



Reading the Landscape: A Field Walk Through Jamdoba Badland (Singhargoriya), Bankura, West Bengal

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Abstract: This paper presents a geographer's empirical field observations during a walking survey through a small-scale badland terrain in eastern India. The study interprets land degradation patterns, micro-geomorphological features, ecological transitions, and anthropogenic triggers through qualitative description and photographic evidence. The paper argues that even miniature badland units offer rich insights into erosional processes, geomorphic evolution, and socio-ecological vulnerabilities. Through a conducted field survey, this study tries to explore the condition of the physical landscape by analyzing structural evidence of erosion, human-induced stress, ecological shifting, and soil depletion. In the eastern part of India, the laterite terrain of Jamdoba is the ideal example of a fragile environment in a badland area. This study is particularly significant from a micro-geomorphological perspective, utilizing qualitative analysis, observational techniques, and photographic evidence. Some geomorphological characteristics, such as rills, gullies, and bare surfaces, along with anthropogenic interventions like fuelwood collection, grazing, and cultivation, are exacerbating land degradation. This study presents a contextual approach to the landscape of Jamdoba Badland, emphasizing the direct engagement of physical geography and environmental concern within the lateritic terrain. This study provides a comprehensive examination of gradual land degradation, peripheral ecological areas, and the implications of landscape change, employing field-based and observational methods.

Keywords: Badland, Topography, Lateritic, Degradation, Micro-Features, Field-Based Geographical Observation, Landscape Interpretation

1. Introduction

Badlands are highly degraded lands caused by severe erosion, limited vegetation, and disturbed soil structures (Bryan, 2000; Wischmeier & Smith, 1978). While often examined in large arid and semi-arid regions, smaller badland patches provide close, accessible views of geomorphological processes, including both natural and human-made environmental stresses. This paper documents and analyses a walk across a lateritic badland located at the transition zone between the plateau and plains in eastern India, particularly in the Rarh Bengal region (Sarkar and Das, 2016; Bhattacharya et al., 2018). In western West Bengal, mainly in Bankura district, the presence of laterite terrain is a unique geomorphological factor influencing micro-level badland development (Bandyopadhyay, 2014; GSI, 2001, 2001, 2007). In the Rarh Bengal area, lateritic surfaces indicate long-term denudation, diverse weathering processes, and reactivation of fault systems during the late Quaternary period (Chakraborty, 2003; Ray & Basu, 1999; Sarkar et al., 1990). This study highlights areas that are highly vulnerable to land degradation caused by natural factors and human activities, such as overgrazing, fuelwood collection, and unsustainable land use (Goudie, 2006; Sarkar & Ghosh, 2017). The

Jamdoba terrain, located in Bankura district, lies at the edge between the alluvial plains and the lateritic plateau. Due to geomorphological processes and human activity, this area shows features such as gully erosion, crusted soils, and sparse vegetation (Mandal & Sarkar, 2023; Bhattacharya et al., 2018). Through field observations and geomorphological theory, this study aims to identify signs of land erosion, ecological stress, and soil degradation. The importance of this research lies in addressing land degradation in fragile ecosystems within a region like Jamdoba Badland, which has been little studied (Nandy, 2001; Bandyopadhyay, 2014).

2. Data and Methodology

A qualitative geo-walk survey was conducted over 3 hours, combining Sketch mapping, Soil texture observation, identification of Micro-geomorphic features, documentation of geomorphic processes, Vegetation documentation, Interviews with local people, Geotagged photography, and Geomorphological annotation.

3. The Study area

3.1 Geographical exposure

The central and northeastern regions are characterized by thickly wooded areas, showcasing a brownish-green hue that signifies a mix of dry deciduous forest and lateritic scrubland. Degraded areas within the forest appear as bare or sparsely vegetated patches. Agricultural fields, characterized by a grid pattern, dominate the southern half and eastern edges, displaying various colours (green, light brown) that suggest active farming, fallow land, and potentially areas using irrigation versus rain-fed methods. Numerous villages are situated along the forest's edge, with a significant cluster located in the lower-left (southwestern) section. Smaller hamlets or communities are dispersed throughout the southern area (Fig. 02). Outside the Badlands, several water bodies, including ponds and tanks, are prominent, particularly on the southeastern and northern sides of the area (Fig. 02). These artificial water sources are likely utilized for irrigation, fisheries, and household purposes. A linear canal and road run parallel and cross the central region, indicating water supply infrastructure and significant connections in the forest-agriculture interface zone, along with visible roadside deforestation. Minor roads or paths branch off from this main route, linking to various settlements and fields.

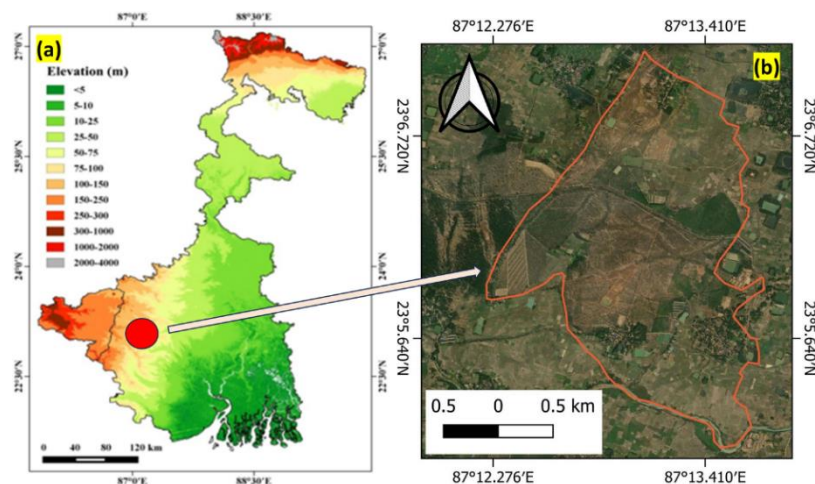


Figure 01: Location of the Study area, (a) map of West Bengal, (b) Census Village mouza of Khapmayna.

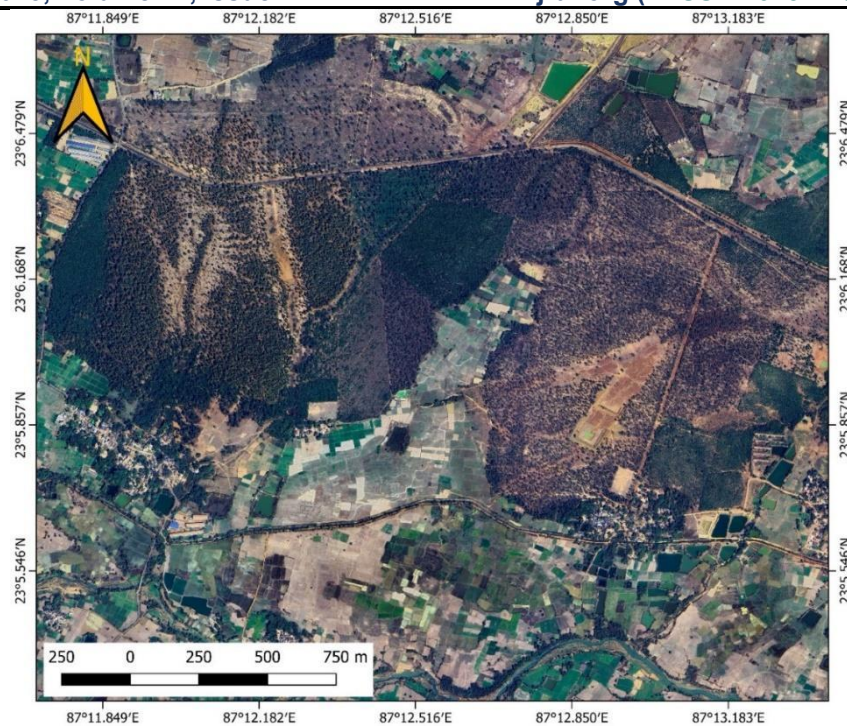


Figure 02: A high-resolution satellite image captures the landscape of the Jamdoba badland region, which is part of the Rarh plateau in Bengal. Located in a lateritic badland zone, Jamdoba sits at the boundary of the foothills and plateau of the Chhotanagpur region. The map indicates the characteristics of the Lateritic uplands prevalent in the central forested area. These regions are prone to erosion and may represent a badland or emerging badland area (rugged and eroded). The southern and southwestern parts feature lower elevation agricultural plains. The overall topography slopes downward from north to south, likely draining towards the river visible in the lower section of the map.



Figure 03: This high-resolution satellite image captures an eastern section of the **badland landscape** within the **Jamdoba area** (Rarh Bengal region) and provides valuable insights into its geomorphic, ecological, and anthropogenic characteristics.

3.2 Environmental Context

Tropical monsoonal climates, characterized by substantial rainfall and alternating wet and dry seasons, are prevalent within the Jamdoba landscape. These conditions are typically found in upland interfluvies, commonly serving as caps for hills or plateaus. In the context of India, such geological profiles predominantly characterize the fringe of the Chhotanagpur Plateau, encompassing regions such as Bankura, Purulia, and West Midnapore. The agricultural practices in this region are hindered by poor soil fertility, acidity, and low water retention capacities. Consequently, soil amendments are essential for effective cultivation, and these must be applied with careful consideration of hydrological factors. The local and regional hydrology functions as an aquitard, potentially obstructing the deep percolation of water. Once the duricrust is compromised, the underlying loose laterite experiences rapid erosion, resulting in the formation of Badlands.

4. Observations and Insights

4.1 Geology, Lithology, and Stratigraphy

Jamdoba Badland lies on the western margin of West Bengal and forms a part of the Chhotanagpur Granite Gneiss Complex (CGGC) in its western region and the Rarh Bengal Plain in the east. The Chhotanagpur Gneissic Complex (CGC) comprises high-grade metamorphic rocks, including gneiss and schist, and represents the oldest basement complex in the region (GSI, 2011). Singhbhum Group equivalents (locally developed as metasedimentary belts) are composed of quartzite, phyllite, and dolomitic limestone bands, often folded and intruded by granitic bodies that formed during the Middle to Late Proterozoic era (Nandy, 2001). The district is geologically significant as it represents a transitional zone between the ancient Precambrian rocks of the Chhotanagpur Plateau and the Quaternary alluvial plains of eastern Bengal (Sarkar & Das, 2016). This region is structurally controlled and has undergone multiple phases of deformation and metamorphism. The regional geology of this area is characterized by numerous faults and shear zones, which are predominantly aligned in NE-SW and NW-SE directions. These tectonic features are products of Proterozoic orogeny and have influenced the geomorphological evolution of the area (Sarkar et al., 1990). The western part of this region is characterized by undulating and rugged terrain with exposures of Precambrian crystalline rocks. In contrast, the eastern part is comparatively flat, consisting of alluvium deposited by rivers such as the Damodar and Dwarkeshwar (Bhattacharya et al., 2018). Regional geology is composed of Archaean rocks (granite gneiss, mica schist, phyllite, and quartzite) and granitic intrusions (pegmatite, quartz veins, and basic dykes) (GSI, 2001). Includes porphyritic granites, pegmatites, and aplites. Found mainly in western and southwestern Bankura, representing late-stage tectonic events (Sarkar et al., 1990).

The eastern part of the region (Bankura district) is characterized by lateritic soils and ferruginous crusts, derived from the weathering of crystalline rocks. Significant lateritic badland topography is observed in areas such as Bishnupur and Sonamukhi (Sarkar & Ghosh, 2017). The eastern part of Bankura is covered with Recent and Sub-Recent alluvium, comprising sand, silt, and clay deposited by the Damodar and Dwarkeshwar rivers (Ray, 2009). Alluvial Deposits are concentrated in the eastern part, near rivers such as the Damodar and Dwarkeshwar, comprising silt, clay, and sand from Quaternary fluvial deposits (Chakraborty, 2003). The eastern part of the Bankura district lies between the Chhotanagpur plateau and the Ganga, Brahmaputra, and Meghna deltas. This geomorphic transition zone is composed of alluvium, like sand, silt, and clay, of Quaternary age. The district exhibits a transitional zone from the Chhotanagpur Gneissic Complex in the west to the alluvial plains in the east, marking a shift from hard rock to soft sediment formations (GSI, 2007). Recent alluvium of the Damodar-Kasai River system was composed during the Quaternary Period and is characterized by Unconsolidated sands, silts, and clays forming fertile agricultural lands in the eastern zone (Chakraborty, 2003). The western part of the district is underlain by metamorphic rocks, while the eastern part grades into Quaternary alluvium of the Gangetic plains (Nandy, 2001). Lithology of the Jamdoba badland area is composed of Ferricrete, pisolite laterite formed during the Tertiary, and development is continuing up to the present time (Fig. 03). The formation of laterite in this region is attributed to the tropical weathering of bedrock, primarily granite and gneiss (Ray & Basu, 1999). The composition of laterite is based on the Chhotanagpur Gneissic Complex (Granite gneiss, mica schist, quartzite) of Archaean age. These rocks show a high degree of metamorphism and deformation (GSI, 2011).



Figure 04: This photograph shows a close-up of a rock surface with prominent trace fossils (ichno-fossils), likely burrow structures, and a 10 Indian Rupee coin for scale. In the picture, the 10 INR coin (~27 mm diameter) provides a useful scale: The individual burrow structures are 1–3 cm wide. Total pattern spread is roughly 10–15 cm across. Suggests activity by medium-sized invertebrates, likely crustaceans or polychaetes.

4.2 Ichnofossils (Trace Fossils) and Ichnogenus Significance

Rock exposure (laterite duricrust) exhibits branching, meandering, and interconnected grooves or ridges on its surface. These are not body fossils, but evidence of biological activity, such as Burrowing by ancient organisms (likely invertebrates, including worms, arthropods, or crustaceans) (Fig. 04). They represent feeding trails or locomotion traces within soft sediment before it lithified. Based on the morphology (dendritic, irregular patterns), it resembles *Thalassinoides* – horizontal burrows, often Y- or T-shaped (crustacean origin). *Planolites* or *Palaeophycus* – simple, cylindrical feeding burrows. It could also resemble *Scoyenia*, found in fluvio-lacustrine or floodplain environments. These ichnofossils are indicators of paleoenvironments, specifically shallow marine, estuarine, lagoonal, or fluvial settings, reflecting paleoclimate and oxygenation conditions, which include a well-oxygenated substrate, possibly in intertidal or subtidal zones.

4.3 Petrological significance

Rock Type in this area appears to be lateritic or ferruginous sandstone/conglomerate. The reddish-brown to yellow ochre colour suggests iron oxide cementation, with the presence of small quartz grains and pebbles. Likely tertiary or laterite-formed sedimentary rock, commonly found in the Garhbeta–Rarh Bengal region or Ajodhya Hills (Fig. 05). The ichnofossils were preserved before lithification; the sediment was soft enough for organisms to burrow but hardened over time. The preservation is likely due to early cementation and minimal bioturbation afterward. This picture is a significant example of Paleoecology, which indicates insights into ancient ecological conditions (substrate, water depth, oxygen levels). Stratigraphy evidence in this area helps in correlating sedimentary units based on ichnofacies. Reconservation is required; therefore, if part of a larger fossiliferous zone, the area may warrant protection or study. Sedimentary Environment: Likely shallow marine to fluvial transitional zone, with calm deposition and periodic exposure. The study is initiating a paleoenvironmental reconstruction of the landscape along with a trace fossil inventory from the region.



Figure 05: This image shows a lateritic soil profile with a gravelly horizon, a common geomorphological and pedological feature in tropical and subtropical regions like Rarh Bengal, Ajodhya Hills, or the Garhbata-Lalgah upland tracts of West Bengal.

4.4 Soil and Pedogenesis

Soil profile of this area consists of laterite, a highly weathered, iron- and aluminium-rich soil formed under intense leaching and oxidation. The colour of this soil is Reddish-brown, typical of iron oxide (hematite/goethite) content (Fig. 05). Texture: Sandy-silty matrix with distinct ferruginous concretions or pisolites (round, gravel-sized nodules) in the lower part. Well, Stratigraphic Exposure has been found in the Jamdoba badland area. The top layer of the horizon (~30–50 cm) is composed of Homogeneous lateritic soil, characterized by a compact, hard crust that indicates duricrust development. Resistant to erosion. The transitional zone (Middle zone of the profile) is slightly more porous, showing incipient disintegration of the upper crust. Bottom layer of the laterite profile (~1 m) Gravelly or pisolitic laterite: embedded ferruginous nodules in a red matrix, indicative of prolonged chemical weathering. This zone may be a paleosol or a relic horizon. The soil profile of the Jamdoba landscape evolved through several pedogenesis processes. This profile forms through Intense chemical weathering of parent rock (e.g., granite, basalt, or sandstone). Leaching of silica and bases (Ca^{2+} , Mg^{2+} , K^+ , Na^+). Residual enrichment of Fe and Al oxides → laterite. Repeated wet-dry climatic cycles form pisolites and nodular structures. In places, indurated layers form hard crusts or iron pans. Lateritic regolith is very consistent in this area, which forms due to prolonged weathering under alternating wet and dry conditions. The laterite soil of the Jamdoba badland is characterized by poor fertility and high porosity, making it prone to erosion during the monsoon season (Fig. 06). The soil compactness of the Jamdoba badland is high in crusted areas, along with easily dispersible topsoil in bare zones. The organic litter layer is absent in exposed patches of the soil profile (Fig. 08).



Figure 06 Patches of hardpan on the surface, zone of run of generation as sheet flow, and conversion of sheet flow to rill or gully flow erosion.



Figure 07: This image depicts a soil profile or an exposed soil section, likely situated in a semi-forested area of Jamdoba. The top layer (Dark Brown to Black) represents the O/A horizon, characterized by an abundance of organic matter and decomposed leaves. Its darker coloration is attributed to the presence of humus and organic content. The middle layer (Light Reddish-Brown) likely corresponds to the B horizon or subsoil. The colour and texture of this layer indicate the accumulation of iron oxides, a phenomenon commonly observed in lateritic soils or areas undergoing tropical weathering. This layer appears compacted and exhibits signs of illuviation, a process in which leached materials accumulate. Additionally, the leaf litter at the base suggests a deciduous forest floor, possibly consisting of eucalyptus or similar tree species, as inferred from the shape of the fallen leaves. A tree root or woody stem is evident, embedded within the soil profile, signifying a shallow root system or partial exposure resulting from erosion or cutting (Fig. 06). The vertical grooves and uneven surfaces are characteristic of weathered profiles or badland micro-relief typically found in tropical semi-arid environments.

4.5 Geomorphology of the badland area

The Jamdoba badland area likely falls within West Bengal or Jharkhand, India, and is also associated with the Rarh Bengal uplands (Fig. 01 & 11). Lateritic Badlands, erosional landscapes, and community forest areas are common in this locality. Significant evidence of active erosion has been identified in the Jamdoba badland area, which exhibits classic badland morphology characterized by V-shaped gullies with headward erosion, Bare soil zones, and low vegetation cover, indicating rapid surface runoff. Two Water storage reservoirs are located in the southern part of the Jamdoba Badland. The area is also associated with several check dams, which is evidence of Human intervention to manage runoff or sediment flow (Fig. 15). It is also a classic example of small-scale watershed management or rainwater harvesting. Rill and gully formation, as well as induced erosion, have been identified in this area, which is responsible for the formation and development of the Badlands over this forest area. The geomorphic surface of the Jamdoba badland area is characterized by A combination of shallow rills and gullies, indicating intense erosional activity. Raindrop erosion, followed by sheet erosion and rill erosion, dominates the geomorphic processes in the badland area, gradually leading to the formation of gullies (Fig. 09a, 09 b). The red and brown coloration of the soil in this area suggests laterite soil, rich in iron and aluminum oxides (Fig. 07).



Figure 08: Network of Gully channel in the less vegetated as well as deforested area



Figure 09: The two images provided (marked as a and b) distinctly illustrate varying stages of formation of gully fan, a common characteristic of lateritic badland topography, likely situated in a degraded lateritic terrain of semi-arid and sub-humid Jamdoba (Bankura). (a) Advanced Gully Erosion with Collapse Features, with the initial stage of gully fan formation. This image captures an intensely dissected badland surface, where deep and narrow gullies have emerged due to prolonged fluvial incision and soil piping. The terrain here is precarious, exhibiting signs of retrogressive erosion (the headward expansion of gullies). This observation suggests accelerated degradation, particularly under conditions of intense rainfall, overgrazing, or deforestation. (b) Mature stage of gully fan formation in Badland through Rill and Minor Gully erosion. The ridges and shallow gullies signify ongoing sheet to rill erosion, which may transition into gully erosion over time.

4.6 Landform and Surface Features

Different micro-geomorphic features, such as micro-knolls and depressions due to sheet and rill erosion, the Formation of incipient gullies along slope breaks, Fine sediment accumulation in shallow depressions, and Exposed lateritic crust with rootless zones, were identified during the field visit (Fig. 09a, 09b). The landform and Surface Features of the area accurately represent the badland topography, characterized by a network of rills and gullies, which is indicative of active erosion and sediment redistribution (Fig. 10). The terrain appears as cracked, reddish terrain with little to no vegetative cover. The area is characterized by intense surface runoff, a Lack of vegetation, possibly due to soil degradation or overgrazing, and the Exposure of Lateritic or ferruginous crust to weathering. These features classify the area as an incipient or mature badland, evolving from natural and possibly anthropogenic triggers. The vegetation distribution in this area is characterized by Scattered tree cover in the western and southeastern parts, perhaps including dry deciduous or thorny scrub

species. Forest patches are sparse, fragmented, and largely absent in the gullied badland center. The eastern edge has relatively dense forest, indicating a possible ecological transition zone (Fig. 03).

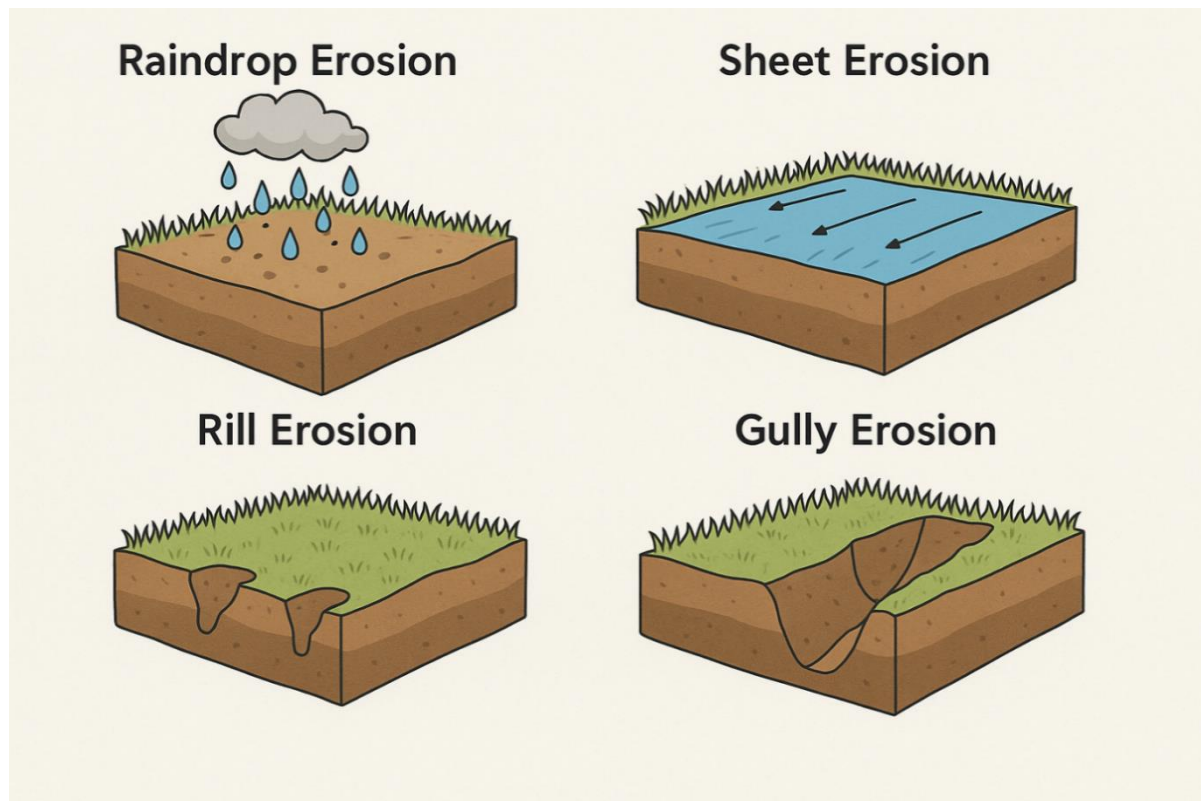


Figure 10: The diagram illustrates four types of water-induced soil erosion: Raindrop erosion (soil dislodged by impact of raindrops), Sheet erosion (thin layer of soil removed evenly), Rill erosion (small channels formed by runoff), and Gully erosion (deep, wide channels caused by intense water flow).



Figure 11: The photograph is a classic example of lateritic terrain located at Jamdoba, Bankura. It is considered a region in Rarh Bengal, West Bengal, or the adjacent Chhotanagpur Plateau fringe areas.

4.7 Geomorphic Instability

The signature of Geomorphic Instability is present in this area. The dominance of rills and gully erosion patterns suggests that the area is geomorphologically unstable., Likely impacted by a high rainfall-runoff ratio, poor vegetation anchorage, and fragile lithology. The zone shows signs of land degradation, with a risk of further desertification if not restored (Fig. 11). The picture also raises some Ecological Concerns. Loss of vegetation cover, combined with the fragmentation of forest patches, poses Threats to local biodiversity and risks the loss of ecosystem services, such as carbon sequestration, shade, and habitat provisioning. Anthropogenic Stress, represented by the water tanks, is a positive human intervention, but not enough to halt landscape degradation. Human interference (paths, overuse) without proper soil conservation exacerbates erosional activity.

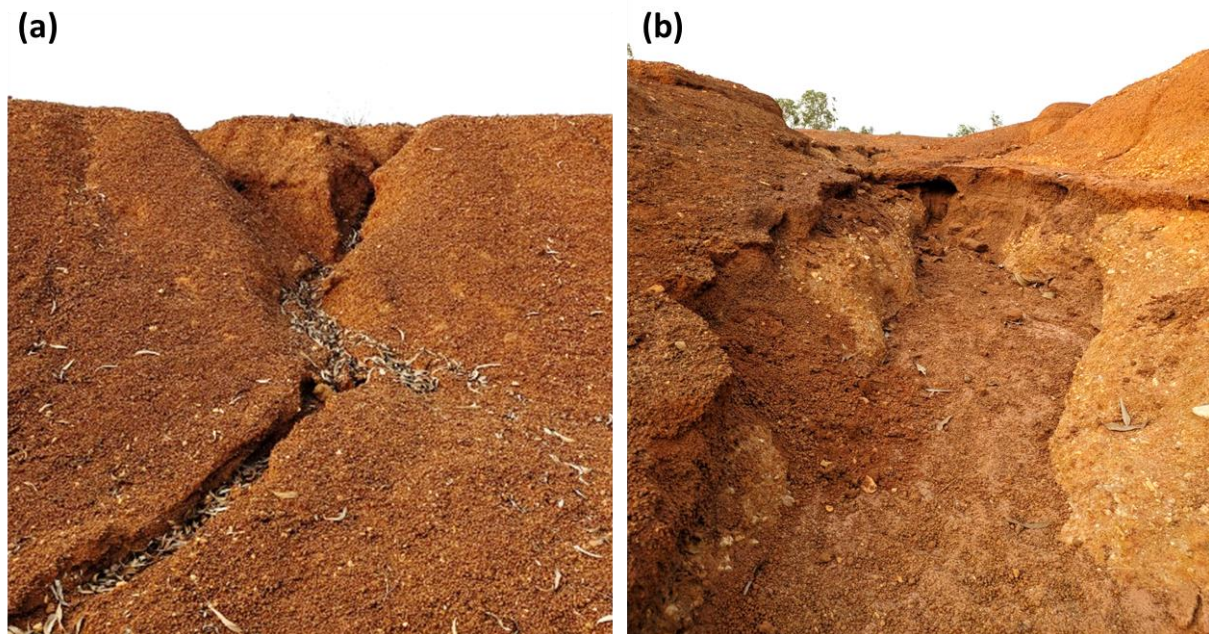


Figure 12 Formation of rill channel (a) in the artificial escarpment. These turn into a wide gully channel due to water action during the Monsoon(b).

4.8 Badland Topography in Lateritic Terrain

The central and upper portions exhibit a deeply dissected terrain, characterized by dendritic drainage patterns and small rills and gullies, typical of badland formations. These erosional features likely result from intense runoff over poorly consolidated lateritic or sandy soils. Rill and Gully Erosion is prominent. The reddish tones and barren surfaces suggest lateritic soil or hardened ferricrete layers with low vegetative cover. The badland topography within the Jamdoba lateritic terrain is characterized by narrow, dissected, and relatively less-rugged landscapes that have predominantly formed as a result of intense erosion of soft, weathered lateritic soils and rocks. Vegetation cover in this region is sparse, attributable to factors such as deforestation, overgrazing, and inadequate land management practices. Consequently, these landscapes exhibit heightened susceptibility to gully formation and rill erosion, ultimately leading to the development of Badlands (Fig. 12a, 12b). The emergence of the Jamdoba badland is primarily driven by a combination of seasonal rainfall, elevated surface runoff, and anthropogenic activities. These Badlands not only reflect geomorphic degradation but also signify ecological distress, including soil loss, declining fertility, and a reduction in biodiversity. Over time, the expansion of the Jamdoba badland area may lead to landscape fragmentation and desertification if left unaddressed (Fig. 13). Nevertheless, through the implementation of effective soil conservation techniques, afforestation initiatives, and active community participation, it is feasible to stabilize these areas and restore their ecological balance. Therefore, the badland topography in lateritic terrain represents both a geomorphological challenge and a critical indicator of land degradation (Fig. 13).



Figure 13: Surface Erosion Accompanied by Burnt Patches of Laterite Duricrust. This image illustrates sheet erosion and minor rill formation on a relatively level lateritic surface. The dark patches signify burned vegetation or biomass, potentially resulting from shifting cultivation, fire clearing, or human activities. These incinerated areas may further expose the soil to erosion, thereby exacerbating the loss of topsoil. In the background, a sparse tree line delineates the transition between degraded land and semi-natural forest or scrubland.

4.9 Vegetation Patterns

The Jamdoba area is characterized by patchy to dense forest cover. However, a central degraded area is located in the centre (Fig. 02). Sparse Tree Cover is a notable example of patchy vegetation, characterized by scattered trees, denser in the south and east (Fig. 03). Degradation of natural vegetation is also going on here, especially in the central and northern parts, where vegetation is sparse, likely due to Soil erosion, Overgrazing, wood-cutting, and Unsuitable edaphic conditions. Scattered scrub vegetation and young saplings indicate early stages of natural re-vegetation or afforestation efforts (Fig. 14). Sparse vegetation cover makes the land highly vulnerable to erosion, especially in the absence of ground binders, such as grasses or organic mulch. The vegetation pattern of the Jamdoba badland area is characterized by drought-resistant species, including *Acacia*, *Eucalyptus*, and *Casuarina*, along with Grasses and shrubs that dominate the inter-knoll zones. The vegetation pattern of this area indicates clear evidence of extreme ecological stress. Vegetation shows patchy recovery in this area.



Figure 14: Scatter vegetation planted by the Forest Department to protect against soil erosion

4.10 Hydrological Inference

The Jamdoba Badland, situated in the lateritic upland zone of eastern India, exhibits distinctive hydrological behaviour due to its rugged microtopography and highly erodible lateritic and sandy-clay sediments. This area is characterized by intense seasonal rainfall, high runoff rates, and a poorly developed drainage network, all of which contribute to the formation of gullies, rills, and deeply incised channels (Fig. 10). The Badlands are essentially micro-watershed systems, where numerous ephemeral streams and rivulets originate and converge, leading to rapid water concentration during monsoons and high sediment yields. The rill-gully network shows flow convergence toward the south. The structure at the bottom likely functions as a water retention structure, possibly seasonal. Hydrologically, the Badlands exhibit a flashy regime, characterized by a rapid response to rainfall, due to low infiltration resulting from compacted soils and sparse vegetation. The micro-watersheds within the Jamdoba region are often bowl-shaped, with steep slopes and narrow interfluvies that accelerate surface runoff. These features contribute to accelerated erosion and sediment transport during peak rainfall, further reshaping the landscape dynamically. Due to minimal base flow and the absence of groundwater recharge zones, the region experiences seasonal water scarcity despite receiving high rainfall. The micro-watershed units are fragmented and disconnected, limiting their capacity to retain water or support sustained vegetation growth.

4.11 Micro-Watershed Character

The drainage channels converge toward the pond area, forming a micro-watershed system. Finally, all the gully channels are lined with the river Bera in the Southeast. Likely managed traditionally to capture runoff from the surrounding elevated lateritic uplands. It can be studied as a model of traditional rainwater harvesting in undulating drylands (Fig. 16). The hydrological inference from Jamdoba indicates a degraded and vulnerable watershed system. To enhance water retention and reduce soil loss, integrated watershed management approaches, such as check dams, contour trenches, and vegetative barriers, are crucial (Figs. 14, 15, and 16). Studying the characteristics of this micro-watershed is crucial for understanding land degradation patterns and planning sustainable rehabilitation in lateritic badland regions.

4.12 Hydrological and Anthropogenic Structures

Two clearly defined rectangular enclosures, made of laterite blocks, are visible in the lower left quadrant. Traditional water-harvesting tanks have been identified in this area (Fig. 16). One of them contains greenish water, indicating standing water, which may be used for domestic, livestock, or irrigation purposes. These are likely excavated tanks with embankments, typical of dryland water management systems in lateritic tracts. The periphery of the tanks appears to be terraced or modified, suggesting efforts to control erosion or manage runoff. Numerous linear paths and trails crisscross the Jamdoba landscape, indicating Frequent human or livestock movement for Resource extraction, such as wood or fodder collection. The absence of paved roads suggests a rural or semi-forest fringe setting.

4.13 Land Use / Land Cover (LULC) Observations

The Jamdoba area is dominated by Forest cover characterized by dense tree canopy. The central exposed area is a signature of a badland or eroded surface, where branching rills and gullies (dendritic to sub-parallel drainage patterns) and Bare, light-coloured terrain indicate soil erosion and possibly lateritic exposure (Fig. 13).

4.14 Anthropogenic Impact

This type of land degradation often results from deforestation, overgrazing, or unsustainable farming practices. Historically, mining, shifting cultivation, or firewood collection could have exacerbated the condition. The formation of Badlands leads to the loss of arable land, reduced groundwater recharge, and conditions similar to those of desertification. This impacts local livelihoods and biodiversity, leading to the marginalization of communities. Past land use in this area has included fuelwood collection, grazing, and clearing. Community afforestation initiatives have been observed during the field Visit (Fig. 14). Several patches, hotspots, and Signs of soil erosion worsened by anthropogenic intervention have also been observed in this area.



Figure 15: Construction of a Check dam on the main gully channel by using blocks of hardpan to reduce soil erosion.



Figure 16: The lateritic gully landscape exhibits significant water accumulation within a sedimentation pond, which has been established through erosion control measures and rainwater harvesting initiatives. This landscape illustrates a deeply incised gully system situated within lateritic terrain. The soil displays a reddish-brown hue, indicative of iron-rich lateritic regolith. A small, artificial rectangular water body is visible at the gully's base, serving either as a seasonal reservoir for water accumulation or as an artificial pond for erosion control. The sides of the gully are steep and are actively undergoing erosion, which signifies ongoing surface runoff and fluvial action, particularly during the monsoon season. Vegetation is limited on the slopes; however, it is visible along the edges, which may suggest vegetation clearance and subsequent land degradation. The image depicts the stages of land degradation in lateritic Badlands. This serves as a hallmark of anthropogenic disturbance, specifically due to burning and early-stage erosion, which occur on flat or gently sloping surfaces.

4.15 Land Use Transformation

The layout of ponds and paths indicates active human intervention in modifying the natural landscape for subsistence. This micro-landscape represents a semi-arid, lateritic plateau area that is likely undergoing active erosion and exhibits human adaptation to challenging geomorphic conditions (Fig. 17). The interaction between natural processes (rill and gully erosion, sparse vegetation) and anthropogenic management (ponds, tracks, and possible agro-pastoral land use) makes it a valuable case for assessing land degradation, watershed management, and traditional ecological knowledge studies (Fig 18a,18b).

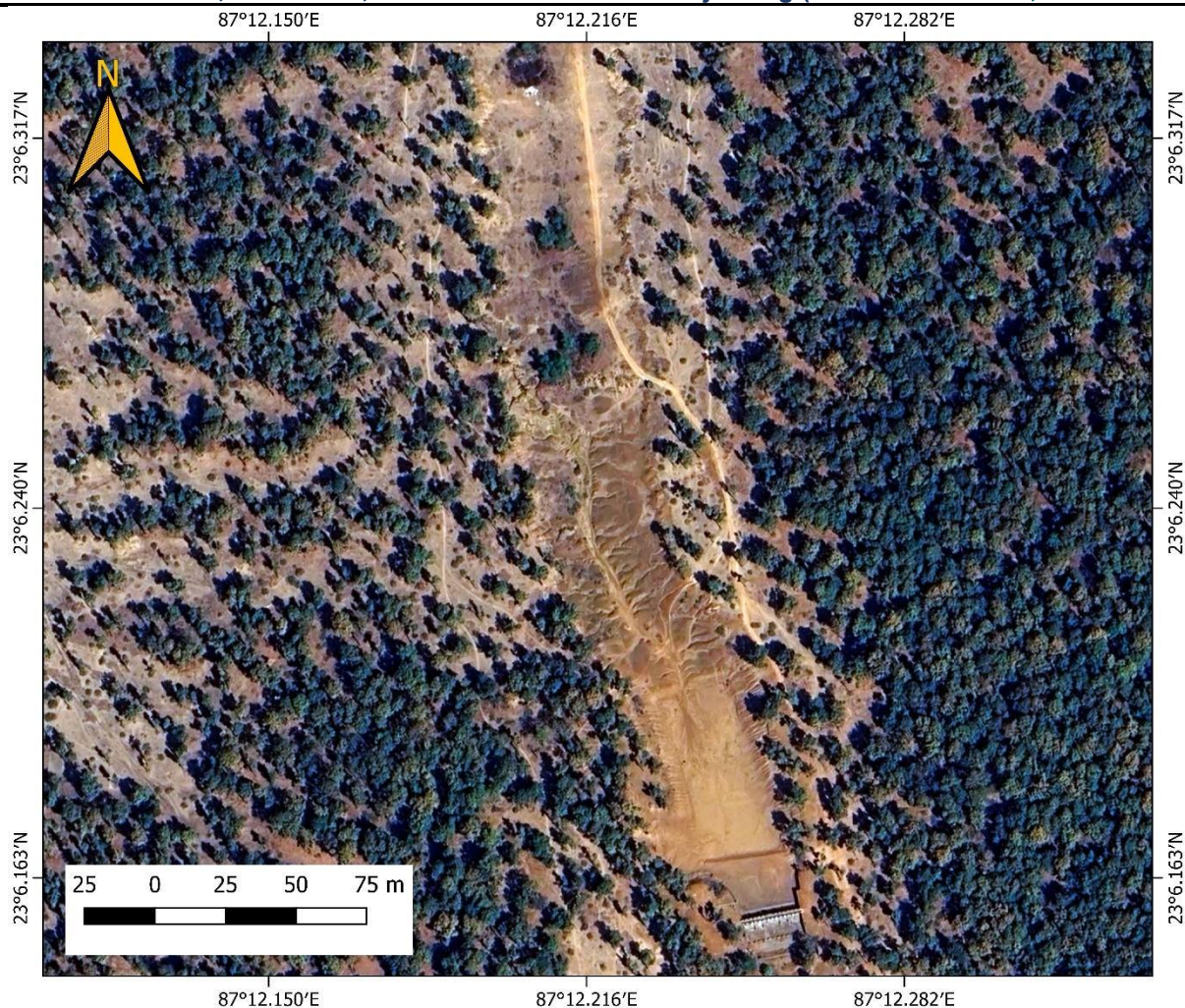


Figure 17: This figure is a high-resolution satellite image that shows local geomorphology, forestry, and land use studies. A dark green colour palette is used, highlighting vegetation (green), exposed soil (light brown), and various structures.

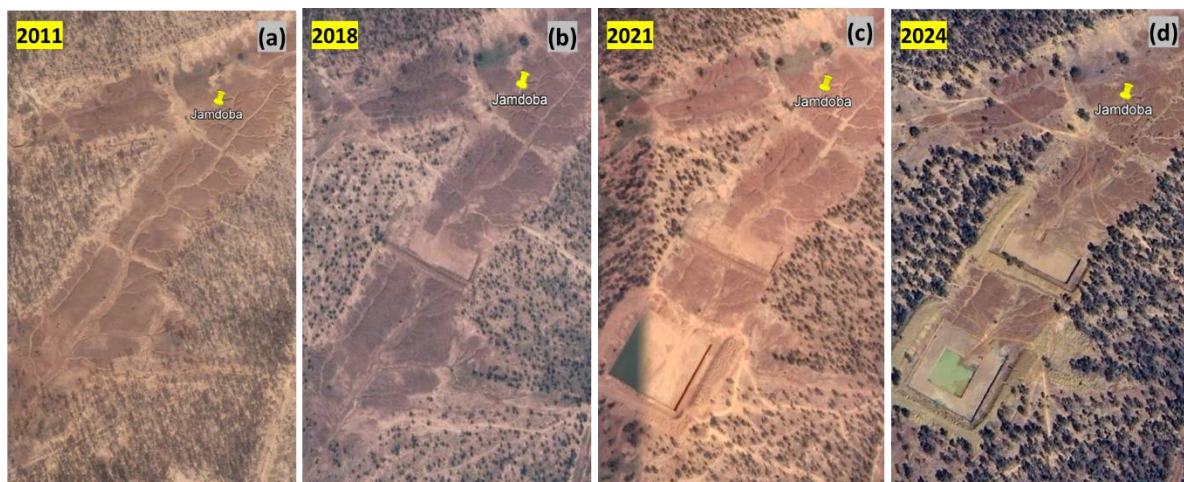


Figure 18: This series of images, sourced from Google Earth (2011, 2018, 2021, and 2024), provides a temporal satellite-based analysis of land transformation in the Jamdoba region, which is likely characterized by lateritic or semi-arid terrain, over a period of thirteen years (2011–2024). Each frame (a–d) illustrates significant geomorphic and anthropogenic changes, which are summarized as follows: (a) In 2011, the land surface exhibits typical badland topography, featuring dendritic gully erosion, rill networks, and sparse vegetation. No major human intervention is observable in this image, which is indicative of natural lateritic terrain that may have been degraded due to soil erosion and insufficient vegetation cover. By 2018, a slight increase in vegetation was observed in patches. A rectangular land modification is present in the southern portion of the image, suggesting the onset of a water harvesting structure or land levelling. Human intervention in the land surface becomes increasingly apparent. In 2021, an earthen embankment and a clearly defined pond structure became prominent in the southern area, indicating a constructed water harvesting structure (potentially a percolation tank or check dam). The image reveals increased surface planning and stabilization,

possibly facilitated by soil conservation initiatives. In 2024, the area now displays two distinctly artificial ponds, with evident embankments and pathways surrounding them. Vegetation cover has substantially increased, particularly around the periphery and slopes, suggesting effective afforestation or natural regrowth. The stabilization of gully erosion is apparent, signifying that land reclamation and watershed management efforts have been successful. This sequence exemplifies a successful model of landscape restoration and watershed intervention, characterized by clear indicators of gully erosion control, water conservation structures, enhanced vegetation cover, and effective land-use planning.

5. Research and Management Potential: Scientific relevance and restoration

The scientific relevance of the study lies in the oral support for the present research. This is the Ideal site for micro-geomorphic studies, erosion modelling, and land degradation assessment. This comprehensive study can also support studies on traditional water harvesting, landscape change, and vegetation dynamics using temporal satellite data. Several Restoration Suggestions can be made through this study. It is required to promote contour trenching, gully plugging, and check dam construction, along with the introduction of native vegetation for soil anchoring. It is necessary to conduct awareness and participation programs for local communities to prevent the overuse of resources. This area is a highly dynamic, erosion-prone badland system within a semi-arid lateritic zone, where human modifications (such as water tanks and trails) coexist with ecological degradation. Therefore, without intervention, the land may continue to degrade. However, targeted geospatial monitoring and community-driven conservation can reverse this trend.

6. Conclusion

Walking through this small, barren zone revealed an active erosional landscape evolving under the combined influence of natural and anthropogenic forces. Although spatially limited, the area serves as a live field lab, showcasing the Stages of erosion, from raindrop impact to gully incision, the Struggle of vegetation to re-establish itself in degraded soils, and the Feedback loop between land degradation and socio-economic marginality. A simple walk through a small badland can provide profound insights into geomorphic processes, soil vulnerability, and landscape resilience. Such areas require sensitive management, restoration efforts, and ongoing monitoring, particularly in rural, semi-arid India, where livelihoods are closely tied to the health of the land.

References

- Bandyopadhyay, S. (2014). *Geomorphological evolution of West Bengal*. Kolkata: K.P. Bagchi & Company.
- Bhattacharya, A., Ghosh, P., & Roy, D. (2018). Landform Dynamics in Lateritic Tracts of West Bengal: A Case Study from Bankura District. *Indian Journal of Geography and Environment*, 45, 92–101.
- Bryan, R. B. (2000). *Soil Erosion: Processes, Prediction, Measurement, and Control*.
- Chakraborty, S. (2003). Late Quaternary sedimentation in parts of the lower Damodar basin, West Bengal. *Journal of the Geological Society of India*, 61(2), 183–190.
- Geological Survey of India (GSI). (2001). *District Resource Map: Bankura, West Bengal*. Geological Survey of India.
- Geological Survey of India (GSI). (2007). *District Resource Map – Bankura District, West Bengal*. GSI Publication.
- Geological Survey of India (GSI). (2011). *Geology and Mineral Resources of West Bengal*. Miscellaneous Publication No. 30, Part II, Vol. 1.
- Goudie, A. S. (2006). *The Human Impact on the Natural Environment*.
- Jain, S. (2019). On the occurrence of the Indonesian ammonite *Macrocephalites keeuwensis* Boehm [M & m] from Kachchh (Western India). <https://doi.org/10.5282/ubm/epub.72914>
- Mandal, S., & Sarkar, A. (2023). Lateritic Landscapes and Human Response: A Case from Rarh Bengal.

Nandy, D. R. (2001). Geodynamics of Northeastern India and the Adjoining Region. Kolkata: ABC Publishing.

Ray, S. (2009). Floodplain dynamics and sedimentation pattern of the Damodar River in Bankura. *Indian Geographical Journal*, 84(2), 35–46.

Ray, A., & Basu, A. (1999). Lateritization and Landscape Evolution in Southern West Bengal. *Indian Journal of Geosciences*, 53(3), 145–152.

Riskas, K. A. (2017). Addressing sources of data deficiency for sea turtles and fisheries in the Indian Ocean and Southeast Asia. <https://doi.org/10.25903/t78h-dx60>

Sarkar, A., & Das, S. (2016). Lateritic terrain of Bankura: A study on soil degradation and landform evolution. *Transactions of the Institute of Indian Geographers*, 38(2), 233–245.

Sarkar, A., & Ghosh, R. (2017). Environmental Hazards in Lateritic Badlands of Bishnupur, Bankura. *Geo-Analytical Studies*, 2(1), 67–74.

Sarkar, S. C., Mukherjee, A., & Dasgupta, S. (1990). Structure and tectonics of the Chhotanagpur gneissic complex, eastern India. *Tectonophysics*, 174(3–4), 345–363

Wischmeier, W.H., & Smith, D.D. (1978). Predicting Rainfall Erosion Losses.