

Study of Social-Ecological Systems and Climate-Related Disasters in the Indian Sundarbans

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ABSTRACT

The interactions or connections between an area's social system and ecological system are referred to as the "socio-ecological system" (SES). The Indian Sundarbans, which can be viewed as an integrated SES, are home to more than 5 million people and are rich in wildlife. The current study examines the aforementioned SES at the microlevel. In order to perform a primary survey using an appropriate questionnaire, four villages from two blocks of the Indian Sundarbans—Madhya Gurguria, Debipur, Satjelia, and Rangabelia—were chosen. The study's findings indicate that the region is heavily dependent on its cattle, fishing, and agricultural resources. In the village economy, relying on numerous resources to generate revenue is the norm. However, this in turn is putting further strain on the already limited resource base. In order to analyse resource usage and flow at the microlevel in the Indian Sundarbans, the article does so. In order to secure the sustainability of both resources and the way of life of those who live in the SES of the Indian Sundarbans, the present study makes the case for the need of a strong framework that supports the inclusive and participatory participation of all stakeholders in resource management.

Keywords: disasters, region, social-ecological system, climate, natural resources

I. INTRODUCTION

While social sciences include the study of society and the economy as well as how to derive economic benefits even from natural resources, natural sciences, with their sole focus on natural phenomena, have been trying to understand ways of protecting nature. In earlier centuries, the line separating the natural and social sciences was distinct and clear. Ecology, the economy, and society do not, however, function independently because they are all a part of the same ecosystem. The 1970s saw the beginning of attempts to combine natural sciences and social sciences as new fields like ecological economics, political ecology, traditional ecological knowledge, etc. emerged. Humans live in a connected world where both the biological and cultural spheres are equally dominant. As a result, the idea of social-ecological systems (SES) aims to incorporate both the natural and social systems that people live in. One of the two systems will unavoidably be impacted by change in the other. For instance, any changes to the natural environment will have an impact on the livelihood of those whose livelihood depends on natural resources. On the other hand, the natural ecosystem will change as a result of resource depletion and pollution. As a result, SES tries to analyse how ecology and society are two systems that are interdependent. In other words, SES is an analytical framework with an anthropocentric viewpoint that integrates the two-way interactions between social and ecological systems (Bots et al 2015). The current study attempts to concentrate on the interactions between natural resources and the people who depend on them in the unique social-ecological system of the Indian Sundarbans. The Indian Sundarbans are located in India's eastern region. More than 5 million people live there, supporting their way of life through agriculture, forestry, riverine and marine resources, and tourism. It is a significant coastal ecosystem. With the aid of primary data, this study attempts to evaluate how well this complex SES is operating. Following focus groups and a standardised questionnaire that was approved by witnesses, primary data from the two Indian Sundarbans blocks, Kultali and Gosaba, were gathered (out of 19 blocks which consist of Indian Sundarbans).

II. REVIEW OF LITERATURE

The term "social-ecological system" (SES) first appeared in the late 20th century. In the 1980s, two scholars, F. Berkes and C. Folke, played a significant role in popularising the term. Researchers have attempted to define SES as a holistic framework that views the ecological and social systems as components of a larger system and places a strong emphasis on the interactions between the two subsystems ever since the concept was first proposed. According to Berrouet et al. (2018), some

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authors have attempted to explain the natural system and social system as separate parts, while others have attempted to explain SES as a whole system (Anderies et al., 2004; Ostrom, 2009). In Bots et al. (2015), one of the crucial definitions is offered. They claim that SES is an integrative framework with an anthropocentric viewpoint and an analysis-oriented approach that takes into account the interactions between social and ecological systems on a two-way basis. SES is defined as an "integrated system of ecosystems and human society with reciprocal feedback and interdependence" by Folke et al. in 2010. Although it is argued that there isn't a precise, all-encompassing definition, the subject's range appears to be growing over time.

Other ideas connected to ecosystems or ecology have also been incorporated into the SES study because the SES framework allows for the analysis of the system as a whole. For instance, the study of SES has a complex relationship with the concepts of resilience, adaptive capacity, robustness, vulnerability, etc. The interdisciplinary nature of the SES notion has resulted in the term's use in relation to a variety of subjects. For example, the concepts of resilience and SES are inextricably linked. The idea of "resilience," which is taken from natural science and applied to social science, attempts to measure a SES's capacity to maintain stability while utilising shifting and adapting strategies (Folke et al., 2010; Cote and Nightingale, 2012; Xu and Marinova, 2013).

Resilience is thought to include adaptive capacity, which is the capability to adapt to disruptions (Folke et al. 2010). Institutions are crucial to adaptive capacity or adaptation because they offer assistance (Cote and Nightingale, 2012; Berkes et al., 2000; Seixas and Berkes, 2003). SES is, however, most frequently employed to frame resource use or management. All resources used by humans are a part of intricate social-ecological systems (SESs) (Ostrom, 2009). In this context, Holling's ideas of resilience and the "adaptive cycle" are crucial. It contains four stages of resource management, such as exploitation, conservation, release, and reorganisation, which function cyclically as opposed to linearly as resource use progresses (Holling and Gunderson, 2002). Co-management or community management has been studied as a resource management method in a specific SES. (Seixas and Berkes, 2003; Anderies et al., 2004). According to this study, strong institutions, monitoring processes and rule enforcement, cross-scale communication, equity, collective decision-making, and the use of ecological knowledge as inputs for resource management are key contributors to strengthening SES. On the other hand, Berrouet et al. (2018) contend that interdisciplinary study is required to fully understand how globalisation affects SES operations. The way that communities interpret the world has an impact on how they manage their resources (Cote and Nightingale, 2012). Therefore, one of the key tools for social-ecological adaptation should be the application of local ecological knowledge or traditional ecological knowledge. The aforementioned ideas and how they relate to SES suggest that the system itself is unstable and subject to change (either internal or external). Therefore, while examining a SES, it is important to keep in mind how fragile or vulnerable it is. The current research treats the Indian Sundarbans as a larger SES, which includes a number of subsystems, including resource units, resource consumers, the governance system, and other things. Despite the fact that the Indian Sundarbans have been the subject of numerous studies (Sarkar and Padaria, 2011; Das and Tripathi, 2012; Mukhopadhyay and Roy, 2015), each of these studies attempted to focus on a different ecosystem, such as agriculture, aquaculture, fishing, or the natural vegetation, as a separate industry. Therefore, the current research attempts to analyse the operation of a SES at the village level, or the micro-level. The primary goal of the essay is to examine the composition and operation of a socio-ecological system.

III. METHODOLOGY

To get reliable primary data from the study area, a household survey was carried out. The household has been used as a unit of analysis as a result. A total of 200 samples (N = 200) were collected by selecting 50 homes from each hamlet. It was preferred that respondents be drawn from the heads of households. When the home head was not present, adult household members were chosen. To accomplish the research goal, structured questionnaire schedules, participant observation, and interviews with locals and subject matter experts were used as instruments and approaches. The primary data were analysed using descriptive statistics. A comparative analysis approach was used to determine whether there were any discrepancies between the socio-economic structures of two blocks, Kultali and Gosaba. In order to provide a comprehensive explanation of how the SES operates as a system, two blocks were combined.

IV. FRAMEWORK FOR SOCIAL-ECOLOGICAL SYSTEM (SES)

The SES has been described by some scholars as an integrated system of ecosystems and human society with reciprocal feedback and interdependence made up of numerous subsystems and internal factors (Folke et al., 2010; Ostrom, 2009). In other words, SES attempts to explain the reciprocity or interdependence between nature and society, with humanity as the primary focus. Numerous scholars have examined the resource management system using the SES idea (Berkes et al., 2000; Berkes et al., 2003; Ostrom, 2009). They made an effort to differentiate between the westernised concept of resource management, i.e., conservation, and the local resource management system, saying the latter is more sustainable and thus

should be preferred. A lack of thorough analytical frameworks for comprehending or analysing the SES framework was discovered by Colding and Barthel (2019) after reviewing 20 years' worth of research articles on social-ecological systems. There are, however, a few frameworks that have been employed to comprehend the concept of SES, including Ostrom's general framework for analysing the sustainability of SES and Holling's concept of the "adaptive cycle," which includes four stages: exploitation, conservation, release, and reorganisation (Holling and Gunderson, 2002). (Ostrom, 2009). Ostrom's concept of SES is being used in this paper since it attempts to analyse the composition and operation of the local social-ecological system.

Ostrom (2009) asserts that a larger and more complex SES is made up of numerous internal variables and subsystems. Her concept of SES describes the relationships between resource management that change over time and space. Resource Systems (RS), Resource Units (RU), Governance Systems (GS), and Users (U) are the first level's four fundamental systems (U).

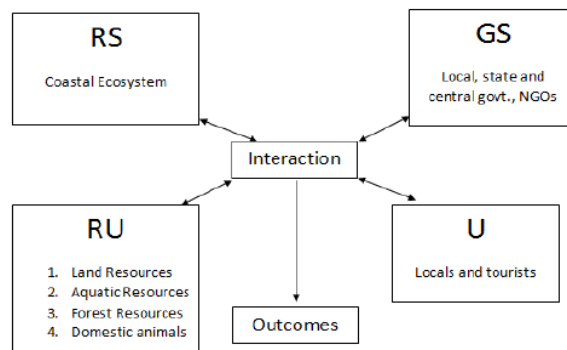


Figure 1: Framework for Social-Ecological Systems (SESs)

The greater coastal ecology of the Sundarbans is referred to in the present study as the resource system (RS). Around 10,000 square kilometres make up the Sundarbans, which are part of the Ganges-Brahmaputra-Meghna Delta. The Indian portion of the Sundarbans only makes up about 40% of the overall area. With a total area of approximately 9600 square kilometres, 4230 of which are designated as conserved forest, the Indian Sundarbans are located between the geocoordinates of 21032' to 22040' N and 88005' to 89000' E. The Sundarbans Biosphere Reserve, which includes one national park and three animal sanctuaries, includes the forest area. As a Ramsar site, the area is also acknowledged as a wetland of significant international significance. The current study considers the Indian portion of the Indian Sundarbans as the larger resource system (RS).

Resource units, in Ostrom's view, are the smaller parts of the larger resource system component. We investigated the resource units used by the villagers and which are part of the village ecology within the larger resource system (RS). The study's resource units (RU) can be broadly split into four categories: (1) Land resources (agricultural land, pastoral land, and common fields); (2) Aquatic resources (river and pond) (fish, crabs, shrimp, and shellfish); and (3) Other resources. (3) Wood, honey, leaves, and medicinal plants are available from the forest (mangroves). (4) Livestock, including goats, sheep, hens, and cows The state's policies, bureaucrats, local government employees, and other non-governmental organisations that actively or inactively participate in resource management in the area in question are all included in the governance system. When individuals handle resource management on their own, they become part of the governance system (GS). Locals, visitors, and anyone else who uses the resources are all considered users (U).

V. CLIMATE AND STUDY REGION

The current study tries to comprehend how the Indian Sundarbans' village-level social-ecological system functions. Kultali and Gosaba, in the South 24 Parganas district, were specifically chosen from the literature review as the two blocks to be used to accomplish this purpose (DasGupta and Shaw, 2015). Purposive sampling was used to choose four additional villages: Madhya Gurguria, Debipur, Rangabelia, and Satjelia (based on their accessibility). Between December 2018 and February 2019, the researcher conducted many fieldwork visits. After stepping foot in the field, she investigated the village's perimeter, created a social map, and then proceeded with a geographical cluster sample.



Source: <https://www.wti.org.in/projects/protecting-tigers-people-and-their-vital-habitats-in-the-sundarban-delta-of-india-and-bangladesh/>

With an average annual rainfall of between 1750 and 1770 mm and temperatures ranging from 36.30 °C (the highest) to 13.60 °C (the lowest), the study region has a hot and humid environment all year long. The hottest month is May, while the coldest is January. Given that the region is located close to the Bay of Bengal's shores, relative humidity is consistently high.

VI. FINDINGS AND DISCUSSION

Religious affiliation, gender, caste, and landholding structure are all fundamental socio-demographic factors. We can better grasp the social-ecological system's structure thanks to these socio-demographic traits. When it came to categorising the households by religion, it was discovered that greater than (or equal to) 87 percent of the households in both blocks fell into the Hindu category. Only 4% of the families polled identified as Muslims, and 13% of the households, largely tribal, did not identify as Muslims (although they mostly practise Hindu rituals). In the homes of those who practised other religions, there was a definite division. When it comes to social status, general had the largest overall proportion (47.5%), followed by SC (29.5%), OBC (17%), and ST (6%). In Gosaba block, which made up 39% of the sample as a whole, the percentage of SC families was substantially greater. Only in the Kultali block did the ST category (Mundas) appear. When it comes to income, we can observe that more households in the Gosaba block (55%) fall into the BPL (below poverty line) category, compared to fewer than half of the households in the Kultali block. However, the classification of APL and BPL was not always precise. Many people qualified for the BPL category but were labelled as APL categories in the official survey, it was discovered. The average monthly household income in both blocks was almost the same, despite the fact that monthly incomes could range from Rs 3,000 (for a tiny fisherman) to Rs 40,000 (for a larger landowner).

Table 1: Socio-demographic features of the study area

Block Name		Kultali	Gosaba
Median age of respondents (in years)		42	41
Respondent	Male %	34	36
	Female %	66	64
Religion	Hindu %	87	96
	Muslim %	0	4
	Other %	13	0
Caste	General (%)	54	41
	OBC (%)	14	20
	SC (%)	20	39
	ST (%)	12	0
Average household size		5.47	4.77
Head of the household	Male (%)	85	86
	Female (%)	15	14
Proportion of literate household heads		58	70

Highest level of education	Post-Graduation and above (%)	10	3
	Graduation (%)	10	10
	Higher Secondary (%)	18	12
	Secondary (%)	38	29
	Upper Primary (%)	20	30
	Primary (%)	4	16
Income category	BPL (%)	42	55
	APL (%)	58	45
Average land holding	Agricultural (bigha)*	4.18	3.57
	Non-agricultural (bigha)*	0.275	0.57
Mean monthly income		10228.5	12062.5

The households' modal values (average sizes) were 5.47 and 4.77, respectively. The smallest number of members in a household, which corresponds to a nuclear family, is 2, while the largest number, which corresponds to a joint family, is 11. While a joint family consists of grandparents living with their son, daughter-in-law, and grandchildren, a typical nuclear family consists of a husband, wife, and their children. Even when the extended family lived in the same courtyard, it was generally found that people preferred to be seen as belonging to a nuclear family rather than a joint family. This trend might be brought on by the implementation of government welfare programmes that distribute funds or ration goods based on families rather than individuals. For instance, 16 kg of rice and a one-time payment of Rs. 10,000 each were distributed to the families affected by Cyclone Aila. It should be noted that a prior study (Jalais, 2014) contends that nuclear families are typical in the research area. In both instances, the average agricultural landholding was a little bit larger than one acre.

The highest educational level attained by any household member was taken into account when analysing the sample population's level of education. In most cases, higher secondary education (18% and 12%) was the next highest level of education, followed by secondary and upper primary education (58 and 59 percent combined). Only 26% of Gosaba's households had children who could attend primary school, and very few of those households had graduates or post-graduates. Resilience and the ability to make decisions depend on a household's highest level of education attained as well as the literacy of the household head. It was found that in every village, the female family members—daughter or daughter-in-law—were more likely to have the highest level of education. In general, girls were more likely than boys to complete their education. Boys are more likely to drop out of school in the area as a result. The household heads were found to be literate in between 58 and 70% of the situations when it came to this issue.

VII. CONCLUSION

The topography of the Indian Sundarbans naturally links nature and society. According to the average for the country, the districts of North and South 24 Parganas in West Bengal, which make up the Indian portion of the Sundarbans, are very populous. People are still moving in from the surrounding areas, which began during the British era. Resources are under more stress due to the anticipated population growth (Bhadra et al. which is also expected to increase. However, the stakeholders with a stake in the area are in a pickle because of the growing population pressure, the restricted access to resources, and the need for development.

According to the current study, the Sundarbans SES has a high level of reliance on water and land resources. Agriculture and fishing are the main economic activities. Second, people choose different revenue streams, which promote the use of numerous resource units. The most chosen alternative source of income is animal husbandry. Gosaba has a wider variety of livelihoods than Kultali. But because of poverty, danger, and instability, people look for diverse sources of income. Additionally, more households in the BPL category were found in the Gosaba block. Even though it was clear from the researcher's observations that women put in a lot of physical effort in various economic activities that went unreported, their participation in economic activities was minimal, and they were also paid less for their job. The older population of the area claims that as time goes on, fish stocks are also being depleted and that the productivity of the land is declining when it comes to changes in resource use patterns. This suggests that the demand for land and resources is rising. As a result, many young people are leaving the area to work as unskilled labourers in other regions of the nation. It is necessary to evaluate the available resource units in the area in order to prevent such a disaster. Additionally, we need to figure out how to use these resources responsibly speaking up.

When discussing the expanding tourism industry and development projects in the Indian Sundarbans, Dr. Pranabes Sanyal, the previous director of the Sundarbans Tiger Reserve, said, "Development can take place as long as it is within sustainable bounds and does not surpass the carrying capacity." Other areas of development are also covered by this idea. The viewpoint of other stakeholders, such as local residents, is crucial in the discussion surrounding resource management and

development. Ostrom (2009) contends that when a population is aware of its resources, it will voluntarily participate in a system of resource management that will be long-term sustainable. According to field respondents, the locals (Kultali and Gosaba) actively take part in repairing the embankment, reforestation efforts, and demonstrations against illegal tree cutting. It might be interpreted as a sign that they are aware of the need for local participation in the management of the resources in the place they call home.

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