RESEARCH ARTICLE

Study on Development of Sustainable Livelihood Framework Approach at Indian Part of Sundarbans by Geospatial and Geo-statistical Analysis

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Abstract

Reclamation for settlement was started in 1770 at Sundarbans and the present population in the Indian part, is around 5.0 million, and gradually increasing, but continuous mangrove degradation made Sundarbans vulnerable. The Livelihood Structures for Sundarbans' residents and amenities are largely dependent upon the Sundarbans' resources, but these livelihood opportunities became vulnerable and face threats from several natural processes and anthropogenic activities. The present study attempted to understand the several dimensions of livelihood strategies for the inhabitants of several occupational groups at Sundarbans; associated opportunities, as well as constraints through the Sustainable Livelihood Framework (SLF) approach (after DFID, 2000) that envisages and comprises the livelihood assets, activities, important vulnerable issues that affect livelihood structures with the complex interactions amongst them. The objective of the present study is to establish a sustainable livelihood through the analysis of five important capitals of the SLF approach for the people of Indian Sundarbans considering the possible vulnerabilities. The same study has been carried out based on the extensive literature review, household livelihood surveys; informant interviews, and Shared Learning Dialogue (SLD) using the participatory approach by selected livelihood groups through several quantitative and qualitative indicators. The study concluded with the recommendation of Mangrove regeneration at Sundarbans.

Keywords: Geospatial & Geo-statistical Analysis; Sustainable Livelihood Framework; Indigenous Knowledge; Community Participation; Sustainable Development; Mangrove regeneration

Introduction

Day et al., (2012) refer that mangroves being the 'Tidal forest' colonize the intertidal zone of tropical and sub-tropical coastal areas that are also said to be True mangroves if they reach five certain and unique characteristics and with these features, they can be called as true mangroves as they are loyal to the estuarine ecology of the intertidal environment, cannot sustain themselves in the terrestrial environment, have taxonomic differentiation from the other terrestrial biota, morphological uniqueness adapted in the intertidal environment like vivipary of the embryo and aerial roots etc, physiological adaptations like salt exclusion, salt accommodation, and salt secretion, community-based composition.

There are several associated synonyms related to Mangrove that is defined as the specific tree, whereas Mangrove wetland is defined as the whole community assemblages of mangroves in the intertidal environment. Mangal is also associated with these that is defined as a swampy ecosystem whereas, Mangrove-dominated estuaries are defined where primary and secondary producers are from tropical estuaries, bays, and lagoons and mangroves are from the intertidal zone. Hutchings & Saenger (1987) defined Mangroves in two different ways either mangroves are the individual species of plant or forests of different species. Mangroves of different

meanings only have the commonality of their morphological, physiological, phylogenetic, and reproductive adaptations amidst the unstable, marshy environment, and extreme saline conditions-based environment. As per Saenger et al., (1983) fifty-nine mangrove plants of the worldwide accepted mangrove species are exclusive and twenty-two are non-exclusive species.

The economic valuation of mangroves has been classified into three groups direct use value, indirect use-value, and nonuse value. Direct use value comprises direct consumptive and non-consumptive services provided by the mangroves for the sake of the inhabitants e.g. revenues earned from fuel-wood, fodder, timber wood, fishery, honey, wax, etc. whereas, indirect use value comprises indirect interaction between people and mangroves like flood control, storm barrier, coastal erosion protection. Non-use-value is referred to as bequest or legacy-based values of mangroves. Mitra (2019) asserted that researchers mostly emphasized four ecosystem services provided by mangroves like nursery services by mangroves, provisional services by mangroves for the dwellers and people of coastal regions, shoreline stabilization, and coastal erosion protection and carbon sequestration and carbon storage pool over the past decades. But recently, signs of progress are on the way for prospecting of the importance of mangrove-based microbes, mangrove actinomycetes.

Literature Review

Sustainable Livelihood Framework (SLF) approach

The sustainable Livelihood Framework (SLF) approach was first coined and defined by Chambers & Conway in 1992. The definition is as follows:
" a livelihood comprises the capabilities, assets (stores, resources, claims, and access) and activities required for a means of living a livelihood are sustainable which can cope with and recover from stress and shocks, maintain or enhance its capabilities and assets and provides sustainable livelihood opportunities for the current and next generation and which contributes net benefits to other livelihoods at the local and global levels and in the short and long term" (Chambers & Conway, 1992).
This approach is nothing but the framework of people's capacity of surviving the possible stresses and shocks. The livelihood structure of a particular community can be sustainable if the community can cope with, recover and

adapt to the possible environmental stresses and shocks, maintaining its capabilities, and increasing opportunities for future generations. Apparently, a Sustainable livelihood system analyses the coping and adaptive strategies driven by certain communities and individuals against several external shocks and stresses e.g. cyclones, floods and policy failures. Coping strategies and adaptive strategies are two distinctive indicators of the above-mentioned system where coping strategies are defined as the short term response system against the environmental stresses e.g. cyclones, floods whereas, Adaptive strategies are the long term based behavioral changes in communities against the possible shocks and stresses and it is also connected with the capacity building of the same. According to Kollmair & Gamper (2002); Banerjee et al., (2023), "….The framework depicts stakeholders as operating in a context of vulnerability, within which they have access to certain assets. Assets gain weight and value through the prevailing social, institutional and organizational environment (policies, institutions, and processes). This context decisively shapes the livelihood strategies that are open to people in pursuit of their self-defined beneficial livelihood outcomes."

Elements of the SLF Approach

There are several elements associated with this approach which are as follows:

Vulnerability context

Vulnerability context is associated with the external framework where certain communities and individuals exist with the potentialities of shocks and environmental stresses e.g. cyclones, floods and policy failures, and seasonality. This context arises when people face the possible harmful threats with inadequate capacity to respond against them and recover from them. In the contextualization of this element, both Vulnerability and Risk are distinguished in such a manner e.g. risk is defined as the potential severity against the likelihood of occurrence of possible threats and shocks whereas, vulnerability is defined as the scale of risk exposure to the external stresses and the capacity of individuals or communities to prevent, mitigate and adapt (DFID, 2000).

For the vulnerability assessment, this framework considered the 'Shocks', 'Trends', and 'Seasonality' to which the community or households were exposed.
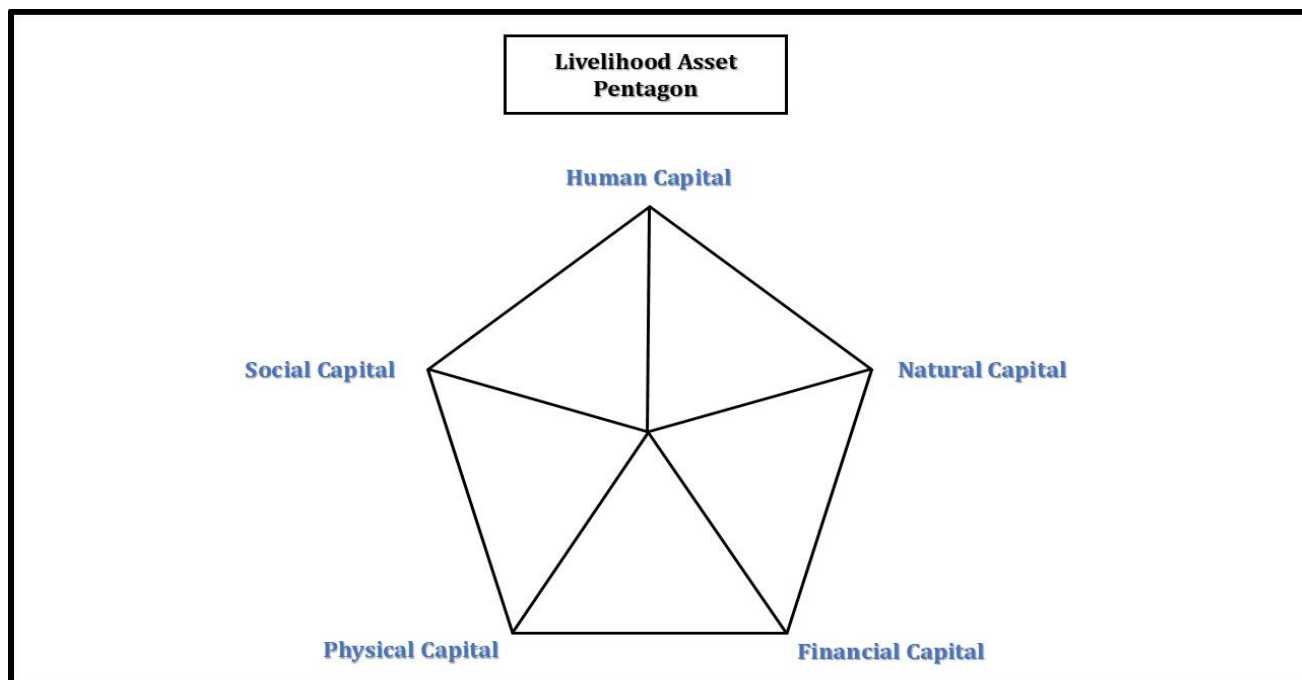
Livelihood assets

SLF approach identifies five types of capitals or assets on which livelihoods are built; Natural Capital, Financial capital, Physical Capital, Social capital, and Human capital. These assets form the pentagon of SLF that is the core of this approach lined with the vulnerability context, policies, institutions, processes, and livelihood outcomes. Human Capital includes human assets related to literacy ratio, skill, dependency ratio, and health and wellbeing of communities (Elasha et al., 2005). Natural Capital elaborates on water, forest, soil, topography, quantity, quality of land, and other environmental resources (Elasha et al., 2005; Scoones, 1998; Serrat & Serrat, 2017). Financial Capital includes gross household income, savings, and other forms of liquidity e.g. remittances.

(Elasha et al., 2005; Scoones, 1998; Yaro, 2004).Irrigation facilities, roads, agricultural assets, transportation equipment, electricity, and others are the Physical Assets or Capital (Scoones, 1998). The fifth capital of the pentagon is, Social Capital is contributed through the benefits of social networking, social relationship, connectivity, trust, reciprocity, membership in political and community-based organizations, professional organizations, other entrepreneur bodies,etc.(Scoones, 1998).
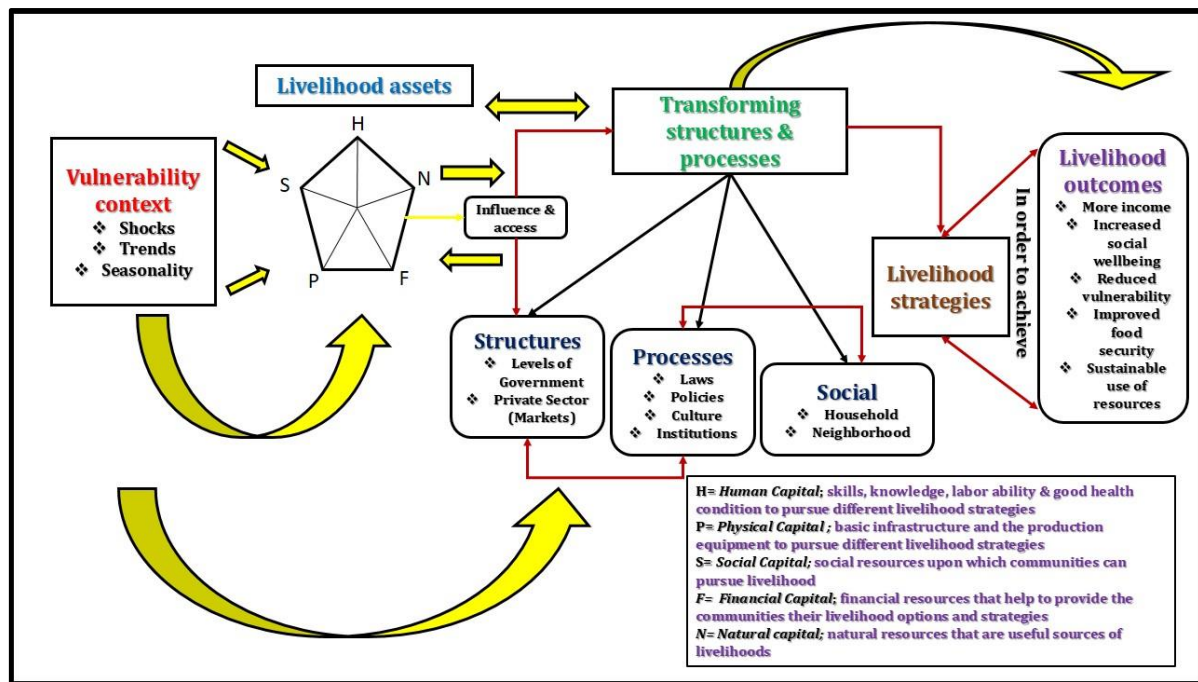
Figure 1.1: Sustainable Livelihood Framework Approach (SLF) (Source: Carney et al., 1999; modified after the author)

Figure 1.2: Livelihood Asset Pentagon (Source: Jana, 2019; modified after the author)

Policies, Institutions

As per DFID, (2000), policies, institutions and their associated processes are not overemphasized as they are connected and operate at top-down level, from the international level to the household level, from the public level to private level. Genuinely, they can lead to access the various types of capitals, livelihood strategies, decision making bodies for the development of possible framework of SLF, leading the pathways for the better livelihood strategies irrespective of several vulnerabilities, risks and decision-making strategies. These sectors can access and influence the decision making processes.

Livelihood Strategies and outcomes

As per DFID, (2000); De & Das, (2021), livelihood strategies are combination of several activities and choices that people may consider for achieving their livelihood goals and options. Being the dynamic process, it is directly dependent upon the livelihood structures, policies, institutions and processes. Each and every household can achieve their individual perspectives of

livelihood strategies and outcomes. Livelihood outcomes are nothing but the outputs of proposed livelihood structures or framework e.g. increased wellbeing, reduction in vulnerability, induction in income generation, overall sustainable development, and strong food security. Livelihood strategies and outcomes are correlated with each other in terms of the process-response relationship in the system of Sustainable livelihood framework approach.

Background on Indian Sundarbans

Lear and Turner (1977) suggested that Mangroves are referred to as outlook the 'coastal ecosystem in a holistic manner, including its common habitat or inhabitant fauna'. According to the Department of Sundarbans Affairs, Govt. of West Bengal, being the part of the Man and Biosphere Programme (MAB), as per the general conference of UNESCO in 1970, the Ministry of Environment and Forests, Govt. of India adopted the MAB program and declared the entire 9630km^2 area of Sundarbans as the Sundarbans Biosphere Reserve in 1989 for coordinating and integrating diversified activities of conservation, preservation, research, and training programs for creating a great synchronization between

nature and human. Sundarbans has also declared a World Heritage Site in 1989 for its own uniqueness. Being the largest delta in the world, it consists of approximately 10,000 km^2 area under mangrove forest out of which 4200 km^{2}of reserved forest in the Indian part and 6000 km^{2}approxofreserved forest in Bangladesh. Another 5400 km^2 of the inhabited region, the non-forest area of India is also known as the Sundarbans region of India along the north and northwestern fringe of mangrove forest. As per the 2004 census, Indian Sundarbans have 274 tigers, out of which Sundarban Tiger Reserve and South 24 Parganas Forest Division have 249 and 25 tigers respectively. 58

species of mammals, 55 species of reptiles, and around 248 species of birds have also blessed the children of Sundarbans.

Indian Sundarbans is not considered the properly designated district of West Bengal but it is located in two districts namely, South 24 Parganas and North 24 Parganas. A total of 13 blocks of South 24 Parganas are under the Indian Sundarbans &6 blocks of North 24 Parganas are under the same (Table 1.1).

Table 1.1: Geo-Ecological units of Indian Sundarbans with associated blocks; (Source: Banerjee, 1998; District Census Handbook, 2011; compiled & modified after the author)

BLOCKS	DISTRICT	NATURE OF DELTA
Haroa		
Hasnabad		
Sandeshkhali I		Active Delta: eastern Sundarbans
Sandeshkhali Ii	NORTH 24 PARGANAS	
Minakhan		
Hingalganj		
Jaynagar I		Stable Delta: Eastern Middle Mature Delta of Hugli
Jaynagar II		
Kultali		Active Delta: Eastern Sundarbans
Canning I		Stable Delta: Piyali-Bidyadhari Plains in the east
Canning II	SOUTH 24 PARGANAS	
Basanti		Active Delta: Eastern Sundarbans
Gosaba		
Mathurapur I		Active Delta: Middle Sundarbans
Mathurapur II		
Kakdwip		Active Delta: Western Sundarbans
Namkhana	SOUTH 24 PARGANAS	
Sagar Island		
Patharpratima		Active Delta: Middle Sundarbans

Four geographic units are considered for the development of Indian Sundarbans which are follows; Deltaic plain**,** Levees**,** Marshes **&** Islands**.** Geographically, Indian Sundarbans is situated at the lower Ganga plain over the composite Ganga delta sedimented by quaternary deposits from the Ganga and its tributaries.
Soilscape of Indian Sundarbans is divided into five groups as per the soil texture, structure, and moisture: a) clay, b) heavy, c) sandy soil, d) sandy loam and e) silt. Banerjee

(1998) mentioned that the soil types of the active delta can be differentiated as the a) Sandy clays and loams with sand dunes that are mainly situated in the western estuarine parts, b) organic and peaty deposits noticeable in the central parts and c) Swampy and marshy soils occurring mainly in littoral parts also referred as mangrove soil. Soil salinity is determined by the influence of the freshwater availability from the upper catchments of Ganga and its tributaries and distributaries and tidal

water intrusions by the several tidal creeks and channels from the southern part. As per the soil salinity distribution, Indian Sundarbans are divided into two soil saline zones e.g. northern part of Sundarbans (salinity up to 8ppt), and the southern part of Sundarbans (salinity 8ppt-20ppt). As per salinity, soilscape can be designated as four types e.g. a) Saline soil having three phases e.g. inundated phase, phase rich in calcite, and phase rich in dolomite. b) Saline Alkali soil having three phases e.g. rainwater washed phase, seawater washed phase, and active delta forming phase. c) Non Saline Alkali soil & d) Degraded Saline Alkali soil/ Saline Turf soil having also three phases e.g. inundated forest phase, cultivated area phase (above sea level) and cultivated area phase (below sea level).

Riverscape of the Indian Sundarbans part is designed by the Hooghly River with their several distributaries with their changing courses, meeting the Bay of Bengal that is one of the characteristic features of Sundarbans. Here, distributaries generally branch off from the main channel with anastomosing in nature again reentering into the main channel or merging with another distributary that's why the same river channel inherits specific names as per their geographical locations. Principal rivers of the area are Hugli, Piyali and Bidyadhari,Muri Ganga, Saptamukhi, Thakuran, Matla, Gosaba, Raimangal and Harinbhanga. Khals are also the distinctive geomorphic features as the depressions filled with the tidal water intrusion.

Climatescape of the Indian Sundarbans is structured by the several climatic parameters e.g. nature of maximum and minimum temperatures, relative humidity, annual average rainfall, wind condition with its proper directions, etc. where average maximum and minimum temperatures are 34°C felt during June & 20°C recorded in December-January, relative humidity is more than 80% due to the heavy rainfall annually that ranges around 1800mm. During monsoon, 75% of the total rainfall emerges during the monsoonal periods specifically from mid-June to September. Southwest westerlies prevail from mid-March to September and from north and northeast prevailing wind is blown during the period of October to mid-March. Banerjee (1998), elaborated climatescape of this region minutely where 'Norwester'occur during the pre-monsoon period and hailstorms also occur associated with the thunderstorms locally named as 'Kalbaisakhi'. These thunderstorms are short-lived and it reduces the temperature by sudden fall of amount. The wind speed of these thunderstorms generally varies from 64-80km/hour but it ranges up to 160km/hour.

Bioscape includes the associated flora and fauna adapted to these forested tracts of the active delta of Indian Sundarbans where, the Mangrove community is the keystone flora and a wide group of associative grasses, shrubs, and sedges are also native to the mangrove vegetation. Banerjee (1998) generally drew out a pattern of vegetation in the active estuarine delta where, three distinct zones are delineated on the basis of tidal intensity, sedimentation type, and the nature of salinity e.g.

a) **A True estuarine zone** dominated mainly by the 'Kala Bean', 'Tora', 'Krippa' situated over the active estuarine banks along the river mouths.
b) **A Middle estuarine zone** dominated by Garjan, jelegaran and Keora
c) **An Inner estuarine/riverine zone** dominated by Sundari, Genwa, Kankra, and the Golepata comprising of lower salinity with more freshwater flow.

Fauna includes the famous Royal Bengal Tiger being the apex of the hierarchy of all terrestrial as well as aquatic animals. Prey of tiger includes pigs, deer, monkeys, birds, crabs, fish, and water monitors.

Following objectives are the primary pillars for this study:

- To study and analysis the SLF approach using livelihood capitals over Kaikhali village
- To get a holistic viewpoint of risk reduction measures through livelihood resilience model

Study Area

The study area **(Figure 1.3)** indulges the Kaikhali Village, Kultali Block under South 24 Parganas district over Indian Sundarbans where in total nine Focus Group Discussions (FGDs) had been run during the monsoon time. The fieldwork was done from 18th August, 2022 to 21st August, 2022. To get a holistic and generic viewpoint regarding the livelihoods and its security, probable shocks against these, FGDs were run across the village and surroundings also. This study area was chosen for its uniqueness in location at riverine tract of Matla River, one of the tourist spot, transportation accessibility.

GPS points were also collected and displayed through maps to get ground level verification particularly where FGDs were run on the basis of availability of people in an unbiased nature (**Figure 1.4**). That's why; group of mixed male and female were also in some FGDs and only female based groups were also in common.

Rationale of the study

Rationale of the study hints behind the fact of importance of Sustainable Livelihood Framework approach that can be useful for every location over Indian Sundarbans. To get a clear picture regarding the possible shocks and vulnerabilities and livelihood options with their benefits and securities of selected groups or households is the primary objective of this approach. It also accommodates the holistic viewpoint of five types of capitals that are under the basic amenities of the people over Indian Sundarbans. This study is incorporated with this holistic viewpoint of SLF approach with associated methodological framework consisting of vulnerable issues of Kaikhali village, Livelihood capital Profile and Composite Score Analysis for risk reduction measures through geospatial tools.
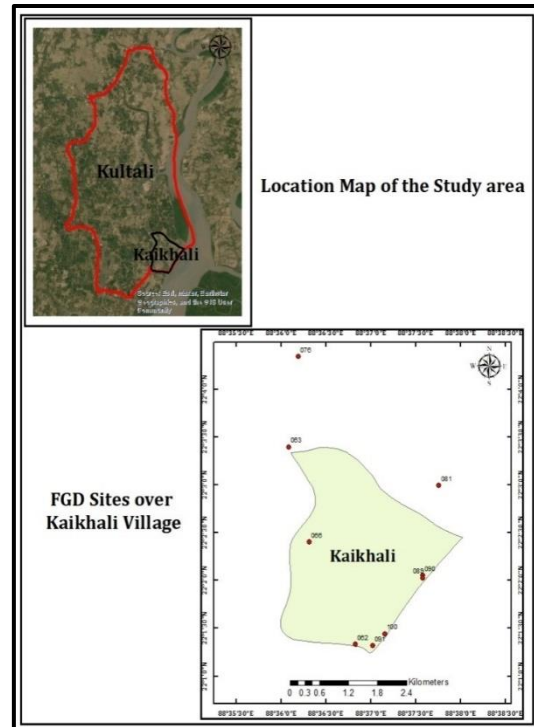

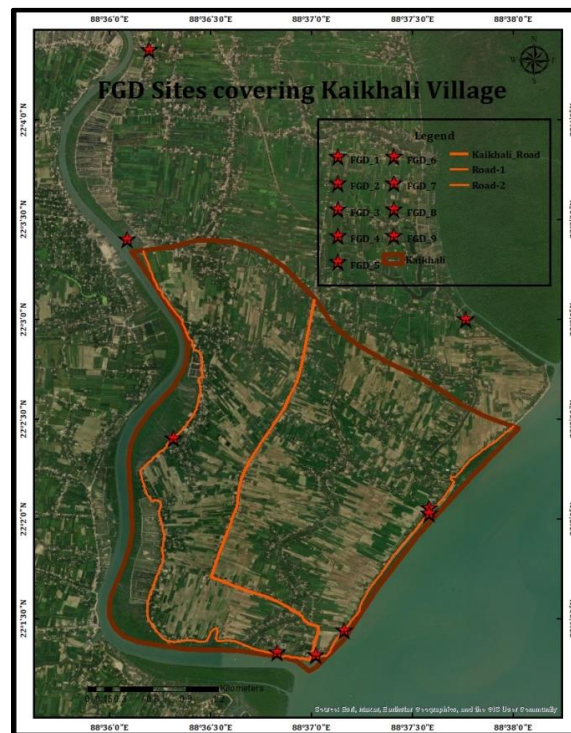**Figure 1.3**: Location map of the Study area

Figure 1.4: FGD Sites over Kaikhali Village, Kultali Block, South 24 Parganas

Methodology

This study is strictly oriented towards the application of existing literature survey and the primary data survey with the help of field surveys. Moench & Dixit (2004) asserted that Shared Learning Dialogue (SLD) is nothing but the frequentative process where a series of learning meetings have to be incorporated for the sharing of insights and common understanding among the people and communicators. It is a bi-directional learning process where reflexive learning process can be augmented to get the basic knowledge regarding the livelihood structures, resilience factors and assessment, verification of the conceptual framework (Sadik & Rahaman, 2010). SLDs were initiated as per the availability of chunks of households being the FGs in a random manner. Subsequent methodological framework has been framed through a flow diagram to get e visual outlook and to make out the hierarchy of the same (Figure 1.5).
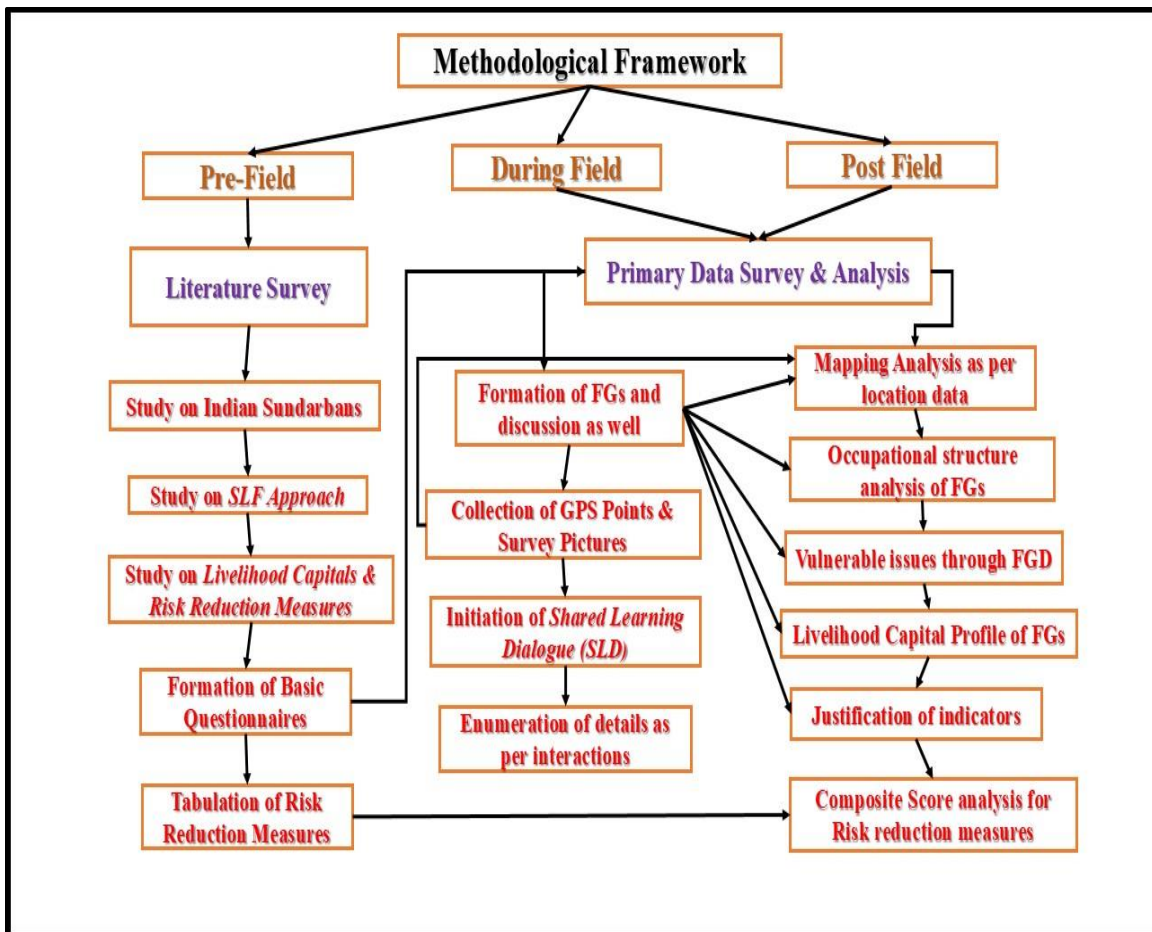

Figure 1.5: Layout of Methodological Framework

Results and Discussions

Occupational Structure of Focus Groups

Table 1.2 shows the frequency distribution table regarding the occupational structures of the selected focus groups where it can be said that as per the analysis; Fishing, Agricultural activities & Shrimp collection are their primary activities by which their livelihoods get secured& Secondary activities are like Transport driver, Business, Aquaculture, Gardener. Fishing is the foremost occupation of the maximum as Kaikhali Village is surrounded by the Matla River and its associated creek named Navipukuria from which they can sustain their fishing and shrimp collection activities. Total number of 158 people was in consideration for the FGDs and breakage of occupations with their numbers is following by the table below:
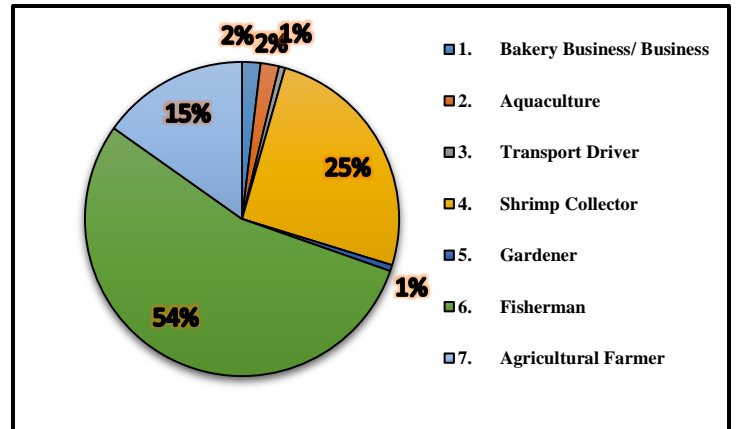
Figure 1.6: Occupational Structure of Focus Groups

Table 1.2: Frequency Distribution Table of FGDs' Occupational Structure

Occupations Structures	Numbers of people associated	% of total
1. Bakery Business/ Business	3	1.90
2. Aquaculture	3	1.90
3. Transport Driver	1	0.63
4. Shrimp Collector	40	25.32
5. Gardener	1	0.63
6. Fisherman	86	54.43
7. Agricultural Farmer	24	15.19
Total Persons of FGD	**158**	**100**

As per Table 1.2, a cartographic analysis has been done to get a proper visualization regarding this through the Figure 1.6, where higher proportion of percentage is associated with the fishing activities and the lowest proportion belong to the transport driver and gardening activities. So it can be said that as per the mode of all activities, primary activities are the main mode and secondary activities are in progress.
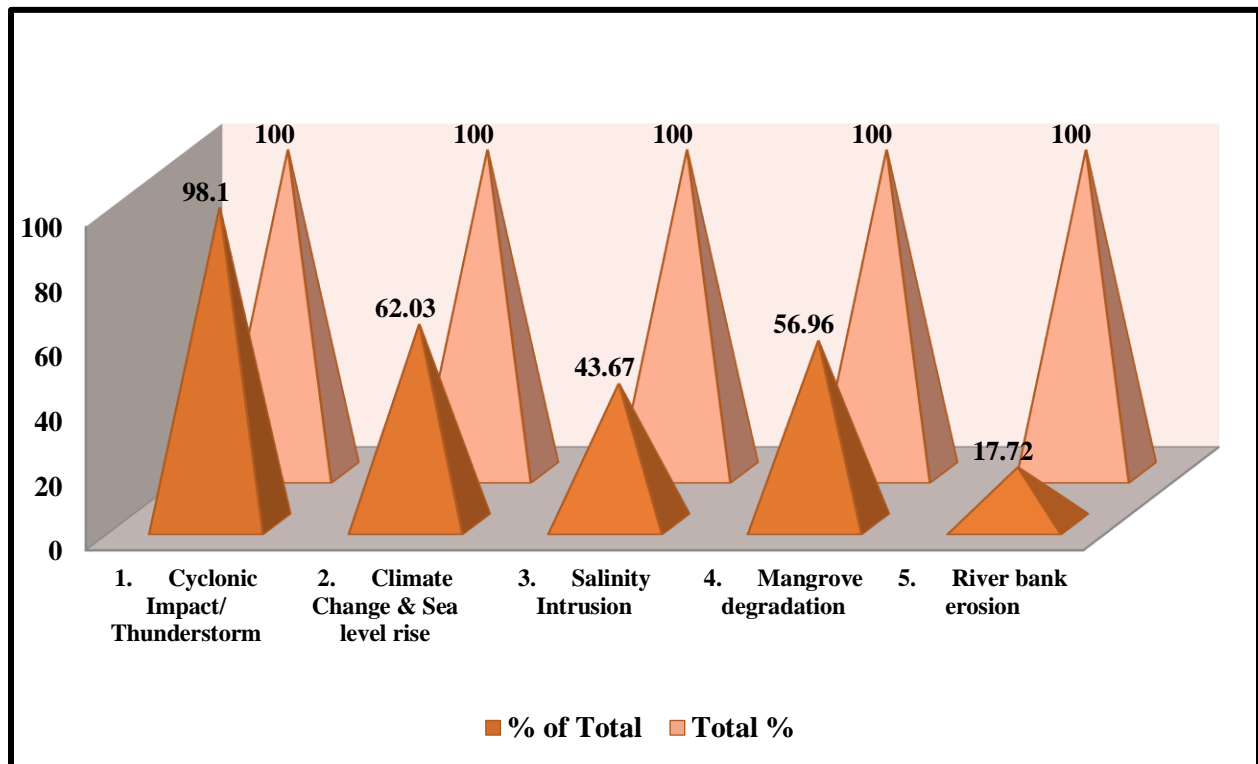
Vulnerable Issues through FGD study

A holistic framework-based study of vulnerability analysis was run through the FGD where communicating groups discussed their possible shocks and vulnerabilities as per the climate change issues and associated salinity intrusion and others. These cumulative effect of several shocks are affecting their livelihood structures day by day but as per the FGD study it can also be sure that villagers are not so alerted and educated about the climate change issues as they pretended it was just a teleological concept or 'God's activity. Therefore, we didn't get any relevant information regarding the possible shocks or vulnerabilities over the village. However, they only pretended on the river bank erosion issues, climate change with salinity intrusion problems and cyclonic impacts, mangrove degradation over the village. If we sort the possible shocks over the village it can be interpreted as following through Table 1.3:

Table 1.3: Possible Vulnerable Issues through FGD Study

Possible Vulnerable Issues/Shocks	Respondents	% of Total
1. Cyclonic Impact/ Thunderstorm	155	98.10
2. Climate Change & Sea level rise	98	62.03
3. Salinity Intrusion	69	43.67
4. Mangrove degradation	90	56.96
5. River bank erosion	28	17.72
Total Respondents=158		

Figure 1.7: Frequency Distribution analysis of vulnerable issues through FGD study

Frequency distribution analysis of vulnerable issues or shocks over the Kaikhali Village through FGD study (Figure 1.7) comprises of the several selected issues by the natives where highest proportion belongs to cyclonic impact/ thunderstorm issues (98.10 %) out of the 158 people and lowest proportion belonging to river bank erosion issue (17.72%). Others issues are climate change & sea level rise (62.03%), Salinity intrusion (43.67%), and Mangrove degradation (56.96%). Cumulative effects of these issues or shocks can prevent the livelihood securities and possibilities hampering the sustainability of the people of Kaikhali village.

Livelihood Capital Profile of Focus Groups

As per the SLF approach, there are five livelihood capitals by which it can be said that any household can sustain their livelihood securities through the basic indicators based on the above-mentioned capitals. Here in this study, as per the five capitals, 11 components have been chosen and 20 indicators have been filtered. A quantitative analysis has been done in a tabular way for the indicator based sub-approach of SLF approach. This livelihood capital profile has been set to get a clear picture regarding the availability and probabilities of their future amenities as per the vulnerabilities (Table 1.4).

Table 1.4: Livelihood Capital Profile of selected FGs over Kaikhali Village

Capitals	Components	Indicators	FGD 1	FGD 2	FGD 3	FGD 4	FGD 5	FGD 6	FGD 7	FGD 8	FGD 9
Social Capital	Demography	Dependency Ratio of the households (%)	420	266.67	250	400	165	190	175	275	142.86
		% of female members to the total numbers in the households	55.56	42.42	42.86	65.71	73.58	51.72	36.36	66.67	52.94
	Network & Relationship	% of households not received any assistance from Neighbours/NGOs/Gov. agencies/relatives & friends	100					100	100	100	
		% of households received assistance from more than one sources		100	100	100	100				100
Natural Capital	Land	Average area of land of the households eroded by cyclone & flood (Katha)	0.5	1	12	0.8	2	1	4	5	3

		Avg. area of agricultural land of the households was affected by salinity due to cyclone & flood (Katha)	2.5	5	16	4	5	2	4	7	9
	Forest based livelihood	% of households using only firewood for cooking purpose	100	100	100	100	100	100	100	100	100
	Drinking water	% of households getting drinking water from the tube well	100	100	100	100	100	100	100	100	100
		% of households experienced scarcity of drinking water during & after disasters	100	78	99	75.6	88.9	100	100	45.8	55
Physical Capital	Housing	% of households living in kutcha house	66.67	69		56	100	60	100	100	100
	Electricity	% of households access electricity	100	100	100	100	100	100	100	100	100
Financial Capital	Assets	Avg amount of agricultural assets of the households (Rs.)	5500	22000	56000	8900		7650			
		Avg. amount of fishing assets of the households (Rs.)				12000	76000	22000	34690	65909	
		Avg. amount of assets of the households (Rs.)	45000	22000	78000	20000	32000	26000	18900	15000	23900

Human Capital	**Finance**	Avg. income from agricultural & fishing activities (Rs.)	20000	38000	98000	45890	53900	34000	30000	12000	20000
		Avg. income from services of the households (Rs.)	8000								
	Health	% of households with a sanitary latrine (%)	66.67	75	100	100	0	58.9	57.9	100	100
		% of households informed that there is difficulty to go to nearest Primary Health Centre (%)	No difficulty	No difficulty	No difficulty	No difficulty	No difficulty	No difficulty	No difficulty	No difficulty	No difficulty
	Knowledge & Skills	% of literate people In the households	34	56	60	57	46	59	60	48	39
		% of households having TV/Radio/Mobile at home to get warning regarding cyclone & flood	100	68	78	100	48	36	59	100	100

Blank cells represent no database as per the FGs' Interaction

Justification of the indicators

Table 1.5 shows the justification as per the indicator based analysis where livelihood adaptive capacity level, insecurity level and vulnerability level have been classified based on qualitative analysis. It can be elaborated that insecurity level/adaptive level & vulnerability level has been classified into high, moderate and low divisions. Different FGs have different scale of measurement of justification. As per the livelihood capitals and their share to the selected groups, it can be said that Kaikhali village's insecurity ranges among high to low divisions as it is a tourist spot that's why, it is in phase of further development however, the interior part remained non-progressive as several livelihood options are quite not feasible for them to access.

Table 1.5: Justification of Indicators

Indicators	FGD 1	FGD 2	FGD 3	FGD 4	FGD 5	FGD 6	FGD 7	FGD 8	FGD 9
Dependency ratio	High dependency ratio=high insecurity level	Moderate insecurity level	Moderate insecurity level	High dependency ratio=high insecurity level	Lower insecurity level	Lower insecurity level	Lower insecurity level	Moderate insecurity level	Lower insecurity level
% of females	Moderate insecurity level	Lower insecurity level	Lower insecurity level	High female numbers=high insecurity level	High female numbers=high insecurity	Moderate insecurity level	Lower insecurity level	High female numbers=high insecurity level	Moderate insecurity level
% of households not received any assistance	High %=High insecurity level					High %=High insecurity level	High %=High insecurity level	High %=High insecurity level	
% of households received assistance from more than one sources		Less insecurity level	Less insecurity level	Less insecurity level	Less insecurity level				Less insecurity level

Average area of land of the households eroded by cyclone & flood (Katha	Lesser insecurity level	Lesser insecurity level	High insecurity level	Lesser insecurity level	Lesser insecurity level	Lesser insecurity level	Moderate insecurity level	Moderate insecurity level	Moderate insecurity level
High salinity in agricultural land	Lesser insecurity level	Moderate insecurity level	High insecurity level	Lesser insecurity level	Moderate insecurity level	Lesser insecurity level	Lesser insecurity level	High insecurity level	High insecurity level
% of households using only firewood for cooking	High insecurity level	High insecurity level	High insecurity level	High insecurity level	High insecurity level	High insecurity level	High insecurity level	High insecurity level	High insecurity level
% of households getting drinking water from the tube-well	High insecurity level	High insecurity level	High insecurity level	High insecurity level	High insecurity level	High insecurity level	High insecurity level	High insecurity level	High insecurity level
% of households experience water scarcity during and after disaster	High insecurity level	Moderate insecurity level	High insecurity level	Moderate insecurity level	Moderate insecurity level	High insecurity level	High insecurity level	Lesser insecurity level	Lesser insecurity level
% of households living in kutcha house	Moderate insecurity level	Moderate insecurity level		Moderate insecurity level	High insecurity level	Moderate insecurity level	High insecurity level	High insecurity level	High insecurity level
% of households access electricity	High adaptive capacity	High adaptive capacity	High adaptive capacity	High adaptive capacity	High adaptive capacity	High adaptive capacity	High adaptive capacity	High adaptive capacity	High adaptive capacity
Avg. amount of agricultural assets of the households	Moderate sensitivity	High sensitivity	High sensitivity	Moderate sensitivity		Moderate sensitivity			
Avg. amount of fishing assets of the households				Lesser sensitivity	High sensitivity	Moderate sensitivity	Moderate sensitivity	High sensitivity	

Avg. amount of assets of the households	High sensitivity & high vulnerability	Moderate sensitivity & vulnerability	High sensitivity & high vulnerability	Moderate sensitivity & vulnerability	Moderate sensitivity & vulnerability	Moderate sensitivity & vulnerability	Lesser sensitivity & Vulnerability		Moderate sensitivity & vulnerability
Avg. income from agricultural & fishing activities	Lesser adaptive capacity	Moderate adaptive capacity	More adaptive capacity	Moderate adaptive capacity	Moderate adaptive capacity	Moderate adaptive capacity	Moderate adaptive capacity	Lesser adaptive capacity	Lesser adaptive capacity
Avg. income from services of the households	Moderate adaptive capacity level								
% of households with a sanitary latrine	Moderate adaptive capacity	Moderate adaptive capacity	High adaptive capacity	High adaptive capacity	Lesser adaptive capacity	Moderate adaptive capacity	Moderate adaptive capacity	High adaptive capacity	High adaptive capacity
% of households informed that there is difficulty to go to nearest Primary Health Centre (%)	Lesser insecurity level	Lesser insecurity level	Lesser insecurity level	Lesser insecurity level	Lesser insecurity level	Lesser insecurity level	Lesser insecurity level		Lesser insecurity level
% of literate people in the households	Moderate adaptive capacity and knowledge skill	High adaptive capacity and knowledge skill	High adaptive capacity and knowledge skill	High adaptive capacity and knowledge skill	Moderate adaptive capacity and knowledge skill	Moderate adaptive capacity and knowledge skill	High adaptive capacity and knowledge skill	High adaptive capacity and knowledge skill	Moderate adaptive capacity and knowledge skill
% of households having TV/Radio/Mobile at home to get warning regarding cyclone & flood	Lesser insecurity level	Moderate insecurity level	Moderate insecurity level	Lesser insecurity level	High insecurity level	High insecurity level	High insecurity level	Lesser insecurity level	Lesser insecurity level

Composite Score analysis for Risk Reduction Strategies/Measures

This subsection is associated with the risk reduction measures or strategies that were selected for the study area as per the vulnerabilities and shocks over Kaikhali village. The correlation between the five capital and the risk reduction measures were shown through the Composite Score that were given by the selected Focus Groups over the village. The applicability of each and every capitals with respect to risk reduction measures were also in tis analysis to get the quantitative viewpoint. Total 20 risk reduction measures can be in action as per the possible shocks and vulnerabilities that were valued frequency wise of every focus groups. Highest score was cumulated as 22 and lowest as 1.

Table 1.6 shows the diagrammatic presentation of the composite score analysis where red arrow shows the negative aproach towards the selected capitalas, yellow arrow shows the positive approach towards the same and green arrow in the compostie score section shows the possibility and probability of the selected risk reduction measures irrespective of selected capitals. For example, Forest health monitoring in Indian Sundarbans, Protection & Conservation of important speciesover Indian Sundarbans & Livelihood Diversification Opportunities having the highest compostie score (22) can be applicable in the Human, Social& Financial capitals as per the FGs' interaction respectively, Provide proper drinking water and sanitation technology is not so relevant measure for the village having the lowest score (1) in the Physical capital getting only single frequency.

Table 1.6: Composite Score analysis for Risk Reduction

Risk Reduction strategies/Measures	Natural	Financial	Physical	Human	Social	Composite Score through FGD
Drainage basin management in rivers of Indian Sundarbans			8	2	2	12
Integrated management plan	2		7	1	4	14
Ecosystem health improvement in Indian Sundarbans			2	6	6	14
Forest health monitoring in Indian Sundarbans			4	9	9	22
Protection & Conservation of important species of Indian Sundarbans(e.g. *Sundari, Royal Bengal Tiger, Red Crab, other relevant species*)	2	2	3	7	8	22
Mangrove plantation in newly accreted or damaged area in Indian Sundarbans		1	2	9	9	21
Application of mangrove regeneration through natural as well as artificial techniques	1	1	1	9	9	21
Ecosystem based adaptive management of rivers in Indian Sundarbans and its upstream areas e.g. *Tidal water management*				7	7	14
Participatory forest management in Indian Sundarbans		1		9	9	19
Enforcement of environmental and forest laws, regulations with strong monitoring and planning				8	9	17
Livelihood diversification opportunities	1	8	9	2	2	22
Training on sustainable use of resources		2	6	3	4	15
Technological & financial help for maintenance of existing drinking water & sanitation facilities			1	1	1	3
Provide proper drinking water and sanitation technology (e.g. *pond sand filter, solar desalinization plant and hygiene toilets*)			1			1
Community based monitoring and proofing system of risk assessment of tiger attack				9	9	18
Tiger conservation programs				9	9	18
Emergency rescue services for the victims of tiger attack				9	9	18
Emergency rescue services for the tigers				8	8	16
Awareness generation for not killing tigers				9	9	18
Strengthening & empowering association of dependent livelihood groups			2		1	3

Valued cells are referred as the applicable capitals irrespective of several risk reduction strategies

Conclusions

The list of concluding remarks have been framed into several bullets to get a generic viewpoints regarding the study:

• As per the FGD study, occupational structures have been studied for the further analysis of livelihood benefits and security where, primary occupations of the selected groups or the majority are Fishing (54.43%), shrimp collection (25.32%) & agricultural farmer (15.19%). The village is surrounded by the riverine tract of Matla River that's why, fishing is their primary activity that helps to boost their livelihoods. Other options are bakery business, aquaculture, transport driver & gardener.

• Possible vulnerable issues have also been caged in this study for the SLF approach where, communicating groups discussed their possible shocks and vulnerabilities. However, villagers are not so alerted and educated about the climate change issues as they pretended it was just a teleological concept or 'God's activity. 98.10% of respondents have their opinion regarding the Cyclonic Impact/ Thunderstorm; 62.03% of respondents have responded towards climate change and sea level rise; 56.96% of respondents responded towards mangrove degradation; 17.72% of total have their response regarding river bank erosion. Cumulative effects of these issues can have the guts to hamper the livelihood options.

• As per the SLF approach, livelihood capital profile has been set as per the focus groups to get a holistic viewpoint regarding the livelihood structures of the villagers. Total 20 indicators have been filtered for the SLF approach. For the Social Capital, two components have been chosen; Demography & Network & Relationship; for the Natural Capital, three components are chosen; Land, Forest based livelihood & Drinking water, for the Physical capital, Housing & Electricity have been chosen; for the Financial Capital, Assets & Finance have been collaborated; for the Human Capital, Health &Knowledge and skills have been selected. Blank cells represent no response or no database as per the FGs' interaction. All the indicators have been quantified with respect to particular units where a vast database has been collaborated through Table 1.4.

• As per the selected components, several indicators have been collaborated and attached with the respective capitals. As per the tabulation, focus group wise database shows up the diversified responses regarding the selected indicators of SLF approach.

• Next, justification as per the indicator based analysis has been analyzed where livelihood adaptive capacity level, insecurity level and vulnerability level have been classified based on qualitative analysis. Insecurity level/adaptive level & vulnerability level has been classified into high, moderate and low divisions.

• In Demography component sector, FG1, FG4 shows high dependency ratio and high insecurity level; FG2, FG3, FG8 shows moderate dependency ratio and insecurity level; FG5, FG6, FG7 & FG9 show the lower dependency ratio and insecurity level. Female numbers are high in FG4, FG5 & FG8; moderate in FG1, FG6 & FG9; lower in FG2, FG3 & FG7.

• In Network & Relationship component sector, FG1, FG6, FG7 & FG8 shows up the high percentage regarding not received any assistance. FG2, FG3, FG4, FG5 & FG9 shows up the lesser insecurity level assuring lower frequency in received assistance from more than one sources.

• In Land component sector, FG1, FG2, FG4, FG5, FG6 securing the lesser insecurity level, FG3 shows up the high insecurity level and remaining shows up the moderate insecurity level in average area of land eroded by natural calamities. FG3, FG8 & FG9 shows up the high insecurity level, FG2 & FG5 shows up the moderate insecurity level and FG1, FG4, FG6 & FG7 assuring the lesser insecurity level in the indicator of high salinity in agricultural land.

• All the FGs are highly vulnerable or insecure related to percentage of households using only firewood for cooking purpose and getting drinking water from the tube-well in Forest and Drinking water component sector. FG1, FG3, FG6, FG7 having the high insecurity level; FG2, FG4, FG5 having moderate and remaining groups having lesser insecurity level experiencing water scarcity during and after disaster.

• In the electricity component sector all the groups are vulnerable accessing the electricity. FG1, FG2, FG4. FG6 having the moderate insecurity level, remaining belongs to the high zone as per living in Kutcha house. For the Assets, all groups are diversified in nature where, agricultural and fishing assets are common.

• In the Finance sector, maximum groups belong to the moderate adaptive capacity level, some securing lower adaptive level and not so good responses from the groups for the average income from the service sector as the village is not so occupied by the service sectors.

• In the Health sector, maximum groups having the higher to moderate adaptive capacity level having the

sanitary latrine, all groups showing the lesser insecurity level regarding the difficulty to got to nearest PHC.

- In the Knowledge and skill sectors, literacy level is more or less high to moderate in nature in every focus groups and households having assets to get warning about the calamities have the responses in a diversified nature.

- Last but not the least, a Composite Score analysis has been formatted for the possible and filtered risk reduction measures only applicable for the village. Forest health monitoring in Indian Sundarbans, Protection & Conservation of important speciesover Indian Sundarbans & Livelihood Diversification Opportunities having the highest compostie score (22) can be applicable in the Human, Social& Financial capitals as per the FGs' interaction respectively, Provide proper drinking water and sanitation technology is not so relevant measure for the village having the lowest score (1) in the Physical capital getting only single frequency.

- Community participation with the SLD technique can be a relevant way to formulate the SLF approach which helps to analyse the suitable adaptation strategy with basic indigenous knowledge for securing and rebuilding livelihood opportunities irrespective of several shocks and vulnerabilities.

- Mangrove regeneration can be one of the possible remedial measures to be applicable as per the environmental suitability that can be sustainable technique to restore the mangrove degradation as mangrove ecosystem is one of the environmental asset of Sundarbans.

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Conflict of Interest

The authors declare no conflict of interest.

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