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Impact of Land Use Pattern Change on Socio-economic Status in Sandeshkhali Blocks of West Bengal

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ABSTRACT

The Sandeshkhali-I and Sandeshkhali-II blocks of North 24 Parganas district form a riverine and deltaic part of the Indian Sundarbans where land is the central basis of livelihood, settlement security, household income and local ecological stability. This paper examines the socio-economic impact of land use pattern change in these two blocks with special reference to the transformation of agricultural land, the expansion of aquaculture, the growth of built-up land, environmental stress and livelihood insecurity. The study is based on the supplied Study material, Landsat-based land use/land cover assessment for 1991, 2001, 2011 and 2021, Census of India data, field survey results from 400 respondents, and village-level observations. The results show that cropland declined from 19,312 ha in 1991 to 13,485 ha in 2021, while aquaculture expanded from 6,776 ha to 11,922 ha during the same period. Built-up land also increased from 1,979 ha to 3,878 ha, reflecting settlement pressure and infrastructural expansion. These spatial transformations have produced serious socio-economic consequences: reduced agricultural income, greater dependence on fishing and aquaculture, seasonal unemployment, distress migration, pressure on common resources, and higher livelihood vulnerability during flood and cyclone periods. Survey evidence shows that salinity in soil, lack of irrigation, low crop yield, seasonal uncertainty, poverty, and livelihood stress are the major social consequences of land use change. The paper concludes that land use change in Sandeshkhali is not merely an environmental or spatial process; it is also a process of socio-economic restructuring that affects employment, income, food security, gendered vulnerability, migration and rural development. Sustainable land use planning, regulated aquaculture, embankment strengthening, crop diversification and livelihood diversification are therefore essential for improving socio-economic resilience in this fragile Sundarban landscape.

Keywords: *Land Use Change; Socio-Economic Status; Sandeshkhali; Indian Sundarbans; Aquaculture; Agricultural Decline; Livelihood Insecurity; Population Pressure; Salinity; Rural Development.*

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1. INTRODUCTION

Land use pattern change is one of the most visible expressions of the relationship between human society and the physical environment. In rural deltaic regions, land is not only a physical surface but also a productive resource, a source of identity, a basis of food security and a foundation for livelihood. In the Sandeshkhali blocks of West Bengal, land use change has become a decisive factor in the socio-economic life of the population because the economy is closely tied to agriculture, fisheries, aquaculture, forest-based resource collection, wage labour and small-scale trade. When land changes from cropland to aquaculture ponds, fallow land, waterlogged surfaces, built-up settlements or saline patches, the lives of farmers, fishers, labourers and marginal households also change. The present paper therefore examines land use transformation as a social and economic process rather than as a purely spatial phenomenon.

The Indian Sundarbans is a globally significant mangrove and deltaic ecosystem, but its inhabited blocks face persistent socio-economic vulnerability. The reclaimed islands and low-lying blocks are protected by earthen embankments, yet these structures are repeatedly damaged by tidal action, storms, riverbank erosion and cyclonic events. The people of Sandeshkhali live in a landscape where natural hazards and human pressure operate together. Population growth increases pressure on land and local resources; market demand encourages shrimp and fish aquaculture; saline water intrusion reduces the productivity of agricultural fields; and settlement expansion creates new demand for roads, houses and services. These changes alter not only land cover but also the balance of household livelihood strategies.

The socio-economic impact of land use change is especially important in Sandeshkhali because agriculture has traditionally formed the basic economic structure of the area. Paddy cultivation, seasonal cropping, homestead gardening, fishing and forest-linked activities supported rural society for a long time. However, the transformation of cropland into aquaculture ponds has created both opportunities and risks. Aquaculture may provide higher income to some landowners, pond operators and traders, but it can also increase salinity, reduce employment for agricultural labourers, weaken food security and create unequal access to benefits. In many deltaic villages, the shift from agriculture to brackish-water aquaculture has reduced the space for traditional cultivation and intensified dependence on uncertain markets.

This study also recognizes that socio-economic status is multidimensional. It includes income, occupation, education, household dependency, access to services, livelihood security, gender relations, migration, resilience to disasters and quality of life. A decline in cultivable land may reduce farm income, but it may also indirectly affect school attendance, nutrition, debt dependence, migration decisions and women's household burden. Similarly, settlement expansion may improve access to markets and services in some localities while simultaneously reducing agricultural land and increasing pressure on embankments and drainage systems. Therefore, a proper understanding of socio-economic impact requires integration of spatial land use data with demographic, occupational and field survey evidence.

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The present paper is prepared around the theme: 'Impact of Land Use Pattern Change on Socio-economic Status in Sandeshkhali Blocks of West Bengal'. It focuses on Sandeshkhali-I and Sandeshkhali-II blocks of North 24 Parganas district, situated in the northern part of the Indian Sundarbans. The paper uses land use evidence from 1991 to 2021 and socio-economic data from Census sources and field survey responses. The central argument is that the changing land use pattern has generated a transition from an agriculture-dominated rural economy toward a more mixed but unstable livelihood structure characterized by aquaculture expansion, marginal employment, seasonal stress and migration.

2. LOCATION OF THE STUDY AREA

The study area covers Sandeshkhali-I and Sandeshkhali-II community development blocks of North 24 Parganas district, West Bengal. These blocks are located in the lower deltaic tract of the Indian Sundarbans and form part of a tide-affected, riverine, low-lying landscape. The broader Sundarban region is formed by the Ganga-Brahmaputra-Meghna delta system and is characterized by tidal rivers, creeks, estuarine channels, mangrove patches, saline soils, marshy lowlands and reclaimed settlement areas. Sandeshkhali is positioned within the transition zone between inhabited rural land and the ecologically sensitive mangrove-dominated Sundarbans.

The location of Sandeshkhali is significant for socio-economic analysis because physical accessibility, embankment condition, river proximity and saline water movement directly influence land use. Villages located near major roads, markets and river corridors often show higher population density and settlement concentration. Peripheral villages with lower accessibility remain more dependent on primary activities and face difficulties in access to education, health care and markets. The blocks are divided by rivers and waterways, and many settlements depend on boats, embankment roads and local ferry systems for daily mobility. This geographical isolation affects the cost of agricultural inputs, the marketing of fish and farm products, access to schools and hospitals, and the capacity to respond to disasters.

The total mapped area used in the LULC analysis is about 37,842 ha. Sandeshkhali-I is more densely populated than Sandeshkhali-II according to 2011 Census data, while both blocks show a strong dependence on agriculture and natural-resource-based livelihoods. The deltaic terrain, low elevation and tidal influence make the region highly vulnerable to salinity intrusion, waterlogging, riverbank erosion and cyclone-related damage. These environmental conditions form the physical background against which land use pattern change and socio-economic transformation must be understood.

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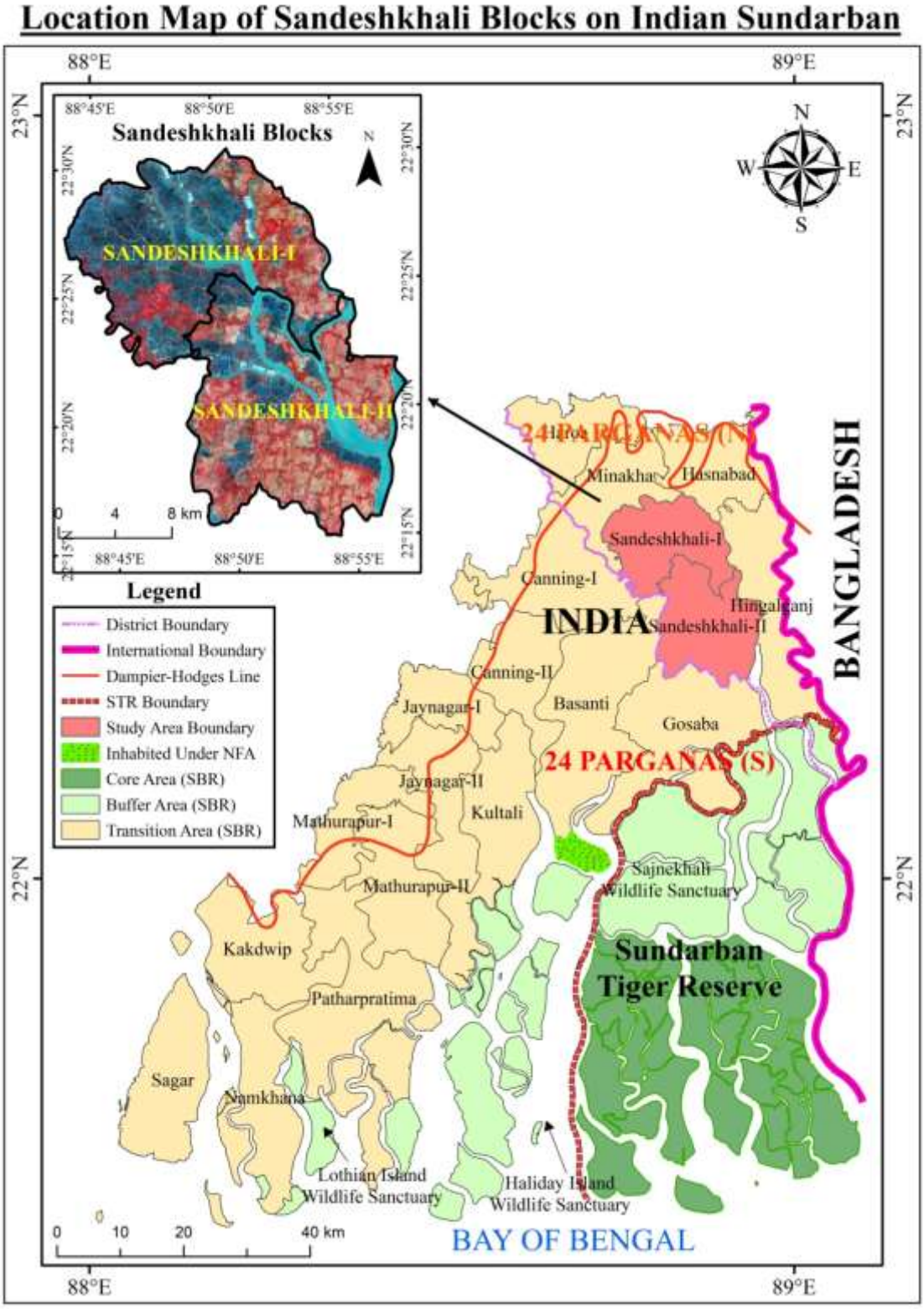

Fig. 1: Location Map of Sandeshkhali Blocks in the Indian Sundarbans

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3. REVIEW OF LITERATURE

A. Banerjee et al. (1998) examined environment, population and human settlements in the Sundarban delta and explained the relationship between deltaic zones, migration, settlement growth and social conditions. Their work is useful for the present study because it links population pressure and environmental fragility with the evolution of human settlements in the Sundarbans.

A.K. Sil (1992) studied the process of socio-economic change among the Oraons in West Bengal and showed that physical environment and social structure jointly influence occupational change. Although the research focused on a different community, it provides a conceptual basis for understanding how environment and economy interact in rural West Bengal.

B.K. Mondal et al. (2010) conducted a micro-level analysis of rural development in Mathurapur Block-II of South 24 Parganas. Their emphasis on primary data, local development indicators and village-level socio-economic conditions is relevant to Sandeshkhali because both areas belong to the greater Sundarban rural environment where local variation is very important.

B.K. Mondal (2012) evaluated community development in rural areas of the Sundarbans. The study highlighted the uneven distribution of development benefits, limitations of infrastructure and dependence on primary occupations. These issues are central to the present paper, particularly in understanding how land use change affects rural development outcomes.

D. De et al. (2014) investigated spatial inequality in health care infrastructure in the Sundarbans of West Bengal. Their work shows that environmental remoteness and weak infrastructure generate social vulnerability. For Sandeshkhali, this is important because land use change often interacts with poor connectivity, health access and disaster exposure.

M.K. Bera et al. (2013) examined adaptation, social vulnerability and flood disasters in the Sundarbans with reference to tribal communities. The study provides a useful framework for linking environmental hazards with livelihood vulnerability and social adaptation. The present research similarly treats land use change as a process that creates differentiated vulnerability among rural households.

M. Bandyopadhyay and R. Basu (2017) analysed spatial variation in the level of development in North 24 Parganas district. Their work is significant because Sandeshkhali is located in the less developed southern riverine part of the district, where infrastructure and economic diversification are weaker than in the urbanized northern and central parts.

A. Mondal et al. (2017) studied literacy as a parameter of disparity in North 24 Parganas and emphasized block-level differences in educational attainment. Literacy and education affect the capacity of households to shift livelihoods, access formal employment and adapt to land use change. Therefore, their findings support the socio-economic interpretation of the present paper.

Subhadip Gupta and Sarkar (2015) discussed the role of female participation in the changing economy of Sundarban blocks of North 24 Parganas. Their study is relevant because land use change affects women differently through changes in agricultural labour, household food security, resource collection, migration and unpaid family work.

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U. Dutta et al. (2018) investigated the socio-economic condition of shrimp collectors in the Sundarbans with special reference to Hingalganj Block. This work is directly relevant to Sandeshkhali because the expansion of aquaculture and shrimp-related livelihoods is one of the central land use transformations in the northern Sundarban blocks. It helps explain why aquaculture may be both an economic opportunity and a source of social and ecological stress.

4. OBJECTIVES OF THE STUDY

1) To examine the major changes in land use pattern in Sandeshkhali-I and Sandeshkhali-II blocks between 1991 and 2021.
2) To analyse the decline of agricultural land and the expansion of aquaculture and built-up land as major indicators of socio-economic transformation.
3) To assess the demographic, occupational, educational and livelihood characteristics of the study area.
4) To evaluate how land use pattern change affects agricultural income, employment, livelihood security, poverty, migration and rural social stability.
5) To identify village-level socio-economic impacts of agricultural instability, poverty and livelihood stress based on field survey evidence.
6) To suggest sustainable planning measures for improving socio-economic resilience in the deltaic environment of Sandeshkhali.

5. RESEARCH METHODOLOGY

The study adopts an integrated geospatial and socio-economic methodology. The spatial component is based on land use/land cover analysis using Landsat series satellite images for four temporal points: 1991, 2001, 2011 and 2021. Landsat 5 TM, Landsat 7 ETM+, and Landsat 8 OLI/TIRS data were used to identify major LULC classes such as mixed vegetation, river, aquaculture, brick kilns, cropland, mangroves and built-up land. The use of a thirty-year temporal span makes it possible to identify both gradual and rapid changes in the landscape.

Google Earth Engine was used for pre-processing, cloud masking, scaling, composite generation and image classification. Spectral bands and indices such as NDVI, EVI, MNDWI, NDBI and BSI were used to improve the identification of vegetation, water, built-up surfaces and bare soil. A random forest classifier was applied with training and testing samples. Accuracy assessment was carried out through confusion matrices, overall accuracy and kappa statistics. The reported overall accuracies were 94.24% for 1991, 88.30% for 2001, 86.04% for 2011 and 85.99% for 2021, indicating acceptable reliability for temporal interpretation.

The socio-economic component is based on secondary and primary data. Secondary data were drawn from the Census of India 2011, district-level sources, government reports and the Study database. These data provide information on population, sex ratio, literacy, occupation, workers and non-workers. Primary data were collected through field survey and questionnaire schedules. The socio-economic impact section uses village-wise responses from 400 respondents, distributed across selected villages such as Hatgachhi, Sarberia Agarhati, Bermajur-II and Bermajur-I. These data

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capture local perceptions of agricultural instability, poverty, livelihood insecurity, aquaculture expansion and seasonality of employment stress.

The analysis follows an objective-wise framework. First, spatial land use changes are quantified in hectares and percentages. Second, these changes are connected with socio-economic variables such as workforce structure, dependency, literacy and income-related stress. Third, field survey responses are used to interpret how households experience land transformation in daily life. Finally, planning implications are developed for sustainable land use and livelihood resilience. This mixed approach is suitable because socio-economic impact cannot be understood through satellite imagery alone; it requires integration of spatial evidence with village-level human experience.

Table 1: Data Sources and Analytical Use

Data / Method	Year / Source	Purpose in the Study
Landsat 5 TM	1991 and 2011	Historical and mid-period LULC classification
Landsat 7 ETM+	2001	Decadal LULC comparison
Landsat 8 OLI/TIRS	2021	Recent LULC condition and change mapping
ALOS/SRTM DEM and SOI boundary	2006 and administrative data	Terrain and boundary support
Census of India	2011	Population, literacy and occupation analysis
Primary survey	2024/2025	Village-level socio-economic impact assessment
GIS and statistical analysis	GEE, ArcGIS 10.8, Excel/SPSS	Classification, mapping, tables and interpretation

6. RESULTS AND DISCUSSION

6.1 Objective 1: Spatio-Temporal Land Use Change and its Socio-economic Meaning

The land use/land cover results show a clear transformation of the Sandeshkhali landscape between 1991 and 2021. In 1991, cropland occupied the largest share of the area, confirming the agrarian character of the region. By 2021, cropland had declined substantially while aquaculture and built-up land had expanded. This change indicates that the socio-economic base of the area has shifted from mainly crop-oriented rural production to a more mixed economy involving fish ponds, brackish-water aquaculture, settlement expansion, wage labour and service-related activities.

The decline of cropland is the most important land use change from a socio-economic perspective. Cropland decreased from 19,312 ha in 1991 to 13,485 ha in 2021, a net decline of 5,827 ha or about 30.17%. This reduction directly affects farm households, agricultural labourers, sharecroppers and smallholders. A decline in agricultural land means a smaller resource base for food production, lower demand for agricultural labour, greater dependence on market-purchased food and higher pressure on alternative income sources. In a low-income rural region, this change can create a long chain of social effects.

At the same time, aquaculture expanded from 6,776 ha in 1991 to 11,922 ha in 2021. This expansion reflects the increasing importance of fisheries and shrimp-related livelihoods. Aquaculture has become a major economic land use in low-lying saline and waterlogged tracts, particularly where

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agriculture is no longer reliable. However, its benefits are uneven. Landowners and pond operators may gain income, but agricultural labourers may lose employment, and small farmers may become dependent on leasing land or working as wage labourers. Therefore, aquaculture expansion is not simply economic development; it is also occupational restructuring.

Table 2: Land Use/Land Cover Change in Sandeshkhali Blocks, 1991–2021

LULC Class	1991 ha	2001 ha	2011 ha	2021 ha	Net change 1991-2021 ha	Change %
Mixed Vegetation	5,498	2,867	2,985	3,783	-1,715	-31.19
River	3,688	3,400	3,579	3,611	-77	-2.09
Aquaculture	6,776	10,695	11,943	11,922	+5,146	75.94
Brick Kilns	81	201	978	311	+230	283.95
Crop Land	19,312	18,303	16,254	13,485	-5,827	-30.17
Mangroves	509	322	292	852	+343	67.39
Built-up Land	1,979	2,054	1,811	3,878	+1,899	95.96

Source: LULC data reproduced and calculated

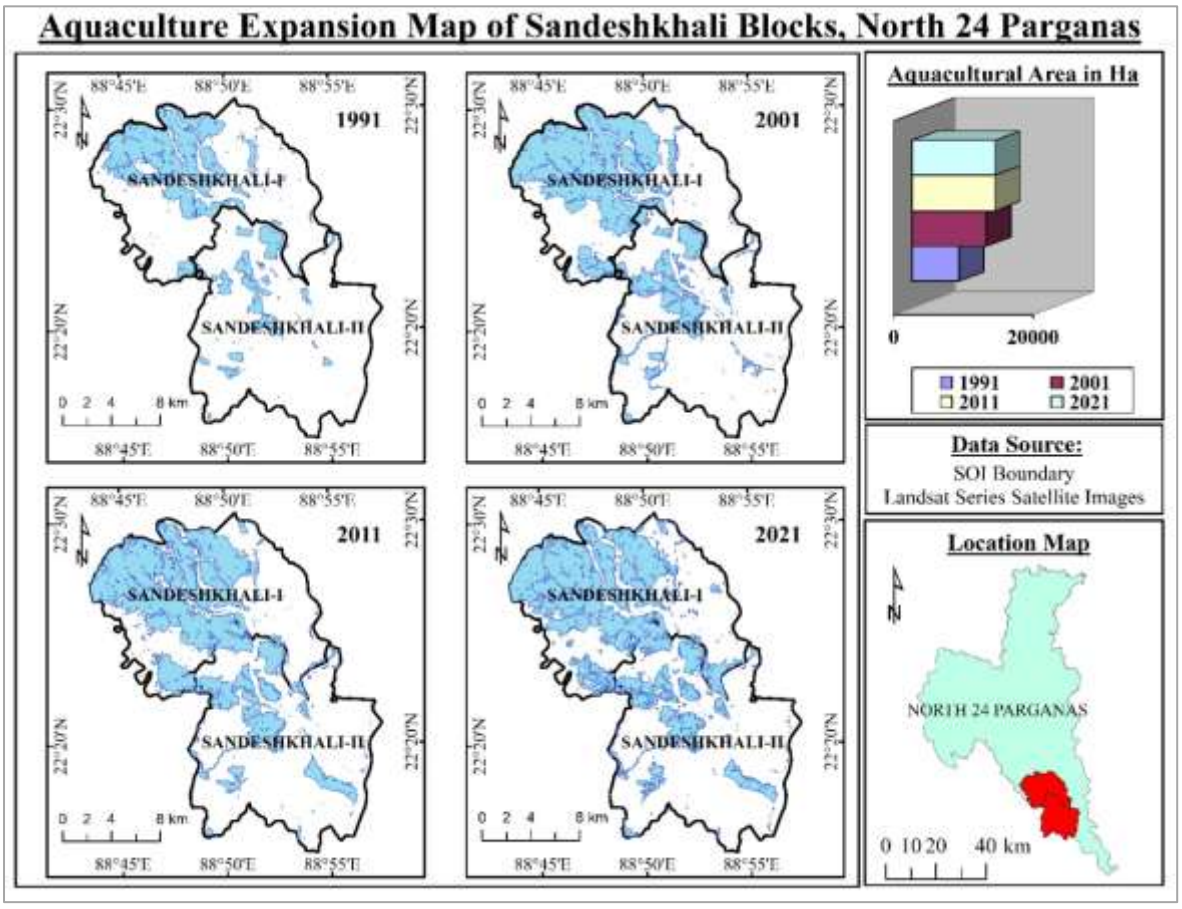

Fig. 2: Aquaculture Expansion Map of Sandeshkhali Blocks, 1991–2021

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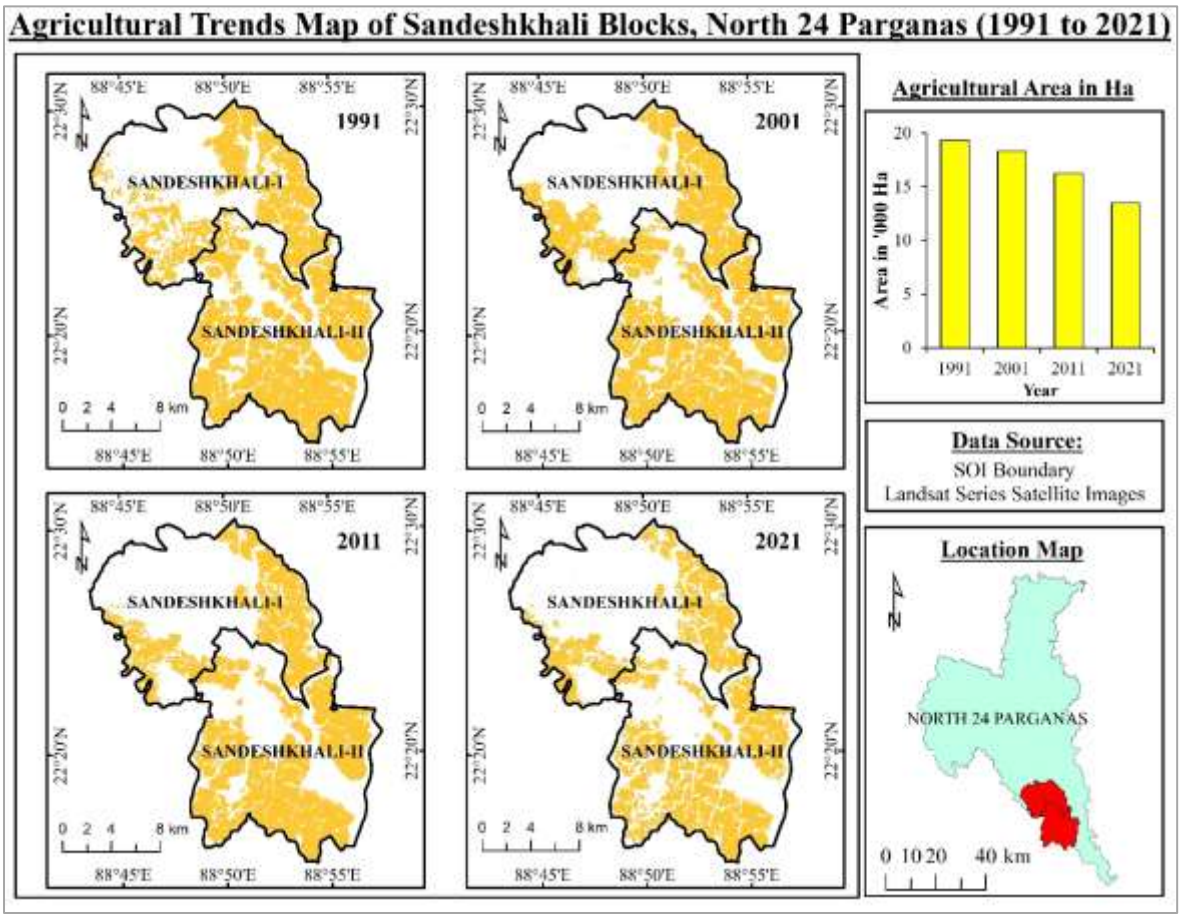

Fig. 3: Agricultural Trends Map of Sandeshkhali Blocks, 1991–2021

Source: Supplied Study Map based on Landsat Series Satellite Images.

6.2 Objective 2: Agricultural Decline, Aquaculture Expansion and Livelihood Transformation

Agriculture remains socially important even when its spatial share declines. The survey evidence suggests that agricultural instability has become one of the major socio-economic impacts of land use change. Salinity in soil, lack of irrigation, mono-cropping, low crop yield and seasonal uncertainty weaken the ability of farming households to maintain stable income. In deltaic villages, agriculture is not simply an occupation; it is linked with food security, social status, local labour demand and household stability. Therefore, the weakening of agriculture creates insecurity beyond the farm itself.

Aquaculture expansion has produced a contradictory socio-economic outcome. On one side, it provides an alternative to crop cultivation where saline or waterlogged conditions make paddy farming difficult. On the other side, it reduces the area under food crops, alters soil and water conditions, and often benefits better-off landholders more than landless labourers. The shift from crop fields to ponds may reduce the number of working days available to agricultural labourers, particularly women and marginal workers. It also changes village-level social relations because access to ponds, capital, fish seed, pumps and markets is unequal.

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The data show that aquaculture growth was fastest between 1991 and 2001, when the area increased by more than 3,900 ha. The later phase shows stabilization, suggesting that land available for conversion may be reaching a limit. At the same time, cropland continued to decline. This means that the socio-economic transition is not only a replacement of one land use by another but also a sign of increasing environmental pressure. Salinity, flood exposure, embankment breaches and poor drainage reduce crop viability and push households toward water-based livelihoods.

Table 3: Expansion of Aquaculture and Socio-economic Interpretation

Year	Aquaculture area ha	Share of total area %	Interpretation
1991	6,775.95	17.91	Baseline stage; aquaculture still secondary to crop farming
2001	10,695.25	28.26	Rapid growth linked with brackish-water fisheries and shrimp ponds
2011	11,943.25	31.56	Expansion continues but rate begins to slow
2021	11,921.74	31.50	Near-stabilization, indicating land and environmental saturation

Source: Prepared by the author based on land use/land cover classification from satellite imagery for 1991, 2001, 2011 and 2021.

Table 4: Decline of Agricultural Land and Socio-economic Interpretation

Year	Agricultural area ha	Share of total area %	Interpretation
1991	19,311.87	51.03	Dominant agricultural landscape
2001	18,303.48	48.37	Moderate decline due to conversion and salinity stress
2011	16,253.88	42.95	Sharp contraction after environmental and economic pressures
2021	13,484.78	35.63	Large-scale weakening of the agrarian base

Source: Prepared by the author based on land use/land cover classification from satellite imagery for 1991, 2001, 2011 and 2021.

Table 5: Major Problems Related to Agricultural Instability

Problem	Hatgachhi	Sarberia Agarhati	Bermajur-II	Bermajur-I	Total respondents	Percentage
Salinity in soil	24	26	28	30	108	27.0
Lack of irrigation	22	23	24	25	94	23.5
Mono-cropping pattern	18	19	20	21	78	19.5
Low crop yield	20	18	17	15	70	17.5
Seasonal uncertainty	16	14	11	9	50	12.5

Source: Author calculation base on primary data

Table 6: Impact of Agricultural Instability on Land Use Pattern

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Land Use Impact	Hatgachhi	Sarberia Agarhati	Bermajur-II	Bermajur-I	Total Respondents	Percentage
Reduction in cultivated land	28	30	33	36	127	31.75
Increase in seasonal fallow land	24	25	26	28	103	25.75
Conversion of crop fields into aquaculture ponds	18	20	24	27	89	22.25
Decline of traditional paddy-based land use	30	25	17	9	81	20.25

Source: Author calculation base on primary data

6.3 Objective 3: Population Pressure, Settlement Expansion and Resource Stress

Population pressure is an important driver of land use change in Sandeshkhali. The total population of the two blocks was 325,441 in 2011, distributed across 75,115 households. Sandeshkhali-I had a density of 967 persons per sq. km, while Sandeshkhali-II had a density of 849 persons per sq. km. Such population concentration increases demand for homestead land, local roads, markets, schools, health facilities, drinking water and employment. As settlement space grows, agricultural land near roads and village centres often becomes fragmented or converted.

The population density map shows that high-density villages cluster around road and river corridors. This pattern demonstrates the importance of accessibility. Villages with better access to transport routes and market nodes are more likely to attract settlement growth, trade and services. However, this concentration also increases pressure on embankments, drainage channels and nearby agricultural land. In the Sundarban environment, where land is limited and flood risk is high, population concentration can quickly become environmental and socio-economic pressure.

Built-up land increased from 1,979 ha in 1991 to 3,878 ha in 2021. This does not simply indicate housing growth; it also reflects the spatial expansion of rural infrastructure, roads, markets, schools and non-farm activities. Such growth can improve access to services, but it may also reduce cultivable land and increase vulnerability if settlement expands into low-lying or hazard-prone areas. In Sandeshkhali, the socio-economic value of settlement expansion therefore depends on whether it is planned, safe and supported by drainage, embankments and livelihood opportunities.

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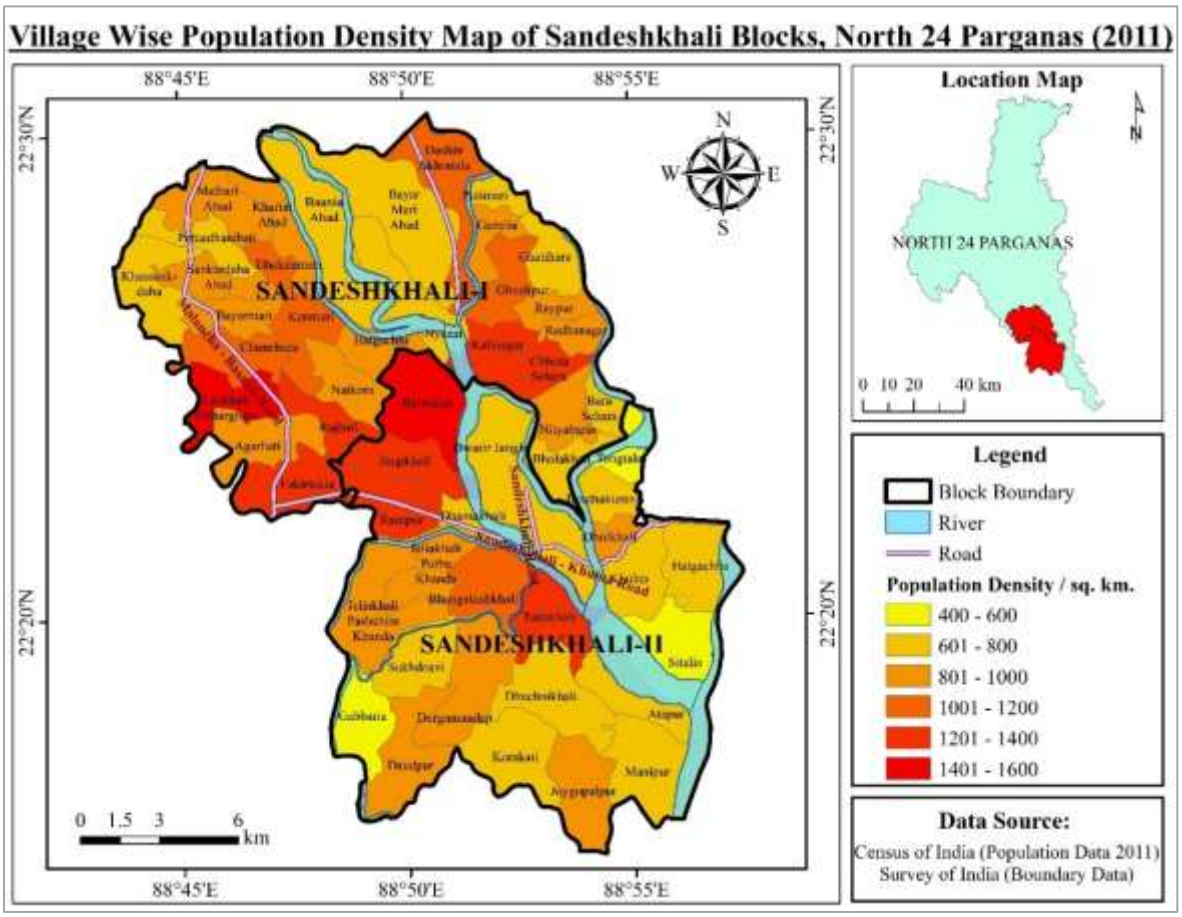

Fig. 4: Village-wise Population Density Map of Sandeshkhali Blocks, 2011

6.4 Objective 4: Occupational Structure, Dependency and Socio-economic Vulnerability

The occupational structure of the study area reveals high dependency and employment insecurity. In Sandeshkhali-I, 61,005 persons were recorded as workers, while 103,460 were non-workers. In Sandeshkhali-II, 61,749 persons were workers and 99,227 were non-workers. The proportion of non-workers is very high in both blocks, indicating a large dependent population. The presence of many marginal workers reflects seasonal, irregular and part-time employment. This is typical of rural economies where agriculture, fishing and casual labour dominate and where formal non-farm employment remains limited.

Land use change has a direct effect on this occupational structure. When cropland declines, the demand for agricultural labour decreases. When aquaculture expands, some new forms of employment appear, but they are not always sufficient or equally accessible. Aquaculture may require fewer labour days than paddy cultivation and may be controlled by those with capital and land. Thus, land use transformation may increase income for some households but reduce labour opportunities for others. The result is occupational polarization: some households diversify into fisheries, trade and services, while others become more dependent on wage labour, migration and seasonal work.

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The occupation profile map reinforces this interpretation. The pie charts show the coexistence of main workers, marginal workers and non-workers across villages, but the non-worker share is substantial. A high non-worker population means that household income must support a large number of dependents. In a context of agricultural decline and environmental instability, this increases vulnerability to debt, migration and distress sale of assets. Therefore, the socio-economic impact of land use change must be understood through the labour structure as well as through land cover statistics.

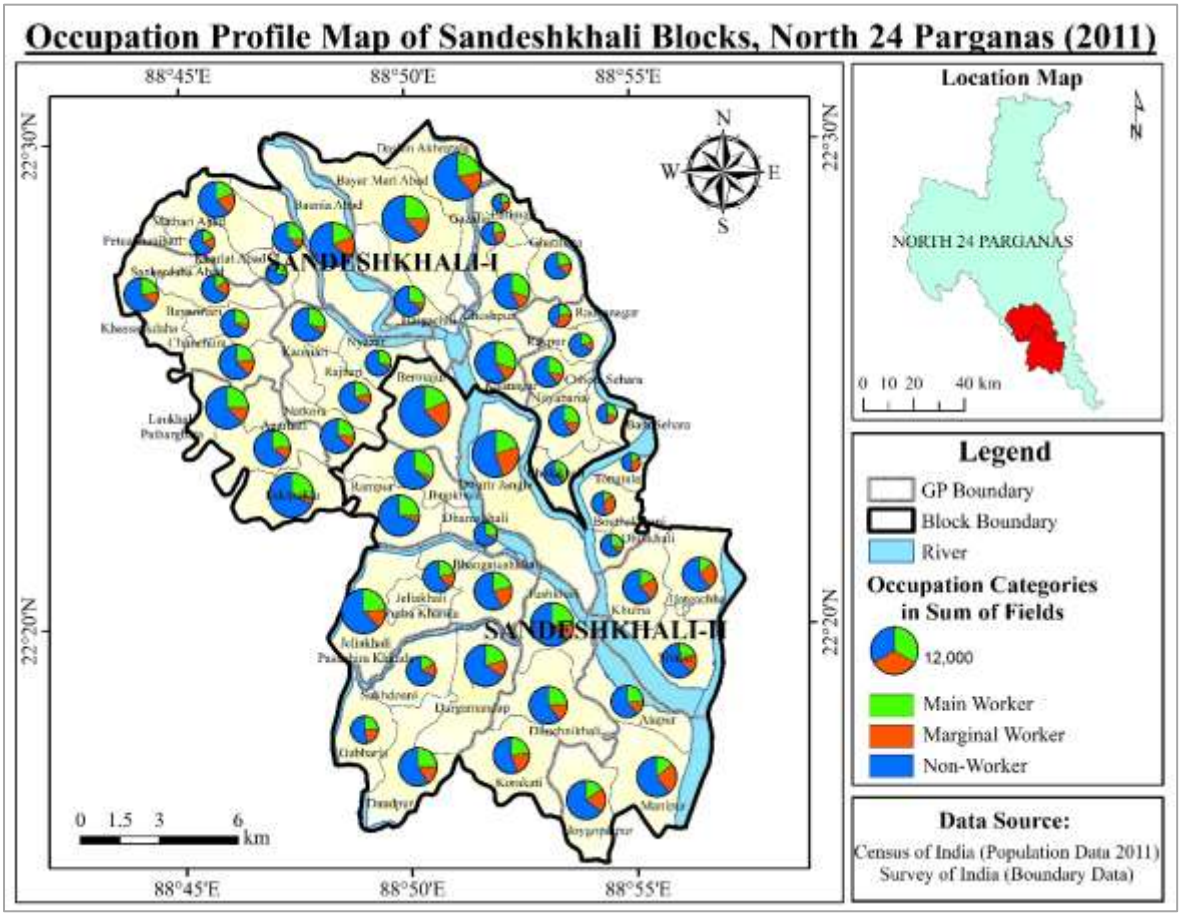

Fig. 5: Occupation Profile Map of Sandeshkhali Blocks, 2011

Source: Supplied Study map based on Census of India 2011.

Table 7: Occupational Structure of Sandeshkhali Blocks

Block	Total Worker	Main Worker	Marginal Worker	Non-Worker	Worker Share of Population %
Sandeshkhali-I	61,005	40,131	20,874	103,460	37.09
Sandeshkhali-II	61,749	34,118	27,631	99,227	38.36

Source: Census of India 2011

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Table 8: Literacy and Illiteracy in Sandeshkhali Blocks

Block	Total Literate	Male Literate	Female Literate	Total Illiterate	Male Illiterate	Female Illiterate
Sandeshkhali-I	100,978	56,501	44,477	63,487	27,424	36,063
Sandeshkhali-II	98,805	56,205	42,600	62,171	25,716	36,455

Source: Census of India 2011

6.5 Objective 5: Poverty, Livelihood Insecurity and Migration

The field survey evidence indicates that poverty and livelihood insecurity are central socio-economic outcomes of land use pattern change. Low income was reported by 121 out of 400 respondents, dependence on natural resources by 105 respondents, seasonal unemployment by 94 respondents, and out-migration or distress migration by 80 respondents. These numbers show that the impact of land use change is not confined to landowners. It affects the wider rural population through labour markets, access to resources, food security and household income.

Livelihood insecurity is produced by several linked processes. First, agricultural land becomes less productive due to salinity, waterlogging, lack of irrigation and crop damage. Second, households shift toward fishing, forest-based work, casual labour and aquaculture-related work, but these activities are often seasonal and risky. Third, disaster events such as floods and cyclones interrupt both agricultural and non-agricultural activities. Fourth, the absence of stable local employment pushes many working-age persons to migrate temporarily or permanently to towns and other states. Migration may bring remittances, but it also weakens household social support and increases the burden on women, children and elderly members.

Seasonality is a major feature of the socio-economic impact. Survey data show that livelihood stress is strongest during the agricultural lean season and during flood/cyclone periods. This means that poverty is not only a matter of low annual income; it is also a matter of unstable income across the year. Seasonal income gaps lead households to borrow money, reduce food expenditure, sell livestock, migrate for work or depend on informal credit. In the long term, such stress weakens resilience and limits investment in education, health and housing.

Table 9: Major Problems Related to Poverty and Livelihood Insecurity

Major Problem	Hatgachhi	Sarberia Agarhati	Bermajur-II	Bermajur-I	Total Respondents	Percentage
Low income	28	29	31	33	121	30.25
Dependence on natural resources	24	25	27	29	105	26.25
Seasonal unemployment	22	23	24	25	94	23.50
Out-migration and distress migration	26	23	18	13	80	20.00

Source: Author Calculation Base on Primary Data

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Table 10: Seasonal Pattern of Livelihood Insecurity

Period of Livelihood Stress	Hatgachhi	Sarberia Agarhati	Bermajur-II	Bermajur-I	Total Respondents	Percentage
Mainly during agricultural lean season	27	29	31	33	120	30.00
During flood/cyclone period	24	25	27	29	105	26.25
Throughout the year	21	22	23	24	90	22.50
During periods of job scarcity/migration	28	24	19	14	85	21.25

Source: Author Calculation base on Primary Data

6.6 Impact Pathways and Planning Implications

The socio-economic impact of land use pattern change in Sandeshkhali can be understood through five connected pathways. The first is the production pathway. When cropland declines or becomes saline, households lose access to stable food production and crop income. This pathway affects not only farmers but also landless labourers, transporters, small traders and input suppliers who depend on the agricultural cycle. A decline in paddy cultivation reduces demand for transplanting, harvesting, threshing and post-harvest labour. As a result, the land use change visible on maps becomes a reduction of working days in village life.

The second pathway is the employment pathway. Aquaculture and fisheries create new work, but these activities do not always replace agricultural employment in equal quantity or quality. Pond management, fish seed stocking, netting, feeding and marketing require labour, but the work is often controlled by landowners, leaseholders or contractors. The landless and marginal workers may get only short-term wage work. Women, who often contribute to agricultural and household production, may lose opportunities if land conversion reduces labour-intensive crop activities. Thus, land use change changes both the type and distribution of employment.

The third pathway is the ecological-risk pathway. Salinity, waterlogging, embankment failure and cyclone impacts reduce the productivity of land and increase uncertainty. These environmental stresses push households toward aquaculture, migration and wage labour. However, unregulated aquaculture may further increase salinity and weaken the long-term suitability of land for agriculture. This circular relationship between environmental degradation and livelihood change is a major challenge for planning in the Sundarbans.

The fourth pathway is the settlement and infrastructure pathway. Built-up growth can bring new roads, markets, shops and service opportunities, but it also uses land that might otherwise support agriculture or vegetation. If settlement expands without drainage and embankment planning, it may

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increase flood exposure and waterlogging. The socio-economic benefit of infrastructure therefore depends on the quality of planning. Road connectivity, market access, school access and health services are necessary, but they must be integrated with hazard-safe land use regulation.

The fifth pathway is the social vulnerability pathway. The burden of land use change does not fall equally on all social groups. Small farmers, sharecroppers, agricultural labourers, Scheduled Caste and Scheduled Tribe households, women-headed households, elderly people and households without migrant remittances are more vulnerable. They have fewer resources to invest in aquaculture, fewer savings to recover from disasters, and less access to formal credit. Therefore, the same landscape transformation may produce profit for some and insecurity for others. This unequal distribution of benefits and losses is the most important socio-economic issue emerging from the study.

Planning interventions must therefore be multi-sectoral. First, agriculture should be supported through saline-tolerant paddy varieties, crop diversification, rainwater harvesting, small irrigation facilities and soil recovery measures. Second, aquaculture should be regulated through zoning, water quality monitoring, embankment protection and restrictions on conversion of prime agricultural land. Third, livelihoods should be diversified through skill development, women's self-help groups, small processing units, fish value-chain development, eco-tourism support and local service-sector employment. Fourth, migration should be treated as a livelihood strategy rather than only as a problem; safe migration support, skill certification and remittance management can reduce distress. Fifth, social protection should be strengthened through insurance, employment guarantee schemes, disaster compensation and targeted assistance for the poorest households.

The findings also indicate the need for village-level land use planning. A single plan for the whole block will not be sufficient because vulnerability varies from one village to another. Villages with high population density require settlement planning and infrastructure improvement. Villages with high salinity and waterlogging require drainage and soil management. Villages with high aquaculture expansion require environmental monitoring and livelihood balancing. Villages with high marginal labour require employment diversification. Such micro-level planning can help convert land use change from an uncontrolled process into a managed and socially beneficial transition.

7. CONCLUSION

The study concludes that land use pattern change in Sandeshkhali-I and Sandeshkhali-II blocks has produced deep socio-economic consequences. The transformation from a largely agriculture-based landscape to one increasingly marked by aquaculture, built-up expansion, salinity-affected land and environmental stress has altered the livelihood structure of the rural population. Cropland declined by more than 5,800 ha between 1991 and 2021, while aquaculture increased by more than 5,100 ha. This spatial shift has weakened the traditional agrarian base and encouraged the growth of fisheries and aquaculture as alternative sources of income.

However, the socio-economic outcome of this transformation is uneven. Aquaculture provides opportunities, but not all households have equal access to land, capital, technology and markets. Agricultural labourers, small farmers, women, marginal workers and resource-dependent households

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often experience greater insecurity. Field survey data show that salinity in soil, lack of irrigation, low crop yield, reduction in cultivated land, low income, seasonal unemployment and distress migration are major impacts. Therefore, land use change has become a driver of both economic diversification and social vulnerability.

Population pressure and settlement expansion further complicate the situation. The two blocks support more than 325,000 people, with high density and a large dependent population. Built-up land growth indicates demand for housing and infrastructure, but in a fragile deltaic environment it also increases pressure on land, drainage and embankments. The occupational structure shows high dependence on marginal and informal work, while literacy data reveal gendered and spatial disparities. These factors reduce the adaptive capacity of many households.

The socio-economic impact is also seasonal. Livelihood insecurity rises during agricultural lean months and during flood or cyclone periods. This seasonal vulnerability pushes households toward migration, wage labour and increased dependence on natural resources. The cumulative effect is a rural society that is adapting continuously but under increasing pressure. The most vulnerable groups require targeted support through livelihood diversification, agricultural adaptation, disaster-resilient infrastructure and social security.

For sustainable development, land use planning in Sandeshkhali must be integrated with socio-economic planning. Regulated aquaculture, protection of agricultural land, saline-resistant crop varieties, improved drainage, embankment strengthening, market support for farmers, skill training, women-centred employment schemes and disaster insurance can help reduce vulnerability. The study demonstrates that land use change is not merely a technical mapping issue; it is a social process affecting income, employment, migration, food security and human well-being. Therefore, future planning for Sandeshkhali must treat land, livelihood and environment as an interconnected system.

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