

Chapter 11

Land Degradation and Its Management Approaches in the Middle and Lower Courses of the Subarnarekha River Basin, India



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11.1 Introduction

The middle part and lower part of the Subarnarekha basin are extended over the states of Odisha, West Bengal, and parts of Jharkhand in eastern India. The river Subarnarekha flows across the states boundaries and empties into the Bay of Bengal in Odisha. Geomorphologically, the region is grouped into parts of lateritic upland tracts, the extensive floodplain region of the Subarnarekha River basin, and the deltaic part of sandy chenier tracts. The river system comprises nine different watershed areas to support the tributary drainage systems within the basin area. The major types of land degradation are identified as soil erosion, landscape dissections, open bare surfaces with stoney, rocky, and lateritic hardpan surfaces, saline tracts of the low-lying delta plain surface, and coastal sandy soil surfaces in the middle and lower catchment areas of the Subarnarekha basin. There is a strong relationship between morphogenetic regions and land degradation types in the river basin. The lateritic upland tracts were densely forested in 1973 (SOI Toposheet), but the encroachment of agricultural plots and settlements into the forest area by occupying forest land through forest cutting has resulted in soil erosion and the formation of hardpan lateritic tracts in the western part of the river basin. However, the riverine flood plains with alluvial soil support agricultural activities, but during catastrophic floods, soil erosion takes place due to the impact of floods and surface runoff characters in the region. The lowermost part of the deltaic beach ridge and Chenier plain of the coastal fringe area are affected by soil erosion due to marine and aeolian processes (Paul, 2002).

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The land degradation processes have been identified by the study, which shows that the slope of the land, surface runoff trends, forest cutting and other human activities, composition of the soil, flood events, and wind-blown activities are the major factors that control the rate of spatial degradation process in the basin. Hence, riling, gullying, and ravening processes of the fluvial activities during the wet monsoon phase produce a significant loss of soil from the top surface of the morphogenetic regions (Paul et al., 2022). Salinization and alkalization are also found in the coastal areas and flood plains of the lower part of the Subarnarekha basin. Using remote sensing and GIS tools, the land degradations under different morphogenetic regions are estimated and monitored in the study area. For the lateritic upland tracts, contour bunding and check dams with suitable cropping patterns may be recommended. Agroforestry, pasture land with cultivation of fodder crops, and crop rotation techniques may be followed for the reduction of land degradation rates in floodplain areas. Finally, the coastal areas need the restoration of habitats (e.g., mangroves, salt marshes, sand dunes, beach ridges, and tidal flats) to protect the high rate of soil loss by planting mangroves, afforestation, and promoting agroforestry in the region. ICZM policies should be adopted in the region to improve the capacity development of the coastal tracts. The objectives of the study are: (i) to identify the different land degradation processes in different geomorphic environments, (ii) identify the degraded lands or watery wastelands, and (iii) pursue the management strategies to combat the degradation of land for its sustainable uses.

11.2 Study Area

The middle and lower catchments of the Subarnarekha River Basin extend from 21°30'N, 22°23'N latitude and from 86°42'E to 87°30'E longitude (Fig. 11.1). This part of the river, including its tributaries, runs through the extreme south-western part of Paschim Medinipur district of West Bengal and the easternmost part of Mayurbhanj and Baleswar districts of Odisha. The study area includes the administrative blocks of Gopiballavpur-I and II, Sankrail, Nayagram, Keshiary, and Dantan-I of Paschim Medinipur (West Bengal), Moroda, Betnoti, and Rasgobindapur blocks of Mayurbhanj district (Odisha), and Jaleswar, Basta, Bhograi, and Baliapal blocks of Baleswar district, Odisha. The entire study area covers an area of 3745 square km. Topographically, the area consists of lateritic uplands, valley cuts, and river valleys of the Rahr Plain in the north-west and the Coastal Plain in the south. In the northwestern part of the study area, topography is moderately undulating, and in the middle part, it is gently undulating, while the southern part is characterized by the flat alluvial plain of the Subarnarekha delta, marked by a number of parallel palaeo-beach ridges and sand dunes along the coast line of the Bay of Bengal (Fig. 11.1).

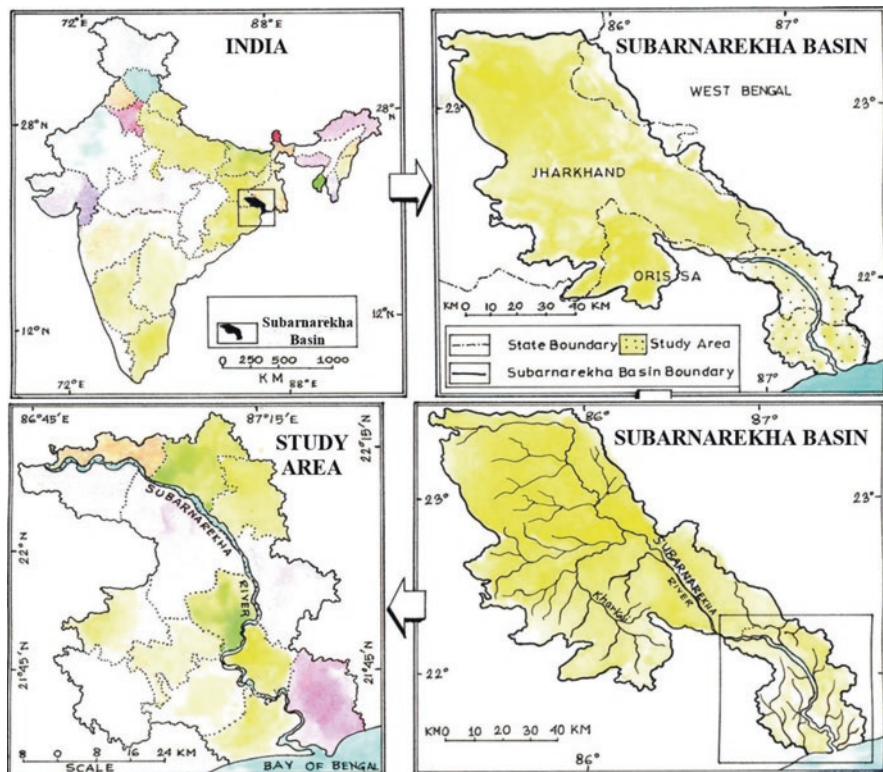


Fig. 11.1 The location Subarnarekha River basin with its middle and lower catchment areas in Odisha and West Bengal, India

11.3 Methodology

Land degradation processes have been studied on the basis of field surveys, Landsat satellite image analysis (2008), study of SOI toposheets (1973), use of a GIS platform, etc. A field survey was conducted across the Singari Khal (Singalila Canal), located at Pindragariya village in Gopiballavpur-I block. The survey reveals that the upland margins (68–70 m in height) with loose soils are highly susceptible to water erosion. The deforested tracts of upland with loose soil are susceptible to sheet, rill, and gully erosion. The highly eroded tracts have been converted into bad land. The lowlands (66–67 m in height), along the ditches, are the depositional surface. But during the flash flood, water erosion at a higher rate is also observed in this zone.

11.4 Results and Discussion

11.4.1 Identification of Land Degradation Types (Regional Diversity of Land Degradation)

Land degradation remains an important global issue in the twenty-first century because of its adverse impact on agronomic productivity, the environment, and its effect on food security and the quality of life (Eswaran et al., 2019; Johnson & Lewis, 2007; Bajocco et al., 2012; Bossio et al., 2010; Blaikie & Brookfield, 2015; Gisladottir & Stocking, 2005). In the diverse landforms of the middle and lower catchments of the Subarnarekha basin, different types of land degradation have been identified. The different types of land degradation processes and water erosion are dominant in the bare laterite uplands and upland margins. Duricrust surfaces, the product of seasonal rainfall and the alternate wetting and drying of laterite upland, are found in the laterite upland. Upland surfaces, upland margins, and valley fill surfaces are more susceptible to soil acidification. Rills and gullies are formed due to fluvial erosion. Land degradation is a process that can occur in any physiographic environment. So far as the bare duricrust surface, laterite mining pits, rills, gullies, and ravines with dissected surface and soil erosion affected areas are identified as major land degradation types in the region. But its type, intensity, and magnitude vary from place to place in the regional settings of the present study area (Table 11.1, Fig. 11.2).

11.4.1.1 Land Degradation in the Upland Surface with Dissected Valleys

The laterite duricrust surfaces are found in the upland tracts of the interfluves in the middle catchment area. Here laterization is the main process, except in the narrow tracts of river channels. The most affected areas lie in the upland areas of Gopiballavpur I and II, Nayagram, Moroda, Betnoti, and Rasgobindapur blocks. In

Table 11.1 Spatial diversity of land erosion rates in the different morphogenetic surfaces under multiple watershed areas of the Subarnarekha River basin (middle and lower catchment)

Morphogenetic surface	Name of the watershed	Rate of soil erosion (ton/ha/yr)
Deltaic low land sandy tract	Khaljori watershed	22
	Subarnarekha watershed	39.5
	Hanskura watershed	26.8
Lateritic upland dissected tract	Burahbolong watershed	15.8
	Bayesmukha watershed	14.6
	Jamira watershed	14.2
Riverine flood plain	Dulung water shed	5.8
	Kaliaghai watershed	5.2
	Kushumri watershed	6

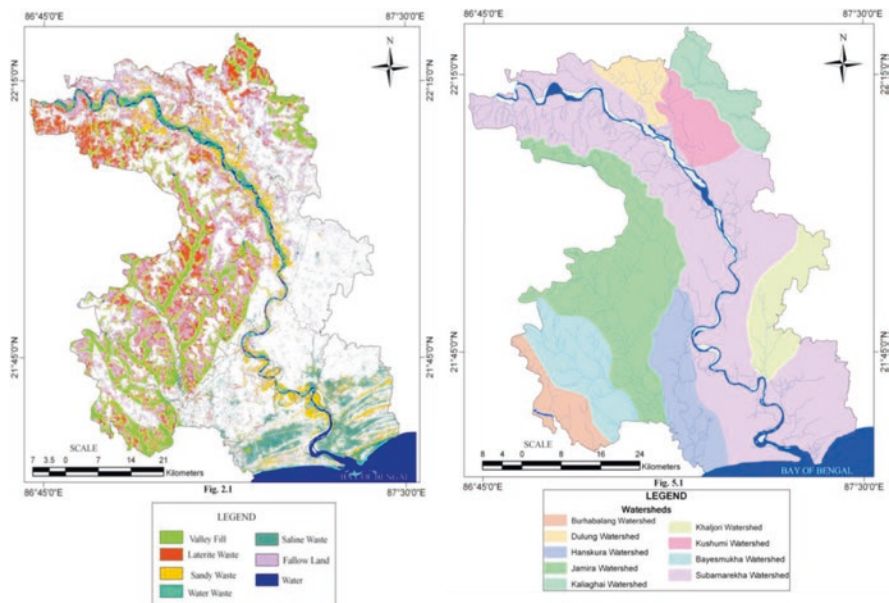


Fig. 11.2 Various types of land degradation characters under nine watershed regions of middle and lower catchment area of Subarnarekha River basin (using Landsat Image and SOI toposheets)

this area, other types of land degradation include rills, gullies, and sheet erosion. It was noticed that the gradient of the land surface was higher (1° – 3°) in compared to other physiographic regions of the study area. Deforestation, weathering, and erosion processes over a long period accelerated the rate of degradation. Upland margins are the most vulnerable areas in this respect (Table 11.1).

11.4.1.2 Land Degradation in the Flood Plains Dominated by Subarnarekha and Other Streams

Land conversion for agricultural uses is the main degradation type in this region. During the field survey, it was observed that most of the farmers use fertilizers, pesticides, and insecticides unscientifically. Besides, they also use less organic manure, leading to the degradation of agricultural land. This picture is acute, especially in the forest agricultural land interface where most of the farmers belonging to Schedule Caste and Schedule Tribe communities have little knowledge about the fertility status of the soil. Besides, more than 50% of the families fall into the BPL category. Probably, illiteracy and poverty are the main causes of ignorance. The soil analysis report and maps prepared from these data reflect that if such a process continues; in the near future, the agricultural land in this area will be gradually degraded. Besides, soil erosion of lower magnitude (less than 5 ton/ha/year) is observed in the areas with a 1–2-degree average slope (Table 11.1).

11.4.1.3 Land Degradation in the Deltaic Flat with Coastal Features

The low-lying land along the seashore and Subarnarekha River side in Bhograi and Baliapal blocks gets inundated by seawater during floods. As a result, lowlands remain uncultivated due to the high salinity of the soil. The aeolian process plays an important role in this area of land conversion. Aeolian erosion and accretion are going on in the coastal belt of the study area. As a result, land in this tract remains in a degrading state. Bare sand dunes are more susceptible to water and wind erosion. The rate of soil erosion in this area is 20–40 tons per acre per year (Table 11.1). Consequently, a number of sandy wastes have formed in this belt. Sandy wastes are also found along the river channels in the form of deposits of sand brought down by the rivers flowing from the uplands.

11.4.2 Process of Development of Land Degradation Types

The processes of land degradation are as follows: (i) physical degradation (comprising crusting, compactation, erosion by water and wind, etc.) and (ii) chemical degradation (comprising acidification, salinization, alkalization, leaching, and faulty agricultural practices, etc.). Some lands or landscape units are affected by more than one process, such as water and wind erosion, salinization, and crusting or compacting the surfaces. However, different land degradation processes are discussed herewith.

11.4.2.1 Water Erosion

Over-cutting of forests, over-grazing, removal of protective plant cover by tillage operations, etc., are contributing to soil erosion through the water erosion process in the study area. The types of water erosion may be categorized as: (i) rain drop splash soil erosion is noticed all over the study area. (ii) Sheet erosion is dominant along the valley fill sites of the upland and floodplain regions of the study area. (iii) The upland tract of the study area is more susceptible to riparian erosion compared to the floodplain and coastal delta's flat surfaces. (iv) The network of gully channels and erosion is well reflected in the true-color Landsat OLI image of Chandabila and Betnoti-Moroda. Very small to medium gullies are found in the study area, and most of them are located in the laterite upland of Gopiballavpur-I and II, Sankrail, Keshiary, Nayagram, Moroda, Betnoti, Rasgobindapur, and Jaleswar block. (v) Stream channel erosion is the scouring of material from the water channel and the cutting of banks by flowing or running water. The rate of erosion accelerates during the rainy season, especially at the time of floods. Bank erosion along the stream channel is common in the Nayagram, Dantan, Jaleswar, and Gopiballavpur-I and II blocks.

11.4.2.2 Flood in the Deltaic Flats with Coastal Features

Flood is an attribute of the physical environment and acts as both an eroding and depositing factor. It promotes the washing away of surface soils by its great force, leading to soil degradation (Paul, 2002). Silting on the river bed, construction of roads and a railway network against the natural gradient, a large number of sprung-up fish farms with protective bunds, heavy monsoon rains, cyclones, tidal waves, and the sudden release of dam and barrage water from the upstream section are the factors of flood in the low-lying coastal tract and rolling flood plain of the study area. In the flood plain area, flooding is caused by heavy rainfall, the sudden release of water from the dams and barrages upstream, and the heavy monsoon. The villages on both sides of the river Subarnarekha are flood-prone. The parts of Gopiballavpur-I and II, part of Nayagram, part of Dantan-I, and part of Keshiary are affected by the flood havoc in the previous decades. The laterite upland is devoid of flooding due to its higher altitude and comparatively steep slope.

11.4.2.3 Wind Erosion

Wind erosion takes place in the deltaic flat of Bhograi and the Baliapal block of the study area. The most serious damage caused by wind erosion is the change in soil texture. Since the finer soil particles are subject to movement by the wind, wind erosion gradually removes silt, clay, and organic matter from the top soil, leaving the coarse soil material. Soil particles are carried by the wind in three ways: salination, suspension, and surface creep. However, some factors influence the wind erosion; these are: (i) characteristics of wind: wind speed, direction, structure, temperature, humidity burden carried, etc., (ii) characteristics of surface: roughness, vegetation cover, obstruction, and temperature, (iii) topography: flat, undulating, broken, and (iv) nature and properties of soil: Texture, structure, organic matter, and moisture content. In the coastal area, wind erosion takes place on bare sand dunes. Casuarina trees and different mangrove trees are planted along the coastal tract of the study area. But recently, due to illegal forest cutting, the sand dunes are susceptible to wind erosion (Paul, 2002).

11.4.2.4 Salinization Problems

Salt-affected soils are unproductive unless excess salts are removed or reduced. From the field study and laboratory analysis of soil samples collected from different parts of the study area, it was found that salt-affected soils are mainly concentrated in the coastal area, where soils suffer from inadequate drainage and seawater inundation. Marshy lands in the Subarnarekha estuary are highly affected by salinity. Soils are said to be saline if they contain an excess of soluble salts.

11.4.2.5 Soil Acidity and Land Degradation

Soil samples collected from agricultural fields in the blocks of the study area were tested to get information regarding the soil acidity and alkalinity. On the basis of pH values obtained from soil sample analysis, it is found that in the laterite upland with valley cuts, soil pH ranges between 4.6 and 6.5, indicating acidity in nature, whereas in the floodplain and delta, the pH ranges between 6.5 and 7.2, indicating neutrality in nature. It must be mentioned that the marshy area in the deltaic flat has a pH higher than 7.5. Moderately and strongly acid soil is noticed in the laterite uplands of Gopiballavpur-I, Nayagram, Sankrail, Rasgobindapur, Moroda, Betnoti, and Jaleswar. In other blocks, the soils are neutral in character. Acid soils are not suitable for further cultivation to grow agricultural crops.

11.4.2.6 Overgrazing and Land Degradation

The livestock population of the study area was 10,81,122 in 2002–2003 and rose to 12,47,495 in 2005–2006. An increasing trend is also found in every block of the study area. So, there is an increase in livestock population with the passage of time. The fodder requirement is met from the nearby forests in the form of grazing and fodder cut for stall feeding. Overgrazing and over-extraction of green fodder both lead to forest and land degradation through a loss of vegetation and physical deterioration in the form of compaction, reduced infiltration, and an increase in soil erodibility.

11.5 Management Strategies

Land management cannot solve the problem of land degradation. By integrating sustainable management of land and watersheds, the problem of land degradation can be mitigated. The entire study area has been divided into eight watersheds. These are: (i) Subarnarekha, (ii) Jamira, (iii) Dulung, (iv) Bayes Mukha, (v) Kusumi, (vi) Burabalang, (vii) Haskura, and (viii) Khaljori. Geospatial studies and field surveys reveal that all the watersheds suffer from different types of degradation. Sustainable watershed management has emerged as a new paradigm for planning, development, and management of land, water, and biomass resources with a focus on social and environmental aspects and a participatory approach. We should keep in mind that it is not merely an anti-erosional and anti-runoff approach; it is a comprehensive, integrated approach. The approach is preventive, progressive, corrective, and curative. Watershed management involves the judicious use of natural resources with the active participation of institutions and organizations in harmony with the ecosystem. According to Mani (2005), watershed development (WSD) is one such approach that is not only eco-friendly but also a hydrologically correct approach for efficient use of soil and water for more agricultural production.

11.5.1 Land Management

The different measures of land management are grouped as follows: (i) structural measures, which include interventions like contour bunds, compartmental bunds, earthen dams, graded bunds, contour terrace walls, contour trenches, bench terracing, stream bank stabilization, check dams, etc. (ii) Vegetative measures include vegetative cover, plant cover, mulching, vegetative hedges, grassland management, agroforestry, etc. Watersheds may contain natural ecosystems like grasslands, wetlands, mangroves, marshes, and water bodies. All these ecosystems have a specific role in nature. (iii) Production measures include interventions aimed at increasing the productivity of land like mixed cropping, strip cropping, cover cropping, crop rotations, the cultivation of shrubs and herbs, contour cultivation, conservation tillage, land leveling, the use of improved varieties of seeds, horticulture, etc. (iv) Gully plugging, runoff collection, land slide control, etc., may be considered as protective measures. Adoption of all the interventions discussed above should be done strictly in accordance with the characteristics of the land taken for management.

11.5.2 Water Management

The broad interventions for water resource management are: (i) rainwater harvesting, (ii) groundwater recharge, (iii) maintenance of water balance, (iv) preventing water pollution, and (v) economic use of water. Some simple and cost-effective rainwater harvesting structures have been suggested in the study area, including: (i) percolation pits or tanks, (ii) recharge trenches or rain pits, (iii) recharge wells, (iv) farm ponds, (v) “V” ditches, and (vii) bench terracing. Economic use of water and the avoidance of affluence in the use of water at individual and community levels may be the major concerns for water management in the years to come. Different agencies have been operating in the study area with the aim of improving rural socio-economic standards and conserving the natural resources, especially land and water resources.

11.6 Conclusion

The intensive study based on fieldwork, remote sensing data, and other relevant information reveals that the study area faces a variety of land degradation and water resource management problems. Developmental activities without much attention to environmental issues have resulted in great pressure on natural resources. However, the following suggestions have been made for the sustainable development of land and water resources in the study area. There is no well-defined land use policy in the whole study area. This lacuna is highly responsible for the current

stage of land degradation and wasteland formation. The land use management policy to be set involves working with government organizations (Ministry of Environment and Forests, Ministry of Water Resource, Ministry of Rural Development, Ministry of Information, etc.), NGOs, and other stakeholders to develop a coordinated approach for sustainable land use management in the context of related cross-cutting issues. The dispute over land ownership and tenure is an age long problem in the region. Proper steps should be taken to increase mass awareness of land use planning and land management, land fertility, and farming systems, including their impacts and sustainability. Afforestation, reforestation, social forestry, and agroforestry should be given special attention as they are major tools for soil conservation, ecological balance, and the conservation of biodiversity. Embankments, along with the sluice gates in the coastal tract, should be higher and stronger to protect the reclaimed agricultural lands behind them. Pesticides, insecticides, and chemical fertilizers are to be used with utmost caution to avoid the possibility of land and water pollution, and more attention should be given to the integrated nutrient and biological pest management strategies. Farmers should use organic manures, green manures, different composts, organic chemicals, eco-friendly pesticides and insecticides, and biofertilizers in addition to chemical fertilizers to protect agricultural land in the particular environment as a whole from degradation. Municipal waste, industrial waste, and domestic waste must all be treated before disposal to prevent environmental degradation.

Rainwater harvesting and groundwater recharge through the formation of storage tanks and the construction of check dams across the drainage channels are essential throughout the study area to reduce the rate of soil erosion and increase the soil moisture retention capacity in the locality. In this regard, the government has adopted a few management plans for the restoration and conservation of forests and for the storage of rainwater in the artificial ponds. Population should be controlled to reduce the pressure on natural resources, especially land, water, and forest resources. Indigenous land and water management practices should be encouraged in the region to reduce soil erosion and land degradation activities. Simultaneously, local knowledge systems and environmental values of landscapes should be given due honor.

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