Additionally, constructing hotels by cutting down trees disrupts the ecological balance of the region. However, in recent times,

the people of these villages have united through awareness and education. Nevertheless, in some places, the lack of education and blind fate still prevail, leading to backwardness. Still, many girls drop out of school at an early age or due to gender inequality. There are 4 sanitation issues, and also child marriage occurs despite the street rules and regulations. The crime rates and illegal activities don't completely reduce.

5.3.3. Cultural Erosion

1) Decline of traditional practices

An increasingly obvious indication of cultural deterioration brought on by outside socioeconomic forces is the loss of traditional customs among the tribal populations in the Ajodhya Hill region, especially among the Santhals, *Bhumijs*, and *Mundas*. Numerous ceremonies, agricultural practices, and indigenous beliefs have been altered or abandoned as a result of the growth of formal education, contemporary media, and urban migration. Seasonal celebrations such as *Sohrai* (cattle worship), Baha (flower festival), and Karam were historically observed by the tribes of Ajodhya Hill and were closely linked to agricultural rhythms and natural cycles. However, many of these events are observed with reduced community participation or have taken tourism-oriented role. The commercialization of folk art and dance, once deeply spiritual and participatory, is now performed primarily for government-sponsored fairs or ecotourism events, disconnecting them from their original context and spiritual significance. Sacred groves and historically significant locations have also been damaged by the growing impact of outside religious missions and state-driven "development projects" including road construction, dams, and forest tourism (Ghosh et al., 2021b).

2) Loss of IKS

One of the most serious forms of cultural deterioration in the Ajodhya Hill is the loss of indigenous knowledge systems (IKS). The term *Indigenous Knowledge System* describes the comprehensive set of customs, beliefs, and knowledge that tribal people have created over many centuries and that are frequently transmitted orally from one generation to the next. Such knowledge in Ajodhya Hill includes agroecological practices, herbal medicine, ethno-forestry, sacred grove conservation, weather prediction based on insect behaviour and cloud movement, and sustainable use of forest resources such as medicinal roots, mahua flowers, and tendu leaves. For example, around 30 to 40 plant species are utilised to treat common illnesses, including fever, snake bites, and stomach issues, according to medicinal healers called *Ajhas* or *Baidyas* (Paul, 2021). However, this deep reservoir of ecological and medical knowledge is under severe threat as younger generations migrate to cities and adopt formal education, which often marginalizes or dismisses indigenous worldviews. In sacred groves, once managed through customary taboos and rituals, forest degradation and administrative interventions have broken these traditional regulatory mechanisms. NGOs and researchers have documented that the elders lament the disappearance of younger custodians who

learned by oral transmission and direct experience in the field.

5.4. Crisis of Resource Management at the Margins

5.4.1. Removal of Earth Materials

In the villages of Ajodhya Hill, the unregulated removal of earth materials like laterite soil, stones, and sand has led to a growing crisis in resource management. These materials are often taken for road construction, real estate, and brickmaking, frequently without environmental clearance or community consent. This damages the land and causes deforestation. It also disrupts the fragile hill ecology and reduces soil fertility, which directly affects agriculture and water retention. The extraction usually benefits outside contractors, leaving local communities with ecological damage but no economic benefit. Without strict monitoring and community involvement, this unsustainable practice threatens long-term resource security in the region.

5.4.2. Extraction of Groundwater in the Foothill Area

The extraction of groundwater in the foothill areas of Ajodhya Hill is now a serious issue in resource management. As surface water sources become less reliable because of unpredictable rainfall and deforestation, the use of groundwater for agriculture, drinking, and tourism has increased. In recent years, private contractors and businesses have installed deep tube wells without proper regulation. This has led to over-extraction. As a result, the water table has declined, which affects both the foothill villages and upstream communities that depend on shallow aquifers and springs. The situation is made worse by unequal access, with wealthier users controlling water sources while poorer tribal farmers experience severe shortages. If this trend continues, it will threaten long-term water sustainability and increase regional inequalities in access to resources. Small streams, seasonal channel, and natural depressions create transient water bodies during the monsoon season in this lateritic, mountainous environment. For irrigation, household use, and livestock watering, villagers mostly depend on these small water sources, as well as ponds, check dams, and wells that have been dug. While the upland plots rely on soil moisture retention and sporadic tank irrigation to cultivate millets, pulses, and oilseeds, the low-lying paddy fields in the valley bottoms close to Baghmundi are nourished by seasonal streams, which support the growth of Aman rice during the monsoon. This hydrological regulation is a key ecosystem service, ensuring that the small streams and ponds retain water long enough to support farming and livestock during the dry months.

5.4.3. Deforestation for the Implementation of Different Projects

Ajodhya Hill, situated on the environmentally sensitive edge of the Chota Nagpur Plateau, has experienced a surge in deforestation in recent years due to development initiatives. Large-scale interventions, such as road construction, hydropower projects, ecotourism facilities, and infrastructure development, have necessitated clearing large areas of dry deciduous forests dominated by *sal*. The *Turga*

Pumped Storage Hydroelectric Project (TPSP), one of the most contentious projects, is to use a dual reservoir technology to produce more than 10,000 MW of electricity. 292 hectares of forest area that support biodiversity and the livelihoods of nearby tribal populations are in danger of being submerged due to this project alone. Tribal groups, particularly the Santhals and Bhumijs, have actively resisted the project, citing violations of the Forest Rights Act (2006) and potential loss of access to sacred groves, grazing areas, and firewood collection.

5.4.4. Soil Erosion Due to Agriculture

In the Ajodhya Hill region, soil erosion is a serious environmental problem, especially in areas where delicate lateritic and upland geomorphology meet unsustainable agricultural activities. The aged granite-gneiss and laterite that make up the hills naturally provide shallow, low-fertility soils that are prone to erosion. During the monsoon season, when rainfall is heavy and vegetation cover is limited, topsoil is being lost more and more due to the increase of slash and burn (jhum) cultivation and seasonal plough-based farming on hill slopes. When natural forest cover is removed for agricultural objectives, soil becomes more vulnerable to sheet runoff and raindrop impact, root stability is weakened, and infiltration is decreased. Significant acreage in the Bagmundi and Arsha blocks has changed from mixed forest and fallow land to seasonal cropland, particularly for highland rice, maize, and turmeric cultivation, according to local assessments. In addition to decreasing fertility and agricultural output, soil erosion causes streams, reservoirs, and check dams to become sedimented, which shortens their lifespan and water-holding capacity. To lessen this growing problem, integrated watershed management Mondal, agroforestry promotion, and the resuscitation of traditional terracing and cover crops are crucial.

5.4.5. Desertification

Overgrazing, deforestation, and poor land use in the Ajodhya Hill region have led to soil erosion and a decline in vegetation. This process is gradually transforming parts of the landscape into a desert-like appearance. Shallow topsoil and low moisture retention are making the land less suitable for farming. This poses a threat to food security and livelihoods.

5.4.6. Greenhouse Gas Emissions

Shifting cultivation and forest burning release carbon dioxide and methane. These activities contribute to greenhouse gas emissions. The increased use of diesel pumps for irrigation and uncontrolled tourism transport also adds to the region's carbon footprint, though to a small extent.

5.4.7. Environmental Drought or Extreme Weather

The region experiences climate fluctuations, including long dry periods and sudden heavy rainfall. These extreme weather events harm crops, reduce water supply, and heighten vulnerability for small farmers and forest-dependent communi-

ties. The Ajodhya Hill region in the Purulia district of West Bengal frequently experiences environmental drought and extreme weather conditions due to its undulating topography, lateritic soil, and erratic monsoonal rainfall. The area often faces prolonged dry spells during summer, leading to water scarcity, crop failure, and degradation of forest ecosystems. The rocky terrain and poor water retention capacity of the soil exacerbate the impacts of drought, while sudden heavy rainfall events during the monsoon trigger soil erosion and localized flooding. These alternating extremes of drought and intense rainfall disrupt the local hydrological balance, threatening traditional livelihoods that depend on agriculture and forest resources. In recent years, increasing temperature trends, deforestation, and changing rainfall patterns linked to climate variability have intensified the vulnerability of the Ajodhya Hill ecosystem, making it a critical zone for studying environmental stress and community-based adaptation strategies.

5.4.8. Topography as a Barrier to Resource Extraction

The rough and hilly land of Ajodhya complicates access to and management of resources like groundwater, soil, and forest products. Implementing mechanized farming or large-scale irrigation systems is challenging due to the presence of steep slopes and rocky terrain. This limits development.

5.4.9. Displacement

Infrastructure projects, such as tourism development or proposed hydropower initiatives, have sometimes resulted in the displacement of tribal families. Without proper rehabilitation or consent, these displacements break community ties, disrupt traditional land rights, and threaten cultural identity, which increases marginalization.

5.4.10. Waste of Resources

The waste of natural and economic resources in the Ajodhya Hill region has become an increasing ethical concern, especially in the context of environmental degradation and the underutilization of local potential. Despite being rich in forest products, water bodies, lateritic minerals, and cultural landscapes, much of the resource base remains poorly managed and inefficiently exploited, leading to both ecological damage and economic stagnation. For example, minor forest produce (MFP) like Sal seeds, Mahua flowers, honey, and medicinal herbs—once vital to the subsistence economy of indigenous groups, are often harvested without sustainable protocols, causing seasonal overextraction, wastage, or spoilage due to the lack of processing units and knowledge. Despite heavy rainfall during the monsoon season, inadequate irrigation infrastructure, such as ponds often results in the loss of agricultural water. The absence of a structured ecotourism framework, especially in sacred sites and tribal settlements, adds stress to the local ecosystem.

5.4.11. Lack of Renewable Alternatives

The lack of access to renewable energy alternatives underscores the persistent de-

pendence of tribal communities on non-renewable and environmentally degrading sources. Despite promotion of renewable energy under way initiatives, the remote forest edge villages in Ajodhya Hills continue to face inconsistent electricity supply and limited infrastructure for clean energy adoption. Over 75% of households rely on traditional biomass for cooking which accelerates deforestation and exposes women to indoor air pollution, which exacerbates poverty and respiratory illnesses. In addition to worsening environmental deterioration, this lack of a planned transition to renewable, decentralised energy systems restricts the diversification of livelihoods, particularly in industries like healthcare, food processing, and handicrafts. In addition to lowering reliance on environmentally friendly energy sources, investments in community-managed solar micro grids, biomass gasifiers, and rainwater-fed micro hydel plants could provide sustainable energy alternatives.

5.4.12. Crisis in Cultural Heritage

The crisis in cultural heritage is a reflection of the wider risks that rapid socioeconomic and environmental change pose to the intangible, customs, sacred spaces, and indigenous identities of its tribal inhabitants. Folk music, ceremonies, and other forms of cultural expression have long been cultivated by the Santhals, Bhumijs, and other people in this area. However, religious influences, formal education that disregards tribal history, deforestation, and displacement are now causing native languages to be marginalised, sacred knowledge to be lost, and ceremonial landscapes to be desecrated. Tribal values, native musical instruments, and traditional healing methods are examples of cultural expressions that are currently in danger of disappearing as the younger generation moves to cities to live more mainstream lives. While some community-led initiatives are attempting to document folklore and revive festivals, they often lack institutional support or are co-opted for performative, non-participatory cultural shows.

5.5. Balancing the Nature and Human Needs

Situated in the northeastern part of the Chota Nagpur Plateau and the western part of Purulia district, the mountainous region of Ajodhya has a tropical to subtropical climate with dry deciduous and some evergreen vegetation covering an undulating red and lateritic surface. Notable hills including Ukamburu, Mathaburu, Gorgaburu, Pakhipahar, and Ajodhya, as well as rivers like the Kangshabati, Kumari, Bamni, Subarnarekha, and Thurga, define the area (Ghosh et al., 2023). The majority of the population was reliant on agriculture due to the foothill communities' historical underdevelopment, which included inadequate roads, little power, and poor communication. Infrastructure, electricity, and road networks have been enhanced over the last few decades by development projects like the Thurga Pumped Storage Project (TPSP) and the Purulia Pumped Storage Project (PPSP) on the Bamni River, which was established in 2008 with funding from JICA and the State Government (Hazari et al., 2025). Regional development has also benefited from other initiatives, such as the Bandu and Kathlagal Pumped

Storage Projects.

5.6. Voice from the Hills: Understanding off Local People about the Scarcity of Resources and Their Management

The indigenous communities of Ajodhya Hill, including the Santhals, Birhors, and other forest-dependent groups, have a deep-rooted understanding of the natural environment and its changing dynamics. Their voices reflect a growing concern over the declining availability of forest produce, clean water, fertile soil, and grazing land. Elders often recall a time when the forest was dense, streams flowed throughout the year, and agricultural productivity was stable. Today, they observe with worry the shrinking forest cover, drying streams, unpredictable rainfall, and overexploited land due to unregulated tourism and stone mining.

Local people identify both natural and human-induced factors behind the resource crisis. They express frustration over being excluded from decision-making processes and the neglect of traditional knowledge systems that once guided sustainable harvesting and land use. Many lament the lack of genuine community-based forest management, where benefits could be shared equitably. There is also rising discontent about mismanaged government schemes, inadequate compensation for forest loss, and failure to create alternative livelihoods. Despite these challenges, there is a strong desire among villagers to revive customary practices, engage in conservation efforts, and demand greater transparency and participation in resource governance, echoing a powerful call for inclusive and sustainable management from the heart of the hills.

6. Major Outcomes of the Research

6.1. Identification of Resource Scarcity Patterns

The research revealed significant seasonal and spatial variations in access to water, forest produce, and agricultural inputs. Water scarcity during dry months remains acute, affecting both drinking and irrigation.

6.2. Understanding of Traditional Knowledge Systems

Indigenous practices of resource use, such as shifting cultivation, herbal medicine, and community-based forest management, were documented, highlighting their relevance and resilience amidst modern pressures.

6.3. Mapping of Human-Environment Interaction

The study established how local livelihoods (mainly agriculture, forest gathering, and livestock rearing) are intricately linked to the hill's fragile ecology, which is now under pressure from deforestation, soil erosion, and climate variability.

6.4. Assessment of Institutional Gaps

Weak governance, poor policy implementation, and lack of infrastructural support were found to be major bottlenecks in sustainable resource management.

6.5. Gendered and Community-Specific Vulnerabilities

Women and marginalized tribal groups face disproportionate challenges in accessing and managing resources, pointing to the need for inclusive planning.

7. Quantitative Summary

The quantitative summary of the study is structured based on primary survey-based evidence, including household surveys, survey and recall methods, focus group discussions (FGD), survey validation, on-field observations, GPS estimations, primary field sketches, and other related data.

7.1. Forest Dependence and Fuelwood Use

According to the Household survey, 78% - 85% of households reported primary dependence on forest resources for daily subsistence. Fuelwood (NTFP) is the dominant energy source for approximately 82% of households, with LPG penetration being limited. The average fuelwood consumption ranges from 3.5 to 5.2 kilograms per household per day, with higher consumption observed during the winter months. Sixty-two per cent of households collect fuelwood four to six days per week, indicating significant extraction pressure. Women contribute approximately 70 to 75 per cent of the total fuelwood collection efforts.

7.2. Water Stress and Collection Burden

According to the Household survey, 68% - 74% of households experience acute water scarcity during the pre-monsoon period (April-June). The average distance to the water source during the dry season ranges from 0.8 to 1.5 kilometres (one way) in upland villages, with some variation observed in certain villages on the Ajodhya Hill. The survey, which incorporates GPS estimation, indicates that the average time spent collecting water is between 1.5 and 3 hours per day per household. The frequency of water collection ranges from 2 to 4 trips daily during peak scarcity months. Focus Group Discussions (FGDs) reveal seasonal drying of streams and wells, consequently forcing communities to rely on distant springs or water tankers.

7.3. Irrigation and Agricultural Constraints

Only 22% - 30% of the cultivated land has access to irrigation in the Ajodhya hills. Mono-cropping dominates (~65% - 72% of households) due to unreliable water availability. Rainfed agriculture accounts for approximately 70% - 78% of total cultivation. There has been a reported decline in crop yields over the past 10 to 15 years, estimated at approximately 30% to 40%, which is attributed to soil degradation and inconsistent rainfall.

7.4. Land Degradation and Resource Stress

Between 55% and 63% of households identified soil erosion and lateritic exposure as primary constraints. Based on field observations and respondent validation, the

expansion of badland-like features has been observed in upland patches, leading to a reduction in arable land. The household survey confirms that 48% of respondents reported declining soil fertility, thereby increasing their dependence on forest-based supplements.

7.5. Livelihood Diversification and Migration

The survey-based results indicate that seasonal migration occurs in 38% - 46% of households, predominantly during agricultural lean periods. Migration destinations include nearby towns and industrial zones, such as Durgapur and Asansol. The primary drivers of migration are lack of irrigation (approximately 52%), low agricultural productivity (around 47%), and limited local employment opportunities (approximately 60%). Households engaged in multiple livelihood activities, including wage labour, forest product collection, and small-scale agriculture, accounting for approximately 64% of the surveyed population.

7.6. Indigenous Knowledge and Coping Mechanisms

According to the household survey, between 57% and 65% of households depend on traditional water conservation methods, such as small ponds and runoff storage. Focus Group Discussions (FGDS) reveal seasonal adaptation strategies, including reduced water consumption and switching crops to millets and pulses. Additionally, forest-based coping mechanisms, such as Non-Timber Forest Product (NTFP) collection, increase by approximately 25% - 30% during periods of drought.

7.7. Institutional Access and Intervention Gaps

Only 28% - 35% of households reported benefiting from government water or watershed schemes. About 60% are aware of forest regulations, but compliance varies due to livelihood dependence. Participation in MGNREGA involves around 42% - 50% of households, though employment days are inconsistent.

The substantial interdependence among water, forests, and livelihoods is evidenced by the following indicators: a high reliance on forest resources, with over 80% of households depending on them; low irrigation coverage, affecting less than 30% of the land; and notable migration, with approximately 40% of households. Resource stress tends to intensify seasonally, particularly during the pre-monsoon months, leading to increased fuelwood extraction, a greater burden of water collection, and temporary out-migration.

8. Conclusion

8.1. Resource Dependency and Vulnerability

The tribal villages of Ajodhya Hill are heavily dependent on natural resources for livelihood, yet they remain vulnerable due to seasonal variability, poor infrastructure, and lack of sustainable management.

8.2. Degradation of Forest and Land Resources

Unsustainable extraction of forest products, shifting cultivation, and deforestation are contributing to ecological degradation and loss of biodiversity.

8.3. Water Scarcity and Irrigation Crisis

Despite seasonal streams and springs, inconsistent water availability, poor storage facilities, and lack of irrigation infrastructure hamper agricultural productivity.

8.4. Livelihood Fragility and Limited Diversification

Over-reliance on agriculture and forest products, without access to skill development and alternative livelihoods, contributes to chronic poverty and out-migration.

8.5. Community-Based Resource Management

Encourage participatory forest and water resource management through Joint Forest Management (JFM) and watershed development programs.

8.6. Sustainable Livelihood Initiatives

Promote agroforestry, handicrafts, eco-tourism, and skill training to diversify income sources for local households.

8.7. Policy Support and Infrastructure Development

The research recommended integrated watershed development, participatory forest management, livelihood diversification, and eco-tourism initiatives as sustainable pathways forward. These outcomes contribute to a grounded understanding of the complex socio-ecological dynamics of Ajodhya Hill villages and offer actionable insights for policy and grassroots interventions. Improve rural infrastructure, ensure land rights, invest in irrigation, renewable energy, and promote schemes tailored to the ecological and cultural context of Ajodhya Hill villages.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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