



Sustainable Development and Ethno-Inhabitant in Mangrove Ecology of India: A Case Study on Governance Policy in Sundarban

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Abstract

Criticality: Sundarban is a world heritage Mangrove area in the eastern part of India and the southern part of Bangladesh. My focus area is the rest of the rest of India. The 54 islands in this region are inhabited by people and the Reserve Forest. Strong ethnic feelings are belonging to Schedule Cast, Schedule Tribe, Other-Backward Class-A & B. Sundarban is a bountiful natural resource region of tropical, marine, and other aquatic organisms, endangered Royal Bengal tigers, crocodiles, and other flora-faunas. **Statement of the Problem:** Agriculture is the mainstay of the economy, catering to about 89% of the total population of this region; even the high percentage is landless. They have popular common occupations like farming, honey collection, fishing, crab hunting, etc. A unique occupation is Tiger Charmer (Bauley). There is a broad area of Tiger Widow. Tourism could be another economic activity. However, the infrastructure is still inadequate. Despite the rapid development of science and technology in India, it has avoided traditional and peripheral beings. It has to face tremendous loss of life and property due to natural hazards. **Objectives of the Study:** The study wants to focus on how these ethnic groups take self-initiative for the ecological preservation of the Sundarban. This academic study will possibly try to recommend advanced policies to trim down natural disasters, require realistic and sensible guidelines, illegal approaches, and corruption in mangrove mapping platforms. This study assesses the attitude of local stakeholders towards sustainable management of ethnobotany, permaculture, Mangrove-friendly ecology, etc. **Method:** This study follows the geomorphologic approach, and it adopts the qual-quant survey method on 1220 households and Tiger Widow Village regarding field study. Findings: Anthropogenic pressure, political corruption, and maladministration are obstacles to achieving the Sustainable Development Goals. Institutions like local governance and the Panchayat Raj system are run by public representatives, most of whom are illiterate. Ecological engineering finds an asymmetric relationship between increasing populations and the decline in mangrove families.

Keywords: Sundarban, Ethnic Inhabitant, Tiger Charmer, Mangrove Friendly Ecology, Sustainable Management, Environmental Governance, Tourism, Mangrove Preservation Act

1. Introduction

The concept of sustainable development (SD) is not a new thought. According to the Brundtland Commission, 1978, its current focuses are regarding financially viable ability and societal and ecological concerns for endorsing continuing sustainability. For example, Mangrove forests as natural ethnic plants are significant strategic and common properties that refer to various ecological units like climate transformation, bio-network mitigation, activities as well as shoreline safety, and food production for many profits for sustainable development. The 2005 Millennium Ecosystem Assessment Report explains the benefits of mangroves in the provision, regulation, support, and cultural services. To define the concept of the 17th goal of SD, Hanifah, and Sukendi (2023) have identified the five dimensions of goal in practicing life regarding sustainable mangrove management, which include the following issues/ dynamics:

Table 1: Common investigation of sustainable proportions

| Issues | Factors |
|----------------------|--|
| Ecosystem | coastline abrasion |
| | Mangrove territory difficulty |
| | rehabilitation accomplishment |
| | hose down circumstances |
| Economy | Manufactured goods value |
| | Tourism prospective |
| | Inhabitants earnings level |
| Socio-culture | Have an aesthetic |
| | Mangrove assets industries |
| | Local insight |
| | Collective cohesiveness |
| Law and Institutions | Level of community agreement |
| | Society participation |
| Technology | Mangrove processing engineering |
| | Management conveniences and infrastructure |
| | Means of transportation |
| | Mangrove rehabilitation knowledge |
| | Waste handling machinery |

The various coastal regions of India have a distinct and exclusive type of ecosystem, where mangrove forests act as a natural climate solution that provides proper support to them and the people and wildlife living in the vicinity. But now threatened by disuse patterns, they ensure their sustainability and the livelihoods of millions of people who depend on these precious coastal habitats. Despite these benefits, the total mangrove area has been decreasing day by day (Chisika & Yeom, 2023). In a word, mangrove forests can perform on various goals such as organic, environmental, and fiscal, for the survival of flora and fauna.

Despite so many environmental acts, the Mangrove Preservation Act, working with international institutions and local NGOs, the study investigates the statement of the problem that Sundarbans mangrove region is facing tremendous loss of life and property due to natural hazards. Agriculture is the mainstay of the economy, catering to about 89% of the total population of this region; even the high percentage is landless. They have popular common occupations like farming, honey collection, fishing, crab hunting, etc. A unique occupation is

Tiger Charmer (Bauley). There is a broad area of Tiger Widow. Tourism could be another economic activity, but the infrastructure is still inadequate. Despite the rapid development of science and technology in India, it has avoided traditional and peripheral beings. Regarding those purposes, the study was intended to:

1. To prepare a shoreline geological Map of the Study Area;
2. To study healthy Connections between Sustainable Development and Indigenous Peoples;
3. To investigate the governance policies that support or do not favor the protection of the milieu and ecosystem.

1.1. Key Argument and Significance of the Study

The contemporary era is marked by globalization and urbanization (Bansal, Sarker, Yadav & et.al., 2023). Significantly, the study pays attention to the changing global socio-economic development matrices that come through population growth, urbanization, and climate change and its decline in mangrove forest resources. Schedule Caste, Schedule Tribe, and Other Backward Class communities, with exclusive ethnic customs, morals, and attitudes, maintain their kin-based structure rather than adopting a market-based outcome. According to Bansal et al. (2023), the research investigates six themes i) economics, ii) ecosystem, iii) livelihoods, iv) socio-demographic issues, v) sustainable improvement, and vi) political views, policy guidelines, and partnerships. All subjects and the 2030 Agenda for Sustainable Development aim to make the powerful Indigenous working class look after their rights and engage in joint initiatives to include them in decision-making processes. This text emphasizes the implications of using Indigenous awareness to develop strategies and advance Indigenous management policy in the face of environmental and other changes.

2. Literature Review

This study seeks to explain the role of indigenous communities in promoting mangrove regions and achieving the SDGs. Using an integrative review, the study addressed some of the literature in different sections:

In these texts, written by Doreen Atkinson (2002), *Local Governance and Sustainable Development: Getting the Parameters Right*; IUCN (2017), *Can restoring mangroves help achieve the Sustainable Development Goals?*; Hema Mulakkuveetil & Indira Devi (2021), *Sustainable Management of Mangroves: Developing a socially acceptable management plan*; United Nations (2022), *Mangroves for sustainable development*; Alexander Cesar Ferreira et al. (2022), *Can Sustainable Development Save Mangroves?*; Indira A.L. Eyzaguirre et al. (2023), *Integrating a conceptual framework for the sustainable development goals in the mangrove ecosystem: A systematic review*, etc makes the theoretical framework for concerning mangrove inhabitants and discusses ecological dynamics, biological interactions, and the adaptive mechanisms of species living within these unique habitats. They also put the arguments on sustainable Use and Resource Management, Millennium Ecosystem Assessment (MEA), natural capital and ecosystem-based management (EBM), and Integrated Coastal Zone Management (ICZM). Several texts explain how species thrive in the unstable conditions of mangroves, focusing primarily on adaptive biology, ecological niche approach, trophic dynamics, and also on ecological succession and zonation dimension. This theoretical outline is coupled with their ecological, social, and economic importance.

In the Indian context Rajiv Kumar (n.d.), *Conservation and management of mangroves in India, with special reference to the State of Goa and the Middle Andaman Islands*; P. K. Viswanathan (n.d.), *Development and Restoration of Mangrove Ecosystems Climate*

Change Risks: Interventionist Policies and Outcomes in India; Ruchi Badola et al. (2012), Attitudes of local communities towards conservation of mangrove forests: A case study from the east coast of India; Samyuktha A. Kumar & Zareena B. Irfan (2018). Current Status of Mangroves in India: Benefits, Rising Threats Policy and Suggestions for the Way Forward; Chime Youdon (2020), Protecting Mangrove Ecosystems: Learning from India's Coastal Region analyzed carbon sequestration, shoreline stabilization, National Action Plan on Climate Change (NAPCC), and habitat for diverse marine life including mammals, birds, reptiles, fish, and invertebrates. They discuss how the Indian mangroves play a vital role in the livelihoods of coastal communities. They support fisheries by providing breeding and nursery grounds for many commercially important fish species. In their writings, the authors also discussed that Mangroves also supply non-timber forest products such as honey, tannins, and medicinal plants, contributing to the local economy. These interpretations have focused on the Socio-Economic Importance of mangrove flora and mangrove fauna culture.

Making specific focus regarding Sundarban, some studies and reports like Centre for Civil Society Report (2024), The Threat of Climate Change and Policy Uncertainty to Sunderbans and its People; Joyprokash Mondal (2024), Hygienic Linkage between Green Energy and Sustainable Development: A Case Study on Sundarban in India; Abhra Chanda & Anirban Akhand (2023), Challenges towards the Sustainability and Enhancement of the Indian Sundarban Mangrove's Blue Carbon Stock; Birsha Ohdedar (2023), Opinion: To rebuild the Sundarbans, India needs to rethink its laws; Rakesh Bera & Ramkrishna Maiti (2022), Mangrove dependency and livelihood challenges — A study on Sundarbans, India; Sugata Hazra et al. (2021), Regenerating Mangrove Biodiversity in the Sundarbans Biosphere Reserve India - An assessment of scope and present interventions for ecological mangrove restoration in Sundarban Biosphere Reserve India; Trishita Mondal et al. (2021). Sustainable Management of Sundarbans: Stakeholder Attitudes towards Participatory Management and Conservation of Mangrove Forests; Bisawjit Mallick et al. (2021), Livelihoods dependence on mangrove ecosystems: Empirical evidence from the Sundarbans; Pritam Bhattacharjee & Dr. Pritam Ganguly (2021). Environmental Sustainability for Better Livelihood and Ecology in Sundarban: West Bengal; Mahua Bardhan (2021), Chapter 18 - An Empirical Study on Mangrove Restoration in Indian Sundarbans—A Community-based Environmental Approach; Roy (2021), Climate Change, Ecological Stress and Livelihood Choices in Indian Sundarban; Abhilasha Ganguly (2020), Mangrove forest and sustainability of Sundarban delta; Government of India Report (2020), Tiger Conservation Plan Sundarban Tiger Reserve 2017 – 2027; Subarna Karmakar (2019), Ethnic Identity and Forest Preservation: A Sociological Inquiry on Sundarbans, West Bengal; Trishita Mondal (2019), Sustainable management of the Sundarbans: stakeholder attitudes towards sustainable mangrove policy and management; Rashmi Dutta Dey (2018), Sundarban and Conservation: Historical Perspectives and Contemporary Challenges; Joyeeta Bhattacharjee (2016), India, Bangla Ministers for joint action to protect Sundarbans; Abu N. M. Abdullah (2014), Livelihood Strategies of People Surrounding the Sundarbans Mangrove Forest; Prasanta Kumar Pandit (2013), Past Management History of Mangrove Forests of Sundarbans; Amrita Sen & Sarmistha Pattanaik, “The politics of implementing Forest Rights Act in Sundarban, West Bengal: A Critical Analysis” host a Biodiversity Hotspot of the largest tidal halophytic mangrove forest. These texts intended anthropogenic Impacts and Community-Based Conservation, Aquatic and Avian Life, shoreline protection, and Challenges to Sustainable Development. So they suggest that the world's largest delta for preserving biodiversity needs eco-friendly tourism and sustainable resource use.

A comprehensive text evaluation was conducted to understand the significant issues. This assessment focuses too on developing new urges, and it uses the text as a basis and carries on

finding the latest approach that can recapitulate and synthesize the points of view and thoughts of others.

3. Methodology

This lesson is based on the geomorphologic method and applies the SWOC approach to the mangrove region of the Sundarbans, an Indian forest region. The methodology of this research is based on a constructivist approach. So the present study has adopted the qual-quant method. To get information, opinions, suggestions, and recommendations, this article put forward a successful case study with 1220 households and Tiger Widow Village (occupation as Tiger Charmer (Bauley) as well as tantrika) who are seeking and practicing support for sustainable alternative livelihoods through rural development and resource preservation interventions in the Indian Sundarbans. Investigations, field visits, and consultations were also sourced from five groups and stakeholders, like (i) local people who play roles as forest resource users and forest protectors, (ii) panchayat members and other local leaders such as public representatives, (iii) universities, think-tanks, and professional experts. , working in other institutions, (iv) Government personnel who are responsible for forest protection, (v) universal people who are concerned with mangrove areas of the Sundarbans and their well-being and sustenance. Some tertiary sources are intended from the perspectives of Kenya, Indonesia, etc. mangrove forest literature.

3.1. Data Collection Methods

To better understand the socio-economic status, governance, and sustainable development needs of mangrove-dwelling communities in the Indian Sundarbans, rigorous data collection procedures, well-designed surveys, and appropriate analytical techniques are conducted. In this context, the study attempted to discuss the interaction of their livelihoods and governance:

3.1.1. Household Surveys

The household survey collects quantitative data from mangrove residents. The survey was designed to collect socio-economic data including livelihoods, income, education, and access to natural resources. The population here comes from socio-economic groups, such as fishermen, laborers, and forest-based communities:

- **Demographic Data:** Age, gender, education, household size, and caste or tribe.
- **Livelihoods and Income:** Questioned on primary and secondary sources of income, land ownership, fishing activities, dependency on forest resources, seasonal variations in income, and access to markets.
- **Natural Resource Use:** Focuses on how communities use mangrove forests (eg, fishing, honey collection, firewood, and timber) and resource depletion or management concepts.
- **Disaster Preparedness and Climate Change Perception:** Questions also captured past experiences with disasters, levels of preparedness, early warning systems, and family adaptations.

Result: The collected data show that 70% of the respondents depend on fishing, while others depend on agriculture, honey collection, and wood extraction from mangroves. This data highlights the high dependence on natural resources.

3.1.2. Focus Group Discussions (FGDs)

Focus group discussions provided rich qualitative data and helped to understand governance, resource management, gender roles, and traditional knowledge related to mangrove

ecosystems. It selects cultural norms, enabling structures, and the role of local administrative bodies (gram panchayats).

- **Design:** It includes different sections of the community including men, women, Indigenous groups, and youth to ensure diverse perspectives. It made questions for each group to discuss specific issues such as mangrove conservation, livelihood challenges, and access to government services

Result: FGDs conducted with women's groups in the Sundarbans revealed that while women play important roles in household management and resource gathering (eg, collecting fish or firewood), they often lack a formal voice in local administration decisions.

3.1.3. Key Informant Interviews (KIIs)

The interviews involved in-depth discussions with community leaders, local officials [Local panchayat leaders, forest officials, geographers], NGOs, and experts who have special knowledge of the Sundarbans mangrove ecosystem and its inhabitants, and also have focused on policy gaps and the successes or failures of past interventions.

Result: Forest department officials revealed that illegal cutting of mangroves by local communities often occurs due to a lack of alternative livelihoods.

3.1.4. Ecological and Environmental Data Collection

To understand the interactions between mangrove inhabitants and their environment, notably, the survey collects socio-economic data as well as environmental data. It also monitors mangrove health, biodiversity, and levels of deforestation or degradation.

Result: This questionnaire approach assesses the biodiversity of fish populations, forest health, and soil quality to track the environmental sustainability of livelihood activities.

4. Understanding Theoretical Context

A common understanding of the theoretical context of these inhabitants involves exploring ecological theories, adaptation mechanisms, and the socio-economic dynamics of human communities living in harmony with this environment. So it focuses on Indigenous management theory, sustainable forest management approach, Tragedy of commons thought, Environmentalism, Eco-colonialism, constructivist approach, Public Choice Policy of Governance, Local Institutional Theory, neoliberal localization approach, decentralization, rural development approach, engendering governance policy, Local Empowerment Governance, local system analysis approach, local structure, and functional views.

Ecosystem Theory is firstly based on Structure and Functions which are characterized by complex interrelationships between biotic (living organisms) and abiotic (non-living environmental factors) components. These interrelationships dictate the structure and function of the ecosystem, including nutrient cycling, energy flow, and habitat provision. Secondly, it involves Ecosystem Services such as coastal protection, carbon sequestration, and supporting fisheries. Understanding these services is critical for assessing the value of conservation efforts.

Niche Theory within the mangrove ecosystem is defined by their role in the ecosystem, habitat preferences, and interactions with other species. For instance, the Bengal tiger (*Panthera tigris tigris*) occupies the apex predator niche, while mangrove trees like the Sundari (*Heritiera fomes*) are primary producers. This includes physiological, behavioral, and

morphological adaptations. Inhabitants of mangroves have evolved unique adaptations to survive in high salinity, fluctuating water levels, and anoxic soil conditions.

Island Biogeography Theory shows Species Diversity and Area Relationship and Habitat Fragmentation. This theory explains the number of species on an island (or isolated habitat like the Sundarbans) as a balance between immigration and extinction rates, influenced by the size of the habitat and its distance from the mainland. The Sundarbans are fragmented by rivers and human activities, impacting species distribution and biodiversity.

Through the lens of Socio-Economic Dynamics and Conservation and Management, the local communities depend on the mangroves for fishing, honey collection, and traditional medicine. Sustainable livelihood practices are crucial for balancing human needs with conservation goals. The Sundarbans hold cultural and spiritual significance for the inhabitants, influencing their conservation attitudes and practices. Community-based conservation efforts, such as ecotourism and sustainable resource management, enhance the effectiveness and sustainability of these initiatives. Effective governance policies, including the Wildlife Protection Act, Forest Conservation Act, and Integrated Coastal Zone Management (ICZM), are essential for managing human impact and preserving biodiversity, called Policy Frameworks.

Mangrove Friendly Ecological Governance Study in India

India covers 3% of South Asia's mangroves along the entire coastline. Under the Articles of 51A (g) and 48A, the Indian Constitution as well as the National Forest Policy (1988) directs the State and every citizen to protect and promote a clean environment. West Bengal Forest Department and the World Wildlife Fund (WWF) have jointly provided hygiene and food supplies around the islands to deal with the aftermath of COVID-19. WWF is working with communities at the grassroots level for a more climate-sustainable future, as well as for the islands' ecosystems. The central government and the state government of West Bengal have announced \$130 million and \$837,000 in aid, respectively, to protect and restore the Sundarbans (Mukherjee, 2021). Today, India is devoted to achieving sustainable progress through its determined policies such as the Clear India Mission, Smart City Mission, and the scheme to increase renewable energy production.

Table 2: India's Governance Policy about Mangrove Forest & Environment

| Perspective | Governance Policy |
|--|---|
| Conservation & Biodiversity Protection | Wildlife Protection Act of 1972: Provides legal agenda to defense of scarce groups. |
| | Forest Conservation Act, 1980: Regulates deforestation and promotes afforestation. |
| | Sundarban Biosphere Reserve Management Plan: Focuses on habitat preservation, species protection, and sustainable resource use. |
| | Biodiversity Act, 2002: Conserving genetic variety, ensuring sustainable utilize of its assets and ensuring fair and reasonable allocation of settlement. |
| Adjustment and alleviation regarding Climate transform | National Action Plan on Climate Change (NAPCC): which aims to increase forest/tree cover under National Mission for Green India |
| | State Action Plan on Climate Change (SAPCC): West Bengal's plan tailored to address local climate impacts, focusing on coastal area management and resilience building. |
| Sustainable Livelihoods | Integrated Coastal Zone Management (ICZM) Project: Enhances sustainable development practices along coastal areas, including livelihood diversification for local communities. |
| | MGNREGA: Provides job opportunities in rural communities, including those in the Sundarbans, with an emphasis on environmental conservation projects. |
| Risk Reduction about Disaster | Disaster Management Act, 2005: Set up natural hazard management systems to rescue and relief at central to local levels. |

| Perspective | Governance Policy |
|------------------------------|--|
| | National Cyclone Risk Mitigation Project (NCRMP): Aims to minimize vulnerability to cyclones through infrastructure development and community preparedness. |
| Rehabilitation and Migration | Coastal Zone Policy for stateless people, 2005 |
| | National Rehabilitation and Resettlement Policy of 2007 called NRRP |
| | Right to Fair recompense and clearness in Land acquirement and Resettlement Act in 2013 |

But this is especially true in rural areas, where people do not have as much access to information on sustainable livelihoods. Mangroves outside the notified forest area are considered wetlands and the 'National Conservation Strategy and Policy Statement on Environment and Development of 1992' identifies the importance and exclusivity of wetlands, and wetlands are being affected, recommending micro-level planning for resource development with management planning involving villages, from over exploitation, pollution and other serious losses due to natural causes (MoEF, 1992). The National Environment Policy in 2006 advocated Integrated Coastal Zone Management (ICZM) for sustainable management of coastlines to ensure coastal livelihoods and improve coastal economies in a cooperative and integrated manner to conserve the environment (MoEF, 2006).

The ST and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act 2006, commonly known as the Forest Rights Act (FRA), allotment of land to traditional communities in all forest areas, including core areas of national parks and sanctuaries, in recognition of historical injustice to India's forest dwellers, especially tribals (MoTA, 2006).

The Coastal Control Zone (CRZ) notification was issued by the Ministry of Environment and Forests in 1991 under the Environment Protection Act to protect coastal areas from overdevelopment and industrialization. The country's CRZ areas are defined as coastal extends of sea, backwaters, creeks, bay estuaries, and rivers, which are all affected by tides on marginal land. However, based on environmental sensitivity, geomorphic characteristics, and demographic distribution, CRZs are classified into four significant areas as (Chakraborty, 2011): i) CRZ-I – ecologically sensitive and affected by tidal up to 500 m from the HTL; ii) CRZ-II – Urban built-up area or densely developed area along the coast; iii) CRZ-III – Rural coastal residential units or coastal developed areas and iv) CRZ-IV – Islands, surrounded by water bodies and isolated from the mainland.

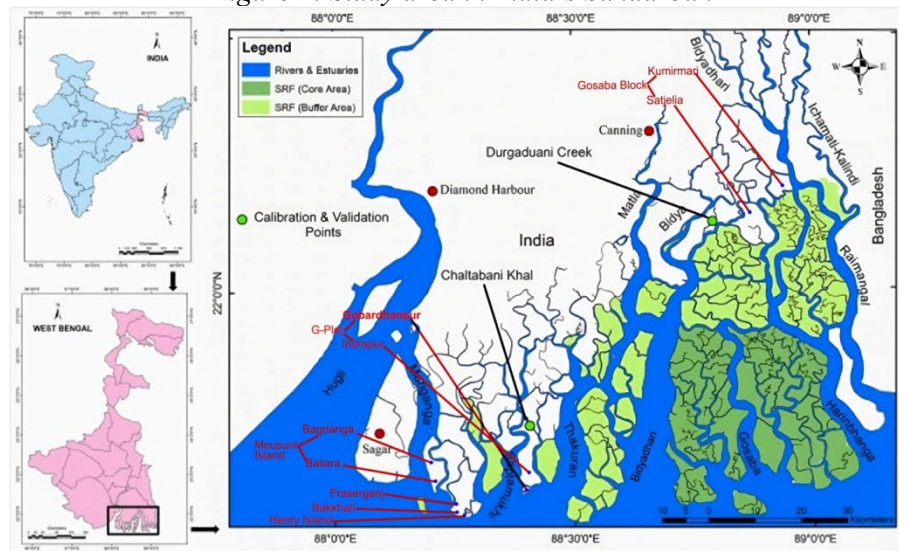
Table 3: Governance Structure for Indian Sundarban

| Governance | Institutional Body | Policy Stakeholder |
|-------------------|--------------------------------------|---|
| Global | International Bodies | <ul style="list-style-type: none"> • UNESCO • International Union for Conservation of Nature (IUCN) |
| National | Central Government | <ul style="list-style-type: none"> • Ministry of Environment, Forest and Climate Change • National Biodiversity Authority |
| Regional | State Government | <ul style="list-style-type: none"> • Department of Environment, Government of W.B. • Sundarban Affairs Department • West Bengal Biodiversity Board |
| Territorial | Local Bodies | <ul style="list-style-type: none"> • Gram Panchayats (village councils) • Local Forest Committees – JFMC, FPC • Irrigation Department |
| Endemic / Topical | Non Governmental Organization (NGOs) | <ul style="list-style-type: none"> • Various national and international NGOs working on conservation, climate adaptation, and community development. |

5. Study Area

The Indian Sundarbans has 102 delta islands, (42 virgin and 54 reclaimed and inhabited) (Dey, 2019) The state of West Bengal lies between 21° 32' - 22° 40'N and 88° 05' - 89° and 100 Located in North South 24 Parganas district (Chakrabarty, 2013) and borders land of India and South Asia. The estuary network of Sundarbans in the part of India consists of the seven most important estuaries. South and North 24 Parganas district comprises a region of the Indian state of West Bengal of 9,630 km² (including 4,992 km² of mangroves). The population of 19 community development blocks is the 2nd biggest and, for the most part, the most densely populated delta in the globe. It is delineated by the Bay of Bengal in the southern part and the 'Dampier Hodges Line' (boundary of the tidal river network and former mangrove forest, 1830) at the demarcation of the north, the Ichamati-Kalindi-Raimangal River to the east part besides of international border of Indo-Bangladesh and the Hooghly River to the west. This province experiences tropical monsoons and tropical storms with low-level floodplains extending up to six meters above sea level (Marcinko et al. 2021). As forest dwellers have strong ethnic feelings, those who belong to Scheduled Castes, Scheduled Tribes, OBC-B in Hindu caste and OBC-A and B in Muslim caste.

Figure 1: Study area in India's Sundarban



6. Data Analysis

Sundarban is a part of India located in the east of the country, its population is approximately 5 million people in 2021, the people who inhabit the Sundarbans come from one of four jatis – the Midnapuris, East Bengalis, Muslims, and Adivasis (Son of soil). Jati hierarchies are locally specific, with over 8.6 percent ethnic groups. This comprises chiefly four groups – the Munda, Santhal, Bhumij and Oraon tribes, each with its unique language, customs, and traditions (Roy, Mukherji, Mookerjee & et. al., 1990). Sundarban region serves as the country's economic and cultural hub.

The Indian part of the 40% of Sundarbans is renowned due to its prosperous biodiversity (Mondal, Bowers & Hossen, 2021). It is well-off in wildlife with 693 species including 210 white fish, 49 mammals, 59 reptiles, 260 bird species, 8 amphibians, 14 crabs, 24 shrimps, and 43 mollusk species (The Sundarban, 1997).

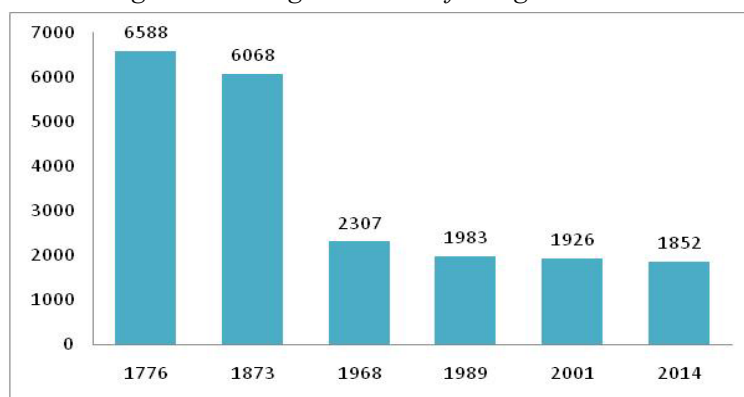
This study attempts to investigate the challenges of sustainable maintenance and supervision of mangrove resources to draw lessons for sustainable forest management. Finally, as this

study explores historical data on forest cover, and thus provides a rich source of information, document content analysis was applied to revise historical trends and patterns over time (Chisika & Yeom, 2023).

Table 4: Changes in mangrove extent and cover statistics over the last two and a half centuries

| Year of surveillance | Mangrove wooded area [km ²] | Area change in % | |
|----------------------|---|----------------------------------|------------|
| | | relating to previous observation | per decade |
| 1776 | 6588 | --- | --- |
| 1873 | 6068 | --- | --- |
| 1968 | 2307 | -62.0 | --- |
| 1989 | 1983 | -14.0 | -6.7 |
| 2001 | 1926 | -2.9 | -2.4 |
| 2014 | 1852 | -3.8 | -3.0 |

Figure 2: Change statistics of mangrove extent



Several cyclones in the latest long-ago such as Aila (2009), Falin (2013), Hudhud (2014), Bulbul (2019), Amphan (2020), Yash (2021), and Remal (2024) with heavy rains amid the COVID-19 pandemic have struck the Sundarban with cycles of immense destruction (Mondal, 2023). It caused massive devastation of life and property (land, home, belongings, etc.). People gathered in school buildings and cyclone shelters despite worries of COVID-19 infection. The Department of Agriculture in West Bengal has predicted that around 3 lakh farmers have suffered heavy losses across 66,362 hectares of the cultivation fields in Gosaba, Pathar Pratima, Basanti & Kultali (Amphan: First Situation Report from Sunderbans, 2020). About half a million youth migrate from the Sundarbans region every year for labor. Climate change forces create a vicious cycle of outward migration in a chronic fashion in the Sundarbans. Reports received show that 2.5 lakh to 3 lakh migrants have returned to their villages, comprising about 50% of families in the Sundarbans. Various reports show that almost every five families have at least one migrant member in the region. In addition, 50 to 250 people have returned to almost every village. Overpopulation has increased the threat of disease on the islands, loss of remittances to migrant families, increased pressure on natural resources (Table 5 & 6), and overtaxed the local labor market economy.

7. Findings

In this study first finding regarding sustainable development may be findings, of five goals, like 1st, 2nd, 8th, 10th, and 13th out of 17th which Sustainable development policy indicates

to touch for human beings. 1st goal guarantees ‘No poverty’. However, the lack of employment options and liquid money has forced the socio-economically marginalized section into the local population. The 2nd goal is for ‘Zero hunger’. Govt., The local NGOs, local clubs, etc. arrange relief funds, rationing only during times of natural disaster and emergencies. 8th aim was ‘Descent work and economic growth’. The beneficiaries among privileged sections get only a maximum of 100 days of daily labor in one economic year. In reality, they get 30 – 50 days. Political corruption and the maladministration process are the obstacles to accomplishing the said goal. The 10th objective is to ‘Reduce inequalities’. Self-help groups try to play sufficient roles for it. The 13th goal is ‘Climate action’. Beneficiaries try to capture tiger prawn seed, and various fishes (damaging to mangrove ecology). Mangrove forest is home to Royal Bengal Tiger and also crocodiles in waterways. This ultimately helps in conserving mangroves, the world's largest blue carbon sink.

The second finding regarding local governance and institutions is that the Panchayat system has been directed by people representatives, actually political representatives; most of them are illiterate, and even local NGOs are more corrupt. This is more proven by the distribution of relief funds to rescue of Amphan disaster.

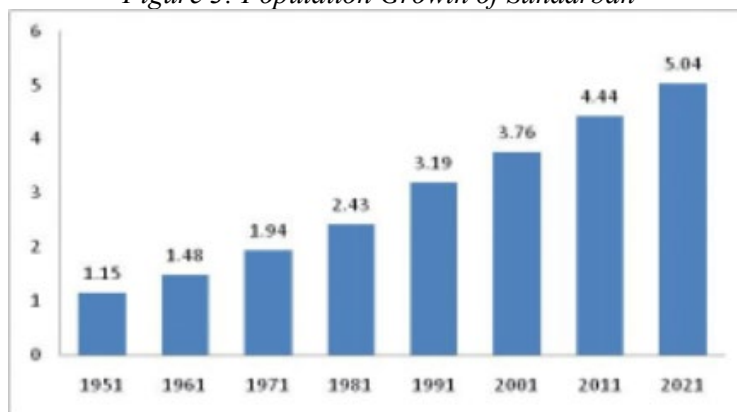
The third finding regarding the inverse relation in ecological engineering shows the disproportionate relationship between a growing population and the causes of sometimes decreasing mangrove families. Table 5 & 6 mention the conditions:

Table 5: Censes wise Inhabitant in Sundarban

| Year | 1951 | 1961- | 1971 | 1981 | 1991 | 2001 | 2011 |
|---------------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| Overall inhabitants | 11,59,559 | 15,32,102 | 20,03,097 | 24,55,365 | 31,54,704 | 37,57,356 | 44,26,259 |

Note: Sarkar, 2012 and District Census Handbook, Census of India, 1951 to 2011

Figure 3: Population Growth of Sundarban

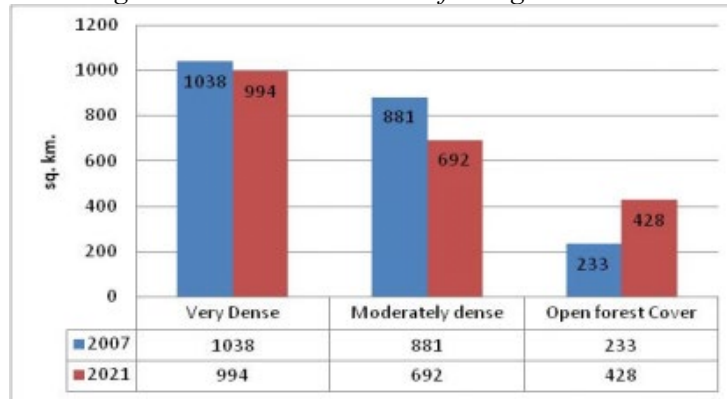


Note: The data is collected by different census and also Tampered by researcher about 2021

Table 6: Declining Dense Mangrove Cover in the Sundarbans (2007-2021)

| cover up category | region (sq. Mile) |
|--|--------------------------------------|
| Incredibly crowded (covering bulk >70%) | 400.77 sq. mile – 383.78 sq. mile |
| Reasonably crowded (70-40% covering thickness) | 340.15 sq. mile – 267.18 sq. mile |
| unlock tree-plant crowded | 89.96 sq. mile – 165.25 sq. mile |

Figure 4: Year wise Growth of Mangrove Forest



The fourth finding regarding anthropogenic pressure on forests enhanced the human-tiger conflict - A sudden increase in anthropogenic pressure witnessed a surge in the human-tiger conflict. Honey collection is risky. Regrettably, the said homecoming migrants do not have the required skills and endurance techniques in the profound jungle, perform similarly to neophyte fishermen or crab gatherers, and turn out to be simple prey for tiger attacks. Data on actual fatal accidents is challenging because official data only show forest permit deaths. Subsequently, Sundarban Tiger Reserve authorities prohibited collection works, which limited the human-tiger conflict but increased scarcity.

8. Result

The Indian Sundarban has about 211400 ha (816.22 sq. miles) of mangrove forests (Figure 4). These resources are found in 15 coastal areas out of 19 blocks. The densest mangrove cover is spread over 99400 hectares. It is followed by seven estuaries and sea islands, in descending order (shown in Map No. 1). It is important to note that Sagar Island, West Canning, and Basanti blocks now show the highest percentage of degraded mangrove area. Figure 2 shows the distribution of mangroves along the Sundarbans coast over decades.

Note that bee trees also like tiger nests because of the honey and easy prey (honey collectors). In that sense, these spots are the "honey-traps" of the Sundarbans. The poorest people entered the reserved forest without a license, so their deaths went unreported. According to media reports, the recent increase in tiger attacks and deaths supports this contention: deaths in 2016-6; 2017-11; 2018-13; 2019-13; and 2020-24 (18 deaths after Amphan), from April 2020 to February 2021-60 deaths; even more than 3000 women are Tiger-Widow till now. According to the Tiger-Widows Welfare Society, many attacks are not recorded, because they entered the forest illegally without a forest pass. Generally, about 4/5 tiger attacks occur every month and 35 people died from January 2021 to October 2021. (Chowdhury, Roy & Brahma, 2022).

We often notice that islanders, especially the youth, are largely educated, benefiting from various public and private institutions. They increase new skills and abilities to transition from forest-based livelihoods to urban-based livelihoods. As an effect, most young people work as day laborers in far-flung towns. Feminine migrate seasonally due to family economic pressure. Both are daily transitions from village to city and seasonal transitions are disrupted (Paul, 2021).

Gender inequality is a common phenomenon in the Sundarbans region of India (Roy & et. al., 2017). Women generally face many problems, including manual labor for food and livelihood; lack of control over income and assets; victims of violence and stress; low social

status; and weak subordinate social position; Presented in policy and decision-making. The workers are engaged on a daily labor basis and get Rs.200/-250/ per day, excluding lunch. The survey also revealed that they belong to backward communities, with about 83 percent of poor families belonging to SC, ST, and OBC.

9. Discussion

Mangroves are salt-tolerant plant ecology commonly originated in tropical and subtropical intertidal territories of the globe. Historically, global sustainable mangrove conservation strategies have sought to reduce hammering and spoiling from natural disasters, meet the permitting requirements of various jurisdictions, and maintain financially viable opportunities for mangrove restoration activities. Earlier than the arrival of colonialism, forest inhabitants were competent to live undisturbed and self-sufficient lives, giving and taking with nature. Colonial greed and neoliberal pillage have broken the pleasant attachment that forest society shares with the natural world. This force-feeding of technology has broken the symbiotic relationship between nature and indigenous people.

Another effect that led to non-targeted technological importation was the erosion of ethnic groups' conventional understanding. The ability of these communities to pass on from one cohort to the next begins in the direction of derailing. Thus, the neglected technological imports were devastating for the autonomous forest society, which at present become ecological refugees/ general poor. Human beings from such communities started moving to the city centers and living in the unorganized sector where they had no skills and lived in slums without any fundamental resources (Sarma, 2016).

9.1. Delimitation

1. An unstructured questionnaire method was followed in this study and data was collected with a random purposive sampling requirement.
2. The study did not face the entire region, so more research is needed into the prospect.
3. Here didn't use Geographic Information System (GIS) and remote sensing for this present study.

10. Conclusion and Recommendation

The UN Report, 2021 suggested that interactions with indigenous peoples, their lands, and resources should be managed through mechanisms that engage organizations in the decision-making process and make certain prior approval. This revisiting makes interest in deep Indigenous knowledge and expertise for exploring successful bottom-up paradigms of achieving the SDGs to benefit marginalized populations and also bridging the gap between UN-level policies and micro-local community guidelines (Magni, 2016); (Bansal, Sarker, Yadav & et.al., 2023). Ethno-tourism shows potential prospects due to its exclusive and varied substance in the current era of globalization. It is new and striking to investors, in that way behind and promoting concentration into the distinctive culture of the local inhabitants (Prevolšek, Maksimović, Puška & et. al., 2020). The massive impact of ethno-nationalist populism in the Sundarbans actively moves with religion and caste-based. But need an Indigenous and ethnobotanical environmental synchronization.

The Indian Sundarbans, a region of rich biodiversity and vulnerable populations, require appropriate, integrated approaches to improve governance and achieve sustainable development. In this case, recommendations can be made:

- Empowering local panchayats (gram Sansad) with greater decision-making authority can help address the unique environmental and social challenges of the Sundarbans. Capacity-building programs for local people, disaster management, and the use of sustainable alternatives should be prioritized. Governance frameworks should incorporate local knowledge, ensuring that women and indigenous peoples are given citizenship as frontline community members.
- An integrated approach involving multiple sectors—fisheries, agriculture, tourism, and forestry called permaculture—is essential for managing the Sundarbans' fragile coastal ecosystem. ICZM enables various stakeholders to be actively involved in biodiversity conservation, aligning linkages with conservation development monitoring.
- Given the region's vulnerability to climate-induced hazards such as cyclones and rising sea levels, disaster preparedness must be incorporated into governance. Early warning systems, climate-resilient infrastructure (rocks, cyclone shelters, living dams), and sustainability can proactively improve permanent resilience. For recruitment and licensing among local governments, NOs, and international organizations.
- Promoting alternative livelihoods such as eco-tourism, aquaculture, and mangrove-based enterprises can reduce pressure on fragile ecosystems while creating economic opportunities. These green business programs should be initiated, managed, and supported to improve environmental health as well as local economic conditions.
- Encouraging community-led conservation projects such as mangrove reforestation can build local stewardship of natural resources. Payment of Ecosystem Authorities (PES) and community-based wildlife protection organizations should be supported by the government to undertake ecological restoration efforts and implement nature.
- Horizontal interlocking is required among the 19 blocks of Sundarbans under an umbrella model of development led by common slogans: United Sundarbans, Sundarbans Regionalism, Tragedy of Common –Demands of common, Integrated Sundarbans, Common Leaders of Sundarbans, Populist leaders of Sundarbans, etc.

This combination of strong governance, environmental management, and sustainable livelihoods can promote the long-term resilience and development of the Sundarbans.

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