

EVALUATION OF LIVELIHOOD ASSETS OF BEDIA WOMEN: A STUDY OF THE SELECTED BLOCKS IN SUNDARBAN, INDIA

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Abstract

Livelihood capitals and changes in these capitals play an important role in determination of livelihood. The purpose of the study is to examine the spatio-temporal changes of livelihood capitals and affecting factors. Based on the primary survey of Bedia women's livelihood capital change has been measured by descriptive statistical methods. Moreover, principal components analysis has been used for analysing the controlling factors of livelihood capital change from the period 2001 to 2021. The findings of the study show that the total livelihood capital value was 7.86 in 2001 which increased to 10.68 in 2021. In 2001, the value of human capital was highest (2.36) and the value of physical capital was lowest (1.15). In 2021, the value of human capital was also highest (3.31) and the value of natural capital was lowest (1.15). The main reason behind the reduced value of natural capital was decreasing agricultural land. Financial capital and social capital have also significantly increased, which indicates that the status of the Bedia women has improved. Finally, on the basis of the findings some suggestions regarding the betterment of the livelihood capital of the Bedia women have been proposed.

Keywords: Livelihood capitals, Bedia women, Principal components analysis, Sundarbans

1. Introduction

Sundarban is the largest delta system, considered as a UNESCO (United Nations Educational, Scientific and Cultural Organisation) World Heritage Site (Banerjee, 2014, Jamal et al., 2022). Only earthen embankments around the islands are allowed for human habitation. First, human habitation in Sundarban was started with the tribal people. Agricultural land was provided to them for purpose of relocation (Hembrom et al., 2022). Tribal people are natural offspring, and the ecosystem shapes their way of life. They have lived for many generations in a largely independent manner that is obviously distinct from the prevailing and mainstream civilisation (Ramya et al., 2017). The Bedia is a part of tribal community as per The Constitution (Scheduled Tribes) Order, 1950 of the States of Bihar, Jharkhand and West Bengal in India (Tripathy et al., 2018). West Bengal is having a total population of 55,979, which is 1.3% of the total tribal population of this State as per the 2001 census. In 2011, Bedia population grew noticeably to 88,772. Remarkably, their population grew by a whopping 58.58% in only one decade. This rate is well above the all-India average of 49.7% but below the State average of 63.8%. They are mainly from the districts of South and North 24 Parganas in West Bengal which form the Indian Sundarban region (Bandyopadhyay, 2019) and they are living in this region since the reclamation phase of the Sundarban. Women have a significant role in tribal cultures since they put in more effort and are essential to the family's administration and economy (Dhanasree et al., 2014). Most of the time women are the main bread-earners of their family (Banerjee, 2024) yet they are neglected for decision making process of their family (Kundu, 2024). For the progress a society, women need to be empowered (Shuai et al., 2018). Bedia women also have a significant role of their family. Livelihood of all the members of their family depends on the Bedia women too. India is experiencing major socio-economic changes affecting hundreds of millions people in their livelihood (Choithani et al., 2021). The term "livelihood" describes the methodical process of earning a living based on abilities, assets, and practical pursuits (Ahmed, 2022). Livelihood defines basic needs of individuals (Deb

and Mahato, 2019). Livelihood concepts start with how different people in different places live (Scoones, 2009). The livelihood consists of a variety of assets, tactics, pursuits, and other elements universally needed for survival (Chambers and Conway, 1992). Many scholars claim that rural households are dependent on their ability to access livelihood assets such as natural, physical, financial, human, and social capital (Alam et al., 2017). The idea was broadened by the 1992 United Nations Conference on Environment and Development (UNCED), particularly in light of Agenda 21, which promoted the idea that attaining sustainable livelihoods may be a general objective for reducing poverty (Sati and Vangchhia, 2017). The Department for International Development (DFID) sustainable rural livelihoods framework (Carney, 1998) proposes three variables for livelihood strategies. Livelihood assets are a part of sustainable livelihood framework. The Sustainable Livelihood Framework (SLF) comes up of a livelihood approach (Li et al., 2018). High value of livelihood capital can reduce poverty (Liu et al., 2017). There are several ways that livelihood diversification can occur, including contemporaneous, temporal, and spatial diversification (Goulden et al., 2013; Leoni and Indhumathi., 2021).

The spatial diversification shows the changes of livelihood from place to place and temporal change shows the changes of livelihood with changes of time. The impact of livelihood can also be explained by spatio-temporal analysis of livelihood capitals (Wan et al., 2018).

Hence, the present study examines the spatio-temporal changing pattern of livelihood capitals and the various controlling factors of this change within Bedia women in selected Community Development (C.D) block of Sundarban region in West Bengal from the period of 2001 to 2021. Besides, it explores the key factors shaping the livelihood change of Bedia women.

2. Methodology

2.1. Study Area

The Sundarbans are situated between Bangladesh and India (Bagchi, 2017; Jamal et al., 2022) on the delta created by the Ganges, Brahmaputra and Meghna rivers in the Bay of Bengal (Ghosh et al., 2015). The average elevation of the area is very low and the islands are usually 3–8 m in height, and are submerged in tidal surges (Hazra et al., 2002). This island expands over an area of 10,000 sq. km of which 62% situated in Bangladesh and the remaining 38% in India (Ghosh, Schmidt, Fickert, and Nüsse, 2015., Jamal et al., 2022). The water level of this island gradually increases (District Human Development Report, 2009). It is divided into two parts which are Bangladesh Sundarban and Indian Sundarban. Indian Sundarban comprised of 19 community development (C.D.) blocks. Out of 19 C.D. blocks, 13 C.D. blocks pertain in South 24 Parganas district and 6 C.D blocks belong to North 24 Parganas district in West Bengal. The district of South 24 Parganas is situated between 21°29'00"N to 22°33'45"N latitude and 88°03'45"E to 89°04'50"E longitude, and the Indian Sundarbans' area lies between 21°40'00"N to 22°40'00"N latitude and 88°03'00"E to 89°07'00"E longitude approximately (Mondal et al., 2022). The area is exposed to threats like floods, cyclones and sea-level rise. The present study area comprises Sandeshkhali (I & II) C.D. block, Hingalganj C.D. block and Gosaba C.D. block in Sundarban Region, West Bengal. It extends from 20°10'00"N to 22°30'00"N and 88°42'00"E to 89°04'00"E. Total area is 906.37 sq. km.

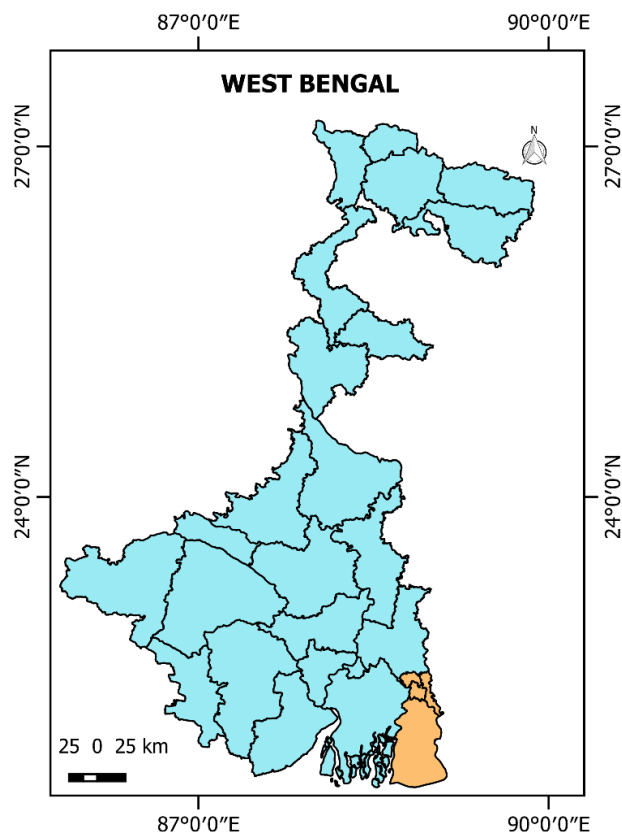


Fig.1: Location Map of the Study Area

2.2. Data Sources

This research is mainly based on primary survey. The primary survey was conducted to achieve in-depth understanding of Bedia community and the livelihood of Bedia women in four community development (C.D.) blocks. Three C.D. blocks from North 24 Parganas and One C.D. block from South 24 Parganas have purposefully been chosen considering the majority of Bedia women population and various socio-economic factors. Purposive sampling method was used to select sample. The questions have been raised mainly on the changing patterns of livelihood capital of the Bedia women during 2001 to 2021 period. It has been surveyed in the age of 40 to 55 years old of Bedia women.

Although this research is based on primary data, some secondary data is needed for fulfillment of novelty. It also requires quantitative and qualitative databases to show the changing scenarios of the target people. The secondary database has covered of different journals, books, newspapers, census reports (2001 and 2011), research articles, etc. The literature survey is also very crucial for analysis, discussion, and interpretation of the present work. Additionally, a number of crucial influencing factors of changing livelihood were found which are summarized in Table 1 (Keshavarz & Karami, 2018; Amghani et al., 2025).

Table 1: Livelihood Capitals of Smallholder Farmers

Number	Structure	Variables
1	Human capital	Education level Household head age Health status of the family The amount of extension training Intra-social communication
2	Social capital	Extra social communication Social links Household liquidity amount
3	Financial capital	Annual household income The amount of government facilities received The amount of compensation received in the form of
4	Physical capital	insurance Size of agricultural land Farm buildings and facilities Farm irrigation equipment and facilities
5	Natural capital	Quantity of small and large livestock Quality of agricultural lands Soil quality Water quality level Access to water source

Source: Based on Keshavarz & Karami, 2018; Amghani et al., 2025

2.3. Research Methods

This research paper primarily assessed the level of Bedia women's livelihood capital and find out the spatio-temporal changes of livelihood capital from 2001 to 2021. For analysis of livelihood capital descriptive statistics like mean ($\bar{x}$) and standard deviation (SD) were used to show the changes of livelihood capital of Bedia women. Such methods have been used by the scholars to show spatio-temporal changes of livelihood capitals (Wan et al., 2018).

When empirically analysing the controlling factors of transforming livelihood, correlation matrix, principal components analysis (PCA) method through SPSS software was used. PCA introduced by Karl Pearson in 1901. As identification of influencing factors principal component analysis is a unique non-parametric statistical techniques and also encyclopaedically accepted in numerous research to reckon the weight of parameters of the study of influencing factors analysis (Wang and Liu, 2023). Large datasets create a difficulty to interpret; Principal component analysis (PCA) is a technique for reduction of dimension of such datasets (Jolliffe and Cadima, 2016). Firstly, PCA retained the utmost probable variance and the second PCA retains the second important variance and so on. As per Kaiser criterion (1960), the number of PCA is ascertained. Based on this rule, the eigenvalues (> 1) have been considered for further analysis. Component scores and loadings are the most valuable factors in PCA results (Rácz et al., 2018). Consequently, IBM SPSS 26 software was used to extract the significant variable. Along with all analysis getting intended results, ethnographic methods were used. QGIS-3.1.2 software was used for mapping.

2.3.1. Design of the Livelihood Capital Indicators and Analysis

Indicators and variables are the very much crucial for assessing livelihood change. Indicator systems from international organizations were consulted during the process of indicator design (FAO, 2001; CICI, 2003; Chen et al, 2013) and the final set of indicators and different types of livelihood capital such as physical, natural, human, financial and social are encompassed. In this study, the main causes of the selections of those indicators are to know the ground truth of livelihood condition of Bedia women and how much changes have occurred in their livelihood capitals in a temporal scale (2000 to 2021).

2.3.2. Selection of Various Livelihood Capitals of the Bedia Women

Physical Capital

Physical capital encompasses basic public amenities which include some infrastructural availability. The physical capital of Bedia women can reflect their basic infrastructural needs of life. House infrastructure, availability of drinking water, road infrastructure and basic toilet facilities were the main physical capital indicators in this research paper. Safe housing and equipment are needed for maintain sustain livelihoods (DFID, 1999). At the same time, drinking water facilities and road infrastructure played the important role of livelihood change of Bedia women's life. These changing determinants also play a crucial role in sustainable livelihoods of the people.

Natural Capital

The term 'natural capital' describes the natural resources that people require in order to carry out their daily activities (He and Ahmed, 2022). Natural capital is one of the most significant livelihood capital. Land is the main component of natural capital. In this study area, agricultural land and irrigated land are the major components of natural capital which are influencing assets of changing livelihood of Bedia women. Livestock is also considered as the important indicator of natural capital

Human Capital

Human capital is perhaps the most significant asset because its core value is very much needed for using the other four capitals (Habib et al., 2023; Sati and Vangchhia, 2017). It has a great role to change livelihood among all five livelihood capitals. The conversion of any materialistic thing to resources depends on human skill, knowledge and labour. In addition to the real local circumstances, this research article chooses three human capital indicators. Indicators are education level of Bedia women which directly affected on their selection of occupation, Occupation status which influenced the monthly income of Bedia women and health condition which is itself an asset and significant indicator for assessing human capital.

Financial Capital

Financial capital has a crucial role to make a sustainable livelihood of people. Livelihood of the people is sustainable when income is higher than expenditure. This is among the all capitals that demonstrate the area's socioeconomic condition. Financial capital such as, economic resources, include income, accumulated wealth, and house ownership has an impact on family resources and resilience (Ngamwong et al., 2024). It also encompasses the monthly income, besides accessing all financial facilities. The total amount of the financial capital depends on the woman of this Bedia tribal family. Here three main indicators have been selected as a financial capital. These are monthly income, accessing of banking facility and savings of the target women. Amongst the three indicators, monthly income is the pivotal indicator of financial capital which helps to make understand the actual living condition of a household.

Social Capital

Social capitals consist of all social relationships (Scoones, 2009). Social capital is a major asset which demarcates the rural livelihood status. This research paper has three indicators of this capital. These indicators are political engagement, important role of making decision in family and as a role of head of the family of women. Political engagement increase social communication, as a role of head of the family shows the women status in society and as a part of decision making of their family revealed that the perception and conception about women. Positive perception always increases the value of social capital.

3. Results

3.1. Change of Livelihood Capital of Bedia Women

Livelihood capital change shows the overall socio-economic transforming scenario of the targeted people. In order to apply any method, the value must be calculated. It is an essential component of the comprehensive evaluation process. Based on the rigorous field survey it was found that a huge change has occurred in the period of 2001 to 2021. Total value of livelihood capital was 7.86 in 2001 ($\bar{X}$ = 1.57, S.D. = 0.42, C.V. = 26.92) whereas 10.68 in 2021 ($\bar{X}$ = 2.14, S.D. = 0.69, C.V. = 32.44). From table 2 and figure 2 we can see capital wise change of livelihood from the period of 2001 to 2021. Every capital has changed very significantly. Physical capital, human capital, financial capital and social capital have risen. The values are respectively 1.15 to 1.96, 2.36 to 3.31, 1.50 to 2.22, and 1.56 to 2.04. Only natural capital value has declined (1.28 to 1.15). So this analysis revealed that the livelihood capital of Bedia women of four blocks has changed.

Table 2: Value of Livelihood Capital of Bedia Women (2001 to 2021)

Capital Type	Capital value in 2001	Rank in 2001	Capital value in 2021	Rank in 2021
Physical	1.15	5	1.96	4
Natural	1.28	4	1.15	5
Human	2.36	1	3.31	1
Financial	1.50	3	2.22	2
Social	1.56	2	2.04	3
Livelihood Capital Value	1.57		2.14	

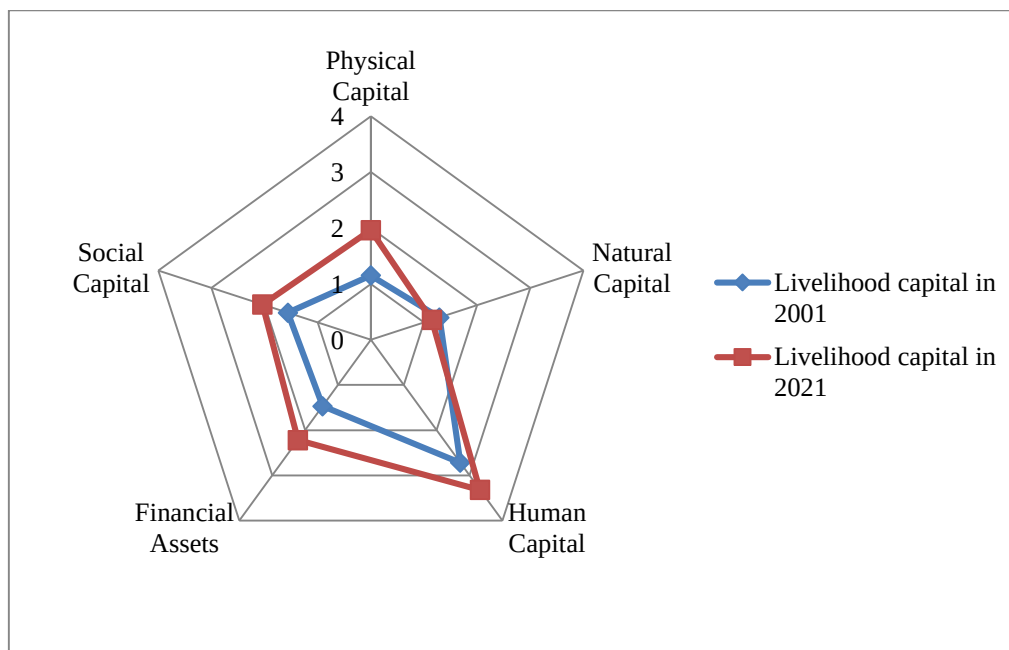


Fig 2: Value of Livelihood Capital in the Study Area (2001 to 2021)

3.1.1. Spatial Changes in Livelihood Capitals of Bedia Women

From the analysis of Table 4, 5 and figure 3, 4, it is clear that livelihood assets changed significantly from one C.D. block to another C.D. block. Capital value also was measured by each indicator of these capitals

of each C.D. block. The livelihood capitals value of Sandeshkhali I C.D. block was 1.58 in 2001 and it is an increased to 2.05 in 2021. In the value of livelihood assets was 1.56 in 2001 and 2.14 in 2021 in Sandeshkhali II C.D. block. It is also significantly changed. The asset value was also raised in Hingalganj and Gosaba C.D. block. The capital value of these two blocks was 1.61, 1.60 in 2001 and 2.16, 2.19 in 2021. Among five livelihood capitals four capitals has increased except natural capital into four blocks.

Table 3: Inter Block Capital Value in 2001

Capital Type	Sandeshkhali I	Sandeshkhali II	Hingalganj	Gosaba
Natural Capital	1.18	1.21	1.43	1.37
Physical Capital	1.10	1.13	1.13	1.16
Human Capital	2.34	2.29	2.38	2.46
Financial Capital	1.71	1.61	1.57	1.48
Social Capital	1.53	1.57	1.52	1.56
Livelihood Capital Value	1.58	1.56	1.61	1.60

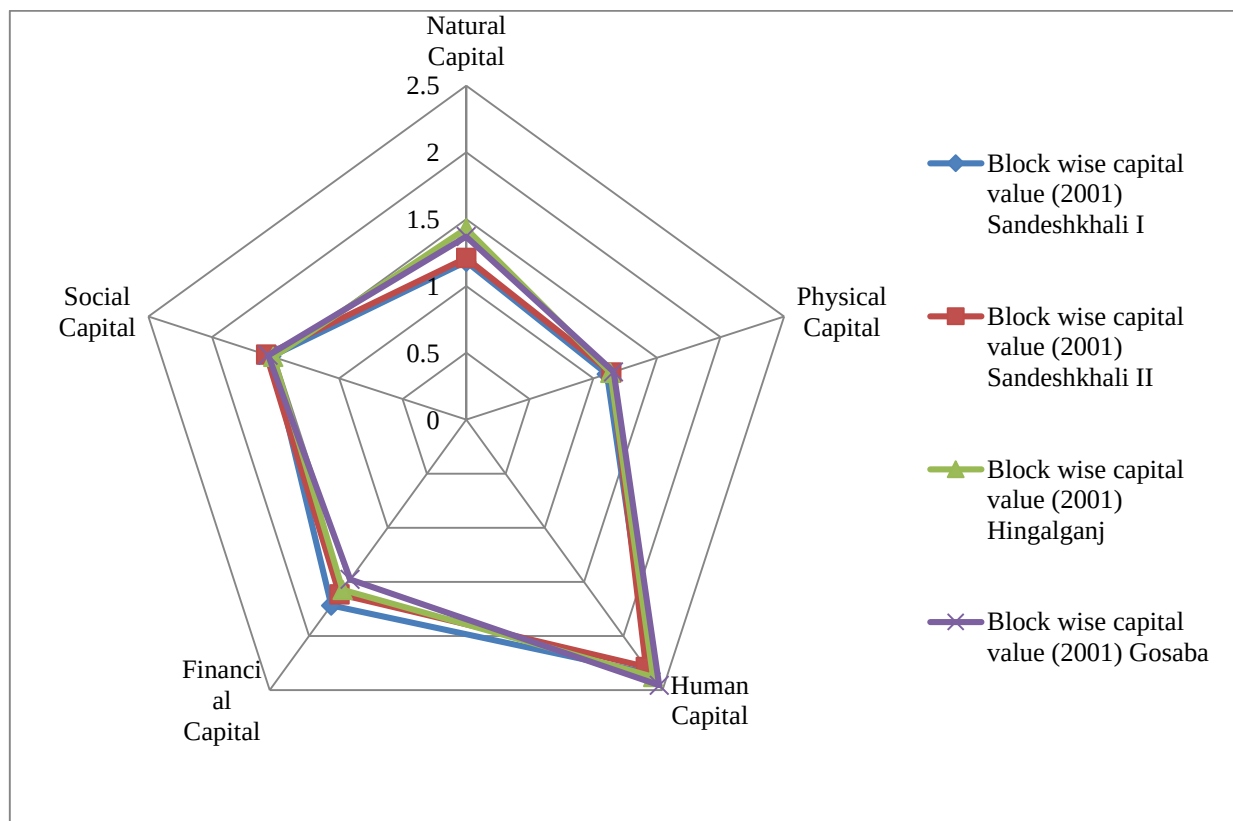


Fig 3: Inter Block Spatial Variation of Livelihood Capital (2001)

Table 4: Inter Block Capital Value in 2021

	Sandeshkhali I	Sandeshkhali II	Hingalganj	Gosaba
Natural Capital	1.00	1.18	1.22	1.24
Physical Capital	1.95	2.00	1.97	1.84
Human Capital	3.24	3.07	3.38	3.59
Financial Capital	2.03	2.36	2.23	2.34
Social Capital	2.04	2.10	2.00	1.97
Livelihood Capital Value	2.05	2.14	2.16	2.19

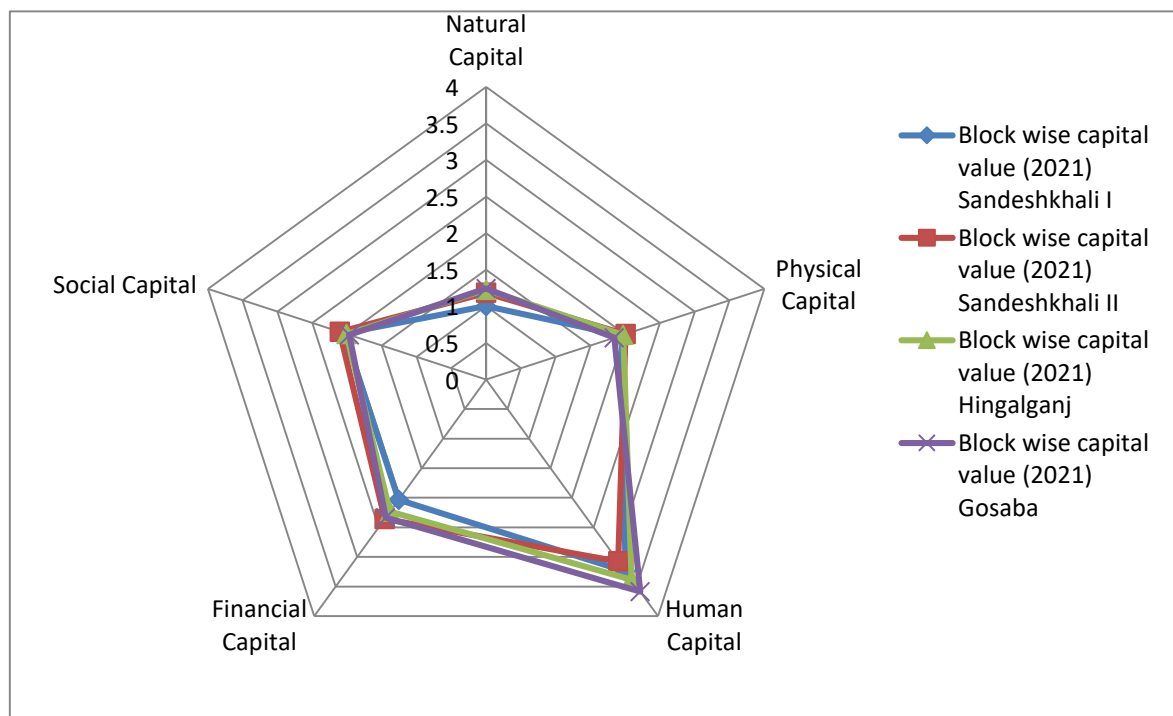


Fig 4: Inter Block Spatial Variation of Livelihood Capital (2021)

3.1.2. Temporal Changes in Livelihood Capitals of Bedia Women

As shown in Table 5, we can understand that livelihood capital switched significantly from the period of 2001 to 2021. Using descriptive statistical methods, calculations have been done of sixteen indicators from five livelihood capitals. The capitals value of physical, natural, human, financial and social capital were 1.15, 1.29, 2.36, 1.47 and 1.56 in 2001 and 1.96, 1.15, 3.32, 2.22 and 2.04 in 2021 respectively. The total value of livelihood capital is 1.57 in 2001 and 2.14 in 2021. The increasing or decreasing of livelihood capital values directed the actual condition of people's life. However, the changes of different capitals as well as different indicators of these capitals are associated with different outcomes and features.

Table 5: Indicators -wise Capital of Bedia Women from 2001 to 2021

Capitals	Indicators	2001		2021	
		Indicator Value	Capitals Value	Indicator value	Capitals Value
Physical Capitals	Road Infrastructure	1.27		2.29	
	Source of Drinking Water	1.89		2.39	

	House type	1.08	1.15	1.92	1.96
	Sanitation Facility	0.35		1.24	
Natural Capitals	Agricultural Land Amount	0.9		0.54	
	Irrigated land	1.56	1.29	1.21	1.15
	Livestock	1.4		1.71	
Human Capitals	Education level	2.1		2.1	
	Occupation	2.73	2.36	4.57	3.32
	Health Condition	2.27		3.3	
Financial Capitals	Monthly income	2.42		3.14	
	Banking Facility	1.09	1.5	2.24	2.22
	Savings	0.99		1.28	
Social Capitals	Engaged in politics	1.07		1.04	
	Family member Consulted with Women	1.31	1.56	1.57	2.04
	Head of the Family	2.3		3.52	
Livelihood Capitals Value			1.57		2.14

Physical capital is related to family features. The value in 2001 is 1.15 and 1.96 is in 2021. The increasing difference is 0.81. In this capital road infrastructure (1.27 to 2.29) has increased significantly, but other indicators like drinking water facility (1.89 to 2.39), basic sanitation facility (0.35 to 1.24) and house condition (1.08 to 1.92) of Bedia women's has increased slightly. Improvement of road infrastructure has a great impact on occupation change of Bedia women. For this improvement occupation has converted primary to secondary activities.

The value of natural capital is decreased with the assets value of 1.29 in 2001 to 1.15 in 2021. Among three indicators of natural capital two indicators are decreased. They are agricultural land (0.90 to 0.54) and irrigated land (1.56 to 1.21). Although another indicator (livestock) is increased from 1.4 to 1.71. Overall changes of natural capital assets are negative.

Human capital's asset value increased from 2.36 (2001) to 3.32 (2021). Among three indicators of human capital occupation is increased significantly. Human capital is a crucial factor which is determined wellbeing of Bedia women. From 2001 to 2021 occupational status has increased from 2.73 to 4.57, health status increased from 2.27 to 3.30. Increasing the value of human capital is the indication of development of Bedia women as well as Bedia women.

The value of financial capital in 2001 was 1.5 and it increased to 2.22 in 2021. Through the field survey, it has been found that Bedia women's income mainly came from agricultural field but, now it depends on secondary field. This capital has three indicators. They are income, banking facilities and savings. Income has increased from 2.42 to 3.14. Banking facility (1.09 to 2.24) also has increased but savings is not significantly increased (0.99 to 1.28). Through the field survey it has been shown that to run a family with the income they earn is very difficult there savings is a luxury for these women.

From 2001 to 2021, the value of social capital has slightly increased. The value transformed from 1.56 to 2.04. Three indicators of social capitals are engagement in politics, importance of these women in family and as a head of the family. These indicators are very much important for developing a society as well as household. The value of these indicators shows women empowerment of Bedia tribal community. The value of Engagement in politics has slightly decreased from 1.07 to 1.04, and other two indicators value has increased 1.31 to 1.57 and 2.30 to 3.52 respectively.

3.2. Influencing Factors of the Transforming Livelihood Capital

Considering the condition of livelihood capital value, a major change has been seen. The result of statistical analysis shows that there is a huge change from 2001 to 2021 of Bedia women's livelihood and also shows how much correlated to one influencing factor with another influencing factor. PCA was used among twelve factors selected from surveyed people. Those factors are family size (x_1), increase of age (x_2), lack of work opportunity (x_3), social network support (x_4), distance from headquarters (x_5), infrastructure development (x_6), transportation facilities (x_7), education level (x_8), brackish water entering (x_9), decreasing of agricultural land (x_{10}), low income level (x_{11}), rules by forest department (x_{12}).

In Sandeshkhali I C.D. block, it can be seen that there are some dominating changing factors of livelihood capital. At first, we computed PCA for twelve factors. Table 6 represents the analysed result, eigenvalues and variance of correlated factors. Six principal components has eigenvalue >1 . The explained variance of the selected PCs are 13.94, 13.06, 10.60, 10.24, 8.69, 8.60 respectively a total of 65.16% of overall variance of the data. The first principal component accounts for 13.94% of the total variance. Therefore the result of PCA shows that brackish water entering (X_9) (-.921) with an eigenvalue 1.67 is the most dominating factor of changing livelihood capitals of Bedia women. Second most dominating factor (PC_2) is family size (X_1) with the value of .824 and eigenvalue is 1.57, decreasing of agricultural land (X_{10}) with the value of -.840 is the third dominating factor. The eigenvalue of PC_3 is 1.27 and fourth, fifth and sixth dominating factors are distance from headquarters, increasing age and infrastructure development with the value of .610, .747 and -.756. The eigenvalue of PC_4 , PC_5 and PC_6 are 1.23, 1.04 and 1.03. Brackish

water entering into agricultural land is a disastrous reason as well as a factor for changing livelihood of Bedia women in Sandeshkhali I C.D. block.

Table 6: Components matrix of the Changing Factors of Livelihood Capitals in Sandeshkhali I C.D. Block

	PC1	PC2	PC3	PC4	PC5	PC6
X ₁	.219	.824	.112	-.152	.143	.049
X ₂	.133	.077	.028	-.199	.747	.172
X ₃	.243	.106	.725	.168	.075	.001
X ₄	.081	-.409	-.094	-.084	.109	.081
X ₅	.189	.384	.016	.610	.055	-.082
X ₆	.134	.052	-.103	-.240	.083	-.756
X ₇	.633	-.595	.250	-.019	-.140	.006
X ₈	.131	-.031	-.052	-.205	.067	.657
X ₉	-.921	-.106	.038	.005	-.001	-.017
X ₁₀	.190	-.071	-.840	.206	.017	-.041
X ₁₁	-.117	-.160	-.042	.785	-.052	.050
X ₁₂	.212	.075	-.029	-.203	-.726	.206
Eigenvalues	1.673	1.568	1.272	1.230	1.043	1.033
% of variance	13.945	13.063	10.604	10.249	8.690	8.609
Cumulative (%)	13.945	27.008	37.612	47.861	56.550	65.160

Table 7 indicates that the twelve influencing components of livelihood capital have changed which is measured by PCA. Five principal components explain 66.65% of the overall variance of the data. The first principal component accounts for 19.95 % of the total variance. The first dominating livelihood capital changing factor is education level (X₈) with the eigen value of 2.39 of Bedia women in Sandeshkhali II C.D. block. The value of PC₁ is -.816. Second influencing factor (PC₂) is family size (X₁) (-.833), third retained

factor (PC₄) is low income level (X₁₁) (.896), next dominating factor (PC₅) is distance from headquarters (X₅) (.850) and fifth influencing changing factor is rules by forest department (X₁₂) with value of .775. This statistical analysis is also reveals the spatial variation of livelihood capital changing factor of Bedia women in Sundarbans region.

Table 7: Components matrix of the Changing Factors of Livelihood Capitals in Sandeshkhali II C.D. Block

	PC1	PC2	PC3	PC4	PC5
X ₁	.115	-.833	.100	.123	-.029
X ₂	.751	-.113	.166	-.216	-.148
X ₃	.282	.441	.301	-.238	.208
X ₄	.175	.789	.047	.155	-.028
X ₅	-.037	.024	-.003	.850	.067
X ₆	-.081	.105	-.573	-.585	.071
X ₇	-.129	-.205	-.572	-.243	.504
X ₈	-.816	-.072	.017	-.111	-.181
X ₉	-.195	-.062	-.148	.419	-.528
X ₁₀	.640	.447	-.030	.022	-.124
X ₁₁	.003	-.037	.896	-.093	.143
X ₁₂	-.074	.038	.011	.170	.775
Eigenvalues	2.394	1.850	1.455	1.236	1.063
% of variance	19.949	15.420	12.123	10.299	8.861
Cumulative (%)	19.949	35.369	47.493	57.792	66.653

Table 8 depicts the PCA on influencing factor of livelihood capital change of Bedia women in Hingalganj C.D. block. Four principal components explain 72.62 % variance of data. The first principal component stands for 28.72% of the total variance of the data and the eigenvalue is 3.45. The first and most influencing changing factor (PC₁) of livelihood capital of Bedia women is lack of work opportunity (X₃) with the value of -.858. Second most dominating factor is education level (X₈) of these women with the value of .865. PC₃ and PC₄ are X₅ (distance from headquarters) (.858) and X₂ (increase age of the women) (.816) respectively with the eigenvalue of 2.64, 1.532 and 1.091.

Table 8: Components matrix of the Changing Factors of Livelihood Capitals in Hingalganj C.D. Block

	PC1	PC2	PC3	PC4
X ₁	.617	.505	.289	.029
X ₂	-.098	.448	.473	.523
X ₃	-.678	-.489	-.170	.164
X ₄	.803	-.199	-.069	.053
X ₅	.151	.218	-.720	.403
X ₆	.730	-.400	.357	-.005
X ₇	.710	.415	-.135	.044
X ₈	.781	-.450	.026	.106
X ₉	-.043	.656	.259	.205
X ₁₀	-.417	-.358	.492	.495
X ₁₁	-.318	.825	.069	-.370
X ₁₂	.065	.299	-.460	.434
Eigenvalues	3.447	2.645	1.532	1.091
% of variance	28.723	22.042	12.763	9.093
Cumulative (%)	28.723	50.765	63.528	72.621

Table 9 represents the PCA on twelve changing factors of livelihood capital in Gosaba C.D. block. Four principal components have been estimated as influencing factors. These factors are explained of 72.621% variance of data. The first principal component accounts for 20.299% of total variance and an eigenvalue is 52.79. Among four factors most dominating factor (PC₁) is transportation facility (X₇) (.915), the second dominating factor (PC₂) is education level (X₈) (-.839). Another two influencing factors (PC₃, PC₄) are brackish water entering (X₉) (-.896) and rules by forest department (X₁₂) (.974) respectively.

Table 9: Components matrix of the Changing Factors of Livelihood Capitals in Gosaba C.D. Block

	PC1	PC2	PC3	PC4
X ₁	-.375	.256	.581	.046
X ₂	.273	-.316	-.045	.339
X ₃	-.277	.318	.044	-.440
X ₄	-.722	.470	.125	-.146
X ₅	.070	-.622	-.356	.072
X ₆	-.010	.445	.026	-.038
X ₇	.915	.049	-.053	.127
X ₈	.011	-.839	.270	.067
X ₉	-.088	.220	-.896	.207
X ₁₀	.654	.397	.545	-.161
X ₁₁	-.068	.032	.030	-.311
X ₁₂	-.192	.051	-.094	.974
Eigenvalues	52.793	27.938	24.688	17.365
% of variance	35.139	18.595	16.432	11.558
Cumulative (%)	35.139	53.734	70.166	81.724

4. Discussion

This study demonstrates that the livelihood capitals strongly influence the change of Bedia women's livelihood both spatially and temporally. It also investigated the factors behind these changes. Every individual capital has a significant role in these changes. Increase value or decrease value of livelihood capital describe the real situation of them. Table 3 depicts block wise overall livelihood capital change from 2001 to 2021. From this study, it is evident that spatio-temporal change of livelihood capital of Bedia women exists in Sundarban region.

Table 10: Block wise capital changing value from 2001 to 2021

Block Name	NCCV	PCCV	HCCV	FCCV	SCCV
Sandeshkhali I	0.18	0.85	0.90	0.32	0.51
Sandeshkhali II	-0.03	0.87	0.78	0.75	0.53
Hingalganj	-0.21	0.84	1.00	0.66	0.48
Gosaba	-0.13	0.68	1.13	0.86	0.41

(NCCV= Natural Capital changing value, PCCV= Physical Capital Changing Value, HCCV= Human Capital Changing Value, FCCV= Financial Capital Changing Value, SCCV= Social Capital Changing Value)

Natural capital has a prominent influence on the change of occupational structure of Bedia women. In this research, agricultural land is the prime indicator of natural capital. Table 14 reveals that natural capital has negatively changed in three blocks among four blocks. This change happened due to the salinity of soil and this is the main problem of the Sundarban. Value of low natural capital shows the engagement in the non-agricultural (Huang et al., 2023). Except Sandeshkhali I C.D. block, it made a negative impact on all other blocks forcing extreme occupational conversion from agricultural labour to daily labour. Result of this research is similar to the research conducted by Kiconco et al., (2025) regarding the relationship between physical capital and sustainable livelihood. This research shows that the improvement of physical capitals such as road infrastructure which helps to access various work opportunity. The development of house type, availability of drinking water and basic sanitation facility indicate the increase the overall income level. Human capital has always played as a key indicator of livelihood change. Human capital has increased significantly; it means that education level, health status and occupational pattern of Bedia women have changed positively. Higher levels of education and good health are the drivers to increase the income of Bedia women. This result disaffirms conclusion drawn by Wang et al., (2021), Kiconco et al., (2025). Good

relation with neighbours is another key indicator for livelihood change (Biswas et al., 2020). For maintaining good behaviour in society, they got chance to join politics. Besides this, they also played role as decision maker in household and acted as the head member of the family indicating the status of women in society as well as their family. . These activities are very much significant for changing livelihood of Bedia women in this study area. While comparing social capitals among four blocks, Sandeshkhali II is in better position than other blocks. Higher value of financial capital generally portrays a higher income for household (Wan et al., 2018). In this research results show that the financial capital of livelihood of Bedia women has meaningfully increased. It also implies that the women are engaged in secondary or tertiary sector. From this point of view, Gosaba block is in far better condition than other three blocks. For this positive change in Gosaba block, tourism was played a pivotal role (Jamal et al., 2022). Tourism opens a door for another way to improve the economic condition reducing the wide scarcity of employment opportunities for women.

5. Conclusions

Livelihood capital is a key factor of determining the real situation of Bedia women in Sundarban region. Human capital has significantly increased. Physical, financial and social capital also slightly increased, but natural capital has decreased. Natural capital is related mainly to agricultural land. In this study area, agricultural land decreased drastically due to brackish water entering in this land. Brackish water converted the land from cultivable to non- cultivable because of increased salinity of the soil. These changes vastly affected these women's livelihood. From the perspective of spatio-temporal analysis of livelihood capital change, a diversity of changes has been seen. The livelihood capital value of Bedia women has significantly increased in Gosaba C.D. block among four blocks from 2001 to 2021. Increases of livelihood capital value indicate a positive condition of their livelihood. Some dominating factors like brackish water entering into cultivated land, education level of the women, family size, low income level, distance from headquarters, lack of work opportunity and rules by forest department have forced to change livelihood capital. For these changing factors, occupational structure of the women has changed from primary sector to secondary sector and they are forced to adapt to their overall change in life.

On the basis of findings, it is suggested that improvement of water availability for cultivation and irrigation system for whole year is required. In Sundarban, there is plenty of water but which is not usable. The availability of drinking water must be improved because in summer season getting drinking water is very tough. For unavailability of drinking water, they are forced to use pond's water as drinking water. Government should Emphasis on infrastructural development, perennial work must be arranged over the year and health sector must be increased for overall development. The most important thing is to increase the availability of work opportunities and making them skilled, which can help them to survive without any fear of extinction.

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Conflict of Interest

The authors declared no conflict of interest in this paper.

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