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Article

Role of livelihood capitals and sustainability on the access to provisioning services: A case study of Gosaba block of Sundarban, India

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Abstract: In marginalized ecosystem-dependent rural communities, access to ecosystem services plays a crucial role in achieving sustainable livelihoods. This study was conducted to find out the influence of various livelihood capital components on the access mechanism for forest-based Provisioning Services (PS) in some selected villages of the Gosaba Block on the fringes of the Sundarban. The contribution of the livelihood capitals to gain access to Provisioning Services (PS) was identified using factor analysis on 160 households, selected through cluster random sampling. The sustainability levels of livelihood capitals were analyzed using the Prescott-Allen method (2001). The natural, financial, social, and physical capitals were significantly below average, while the human capital was close to average. Enhancement of human, physical, financial, and social capital, ease in issuing Biometric Fisherman cards for entering forests, flexibility in borrowing loans, and ecotourism by involving local villagers must be encouraged to enhance forest-based provisioning services in the near future.

Keywords: provisioning services; access level; livelihood capital; sustainability

1. Introduction

Robert Chambers and Gordon Conway formally introduced the Sustainable Livelihoods Concept in 1991. According to the study of Chambers and Conway [1], the Sustainable Livelihoods approach, emphasizes five types of household assets: natural, social, financial, physical, and human capital. These are commonly known as livelihood capital assets which constrain or enhance livelihood opportunities [2]. This approach helps to design development programming at the community level [3]. It also provides analytical basis which helps to apprehend the complex system of rural livelihoods [4]. For empowering and improving the livelihoods of rural households implementation of comprehensive rural development policies will be considered as pillar or bases [5]. Now a days, a Sustainable Livelihoods Approach (SLA) as an asset-based approach can provide holistic and integrated assessments of vulnerability to multiple stimuli [6–8].

In the developing countries Sustainable Livelihoods Frameworks help to know the capital and asset-based livelihoods of people [9]. The asset-based approach is based on “bottom-up” perspective which emphasizes resource mobilization at micro level instead of at macro level [10]. According to the concept adopted by the basic microeconomics that the values of different capitals are non-substitutable [11]. But the value of a capital might be complimentary indicating value of one capital increases or decreases with the increasing or decreasing value of another capital. For relative understanding of sustainable livelihoods substitution and complementarity should be

assessed [12]. Living households and their access to livelihood capitals are one of the determinant factors for assessing development status in rural belts, especially in developing countries [13]. Dehghani Pour et al. [14] investigated the impact of livelihood capitals while choosing livelihood strategies in the Hara Biosphere Reserve. The results of the study indicated that financial, social, and human capitals had a significant positive impact on choosing commercial and mixed livelihood strategies, whereas physical assets positively influenced fishery or livestock livelihood strategy. Similar study was conducted by Forouzani et al. [15] among Karun farmers. The results exhibited that the farmers' social capital was above average, their natural capital was moderate, and farmers' human, physical and financial capital as well as the total assets index were lower than average. Udoh et al. [16] documented the sustainable livelihood assets of farming households in Southern region of Nigeria. The study revealed that farming households had adequate physical, social and natural assets, however deficient in financial and human assets. According to the study of Nowrozi and Hayati [17], to create and achieve a sustainable livelihood for rural households, existing situation should be carefully assessed where emphasis should be given on the views of the heads of households.

Role of Ecosystem services (ESS) approaches are enhancing as it has the inherent capacity for conceptualizing the human-environment relationship [18,19]. Provisioning Services (PS), a kind of ESS, are the material benefits (natural resources) provided by the ecosystem. From the point of view of Rangan in 1997 Access is the term which enables people to get benefit from any resource. It has some political economic aspect in the light of 'access control' and 'access maintenance' which indicates power dominance. Access to PS depends on the available livelihood capitals of the concerned people or the community. How people access benefits from ecosystem services, can be explained through the theory of access. This theory concentrates on people's ability to benefit from natural resources derives not only merely from the legal or property rights but also from a range of social, cultural and economic factors [20]. Scholars emphasized on 'webs of power' while explain the access theory and try to understand how this power can be created, maintained or controlled within broad-scale political economies [21,22]. Chen et al. [23] computed their livelihood assets in sustainable forest commons governance in northwest China. They established the result that livelihoods had changed significantly in the process of sustainable forest governance. Kibria et al. [24] investigated the interactions between livelihood capitals and access to the forest-based provisioning services of the Sundarbans Mangrove Forest in Bangladesh. Access theory put emphasis on how people get benefit from natural resources through a web of means, processes and relations or the access mechanisms [21,22]. Forest areas crisscrossed with rivers, creeks are a potential source of natural resources for livelihood support such as firewood, timber for construction, thatching leaves, honey, and wax collection to local people. Fishery resources in water bodies especially Mud crab is most lucrative in terms of its demand [25–28]. Survey record revealed that 11.3% of population are actively engaged in fishing, 21.1% in fishing related works, 34% employable fisherman and 32% employed fisherman, they all together covering about 98.4% of the habitat [29]. Survey conducted by Das and Mandal [30], revealed that 80% of the

entire population of Sundarban depend fishery activities, including collection of spawn, crab, tiger prawn, and fishes for their livelihood.

Livelihood capitals, such as natural, human, financial, physical and social capital usually influence resource accessibility [31,32]. The size of cultivated land and livestock ownership have significant effect on the livelihood activities of forest dependent villagers [33]. On the other hand, significant impact of availability of working age children and men has been observed on the livelihood strategies [34,35]. Income generation from scientific ESS extraction can help forest conservation [36]. Adequate access to forest resources helps to build up community wellbeing as the marginalized forest dependent communities have limited opportunities for alternative livelihoods [37–39].

Ecosystem services (ESS) approaches are getting importance based on the theory of access through a growing number of research studies [40–43]. On the other hand, some research has examined that emphasis should be given on the composite effect of livelihood capitals in the decision making of households in terms of accessing forest based Provisioning Services (PS) [33,44–46]. Therefore, this study was conducted to examine the influence of different livelihood capital components on the access mechanism for forest-based PS in some selected villages of the Gosaba Block on the fringes of the Sundarban. Accordingly, the research objectives included how much the different components of livelihood capitals impact on forest based PS, determining whether the livelihood capitals are statistically different from average value or not and finally analyzing and categorizing levels of sustainability of livelihood capitals in the study area.

2. Materials and methods

2.1. Study area

Villages of Gosaba Block were chosen as our study area based on its geographic location. The villages are situated just beside the Sundarban Reserve Forest (SRF) in the Indian part and amongst a network of tidal rivers and creecks. (**Figure 1**). River Bidya bounds the region in the west and rivers Gomar and Raimangal in the east [47]. The surveyed villages of Bijoynagar, Birajnagar, Pakhiralay, and Pathankhali belong to Bali II, Rangabelia and Pathankhali GP respectively cover 6.53, 6.15, 4.79, 3.45 square kilometers, and serve 6507, 5328, 3946 and 1414 people, respectively [48]. Major parts of villages of the study area lies proximity to the Sundarban Reserve Forest (SRF) as well as the Sundarban Mangrove Forest (SMF), therefore, the forest is the prime source of livelihood of many of the villagers. However, the surveyed villages of the Gosaba Block lie in the transition area which is the densely settled area located outside the buffer region. My research question is to find out the present status of livelihood capital assets in terms of access to Provisioning Services (PS) of the Sundarban Mangrove Forest. In fact, forest has ecological and economic importance at local, national and global scales. The Sundarbans reserve forest is the pool for resource base for local people as it supplies PS including honey, fish, crabs, nypa leaf, fuelwood and timber [49].

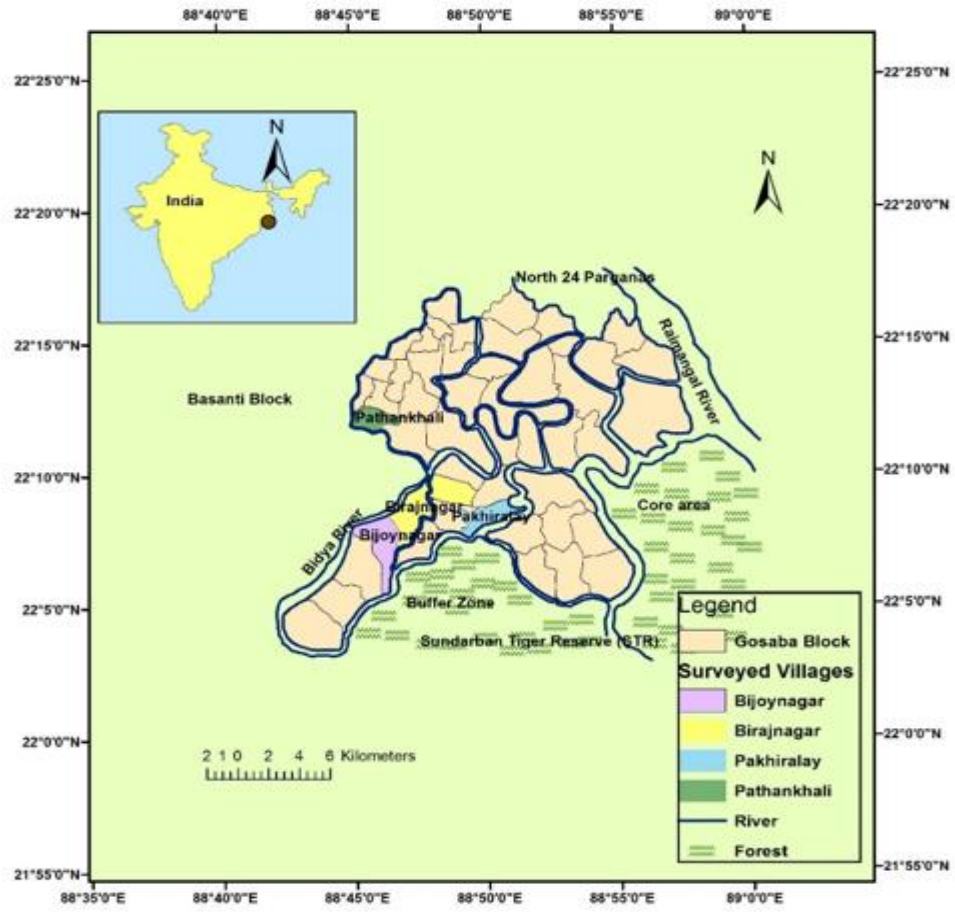

Figure 1. Surveyed villages of Gosaba block of Sundarban, India.

2.2. Methodology

This present descriptive-analytic study uses data collected through direct interviews with households with the help of structured questionnaire within the study area. Samples were selected through cluster random sampling. The clustering was prepared based on the villages adjacent to the SMF. Finally, respondents for a questionnaire were randomly selected through systematic manner with interval five (every fifth house was selected) in the chosen villages. The interviewees were predominantly male because women were usually engaged in home related activities rather than collecting PS from the forest. Exceptions are there in cases of crab collection, fuel wood collection where women may accompany men, thus while interviewing men about this, the views of women were kept in mind. In each village we also conducted a focus group discussion, and interviewed key informants and elderly, experienced people with the help of open-ended questionnaires in order to explore background information on PS collection. With the informal discussion with them we come to identify predominantly six types of livelihood services that were collected by households such as Fishing, Fish and Tiger pawn collection, Crab collection, Crab and fishing, Daily Labor and business. Our sample households (n = 160) were drawn from the villages of Bijoynagar (n = 50), Birajnagar (n = 50), Pakhiralay (n = 30), Pathankhali (n = 30). 50 Sampled Households taken from total Households according to Census [48], and sampled households taken with confidence

level of 95% that the real value is within ± 5% of the measured/surveyed value. Then the Sampled Households taken to the proportion to population size. Finally, Sampled Households were taken for convenience of data Collection. This sample size was deemed sufficient, as there was a negligible variation of quality of life. Livelihood capitals and their components used in the questionnaire are listed in **Table 1**. Secondary data were collected from the Village Directory of India at District and Sub District level, and the Census of India [48].

Table 1. Livelihood capitals and variables taken for different ecosystem services (EES).

Capitals	ESS	Variables taken	Total number of subcomponents
Human	Fishing, Fish and Tiger Prawn* collection, Crab collection, Crab and Fishing, and daily labour.	Average number of family members engaged in particular ESS 1–5 (Score assigned 1) 6–10 (Score assigned 2)	3
	-	Age group 0–14 years (Score assigned 1) 15–59 years (Score assigned 2) 60 and above (Score assigned 3)	-
	-	Level of Education Primary (Score assigned 1) Secondary (Score assigned 2) Higher secondary (Score assigned 3) Graduation (Score assigned 4) Illiterate (Score assigned 5)	-
Physical	-	Asset Level Possession of number of Boats (0-No,1-Yes) Mobile phone (0-No,1-Yes) Solar Plate (0-No,1-Yes) Boat License Certificate (0-No,1-Yes) Fish Net (0-No,1-Yes) Rice Threshing Machine (0-No,1-Yes) Shallow Pump (0-No,1-Yes) Dish T.V (0-No,1-Yes)	8
Natural	-	Possession of land Less than 1 bigha (0.133 hectare) (Score assigned 1) 1–5 bigha (0.133 to 0.668 hectare) (Score assigned 2) 6 to 10 bigha (0.802 to 1.33 hectare) (Score assigned 3)	1
Financial	-	Monthly income Less than Rs.3000 (Score assigned 1) Rs.3000–10000 (Score assigned 2) More than Rs.10000 (Score assigned 3)	1
Social (Data collected from secondary sources)	-	Based on community participation Presence of Agricultural Credit Society Public Distribution System (PDS) Shop Self Help Group	3

Source: primary survey. Tiger Prawn* A large edible prawn of the genus Penaeus with dark bands across the body, Village Directory of India at District and Sub District level, Census of India 2011.

2.2.1. Livelihood capitals and Provisioning Services (PS)

Six types of PS have been identified that were collected by households from focus group discussions. These included Fishing, Fish and Tiger Prawn collection, Crab collection, Crab and Fishing, Daily labor. Livelihood capital variables were then selected based on the individual household interviews, which were the most significant for the collection of the five identified PS. Five livelihood capitals such as human, natural, financial, physical and social capitals were taken into consideration in this regard. However, data related to social capitals are mainly collected from secondary sources. Total numbers of subcomponents taken for human, physical, and natural and financial capitals are three, eight, one and three respectively (**Table 1)**. Rural community engaged in different PS usually has high level of social trust, social cohesion, social participation and other components of social capital. Therefore, we want to find out the contribution of the livelihood capitals for accessing PS by excluding social capitals. Multiple Regression by Stepwise method was performed using SPSS (PASW Statistics 18.0.0) software to identify the contribution of the variables for accessing PS **(Table 2)**.

Table 2. Livelihood capitals and level of access to the provisioning services (PS) of fringe areas of sundarban after performing multiple regression by stepwise method.

Capitals included	Livelihood services included	Variables included	Unstandardized coefficient	VIF (variance inflation factor)	Durbin-Watson
Human	Fishing	Average family members	0.947	1.000	0.200
-	Fish and Tiger prawn collection	-	3.125	1.000	2.605
-	Crab collection	-	1.136	1.000	1.000
-	Crab and fishing	-	2.840	1.000	1.000
-	Daily Labor	-	−4.167	1.000	2.420
-	Business	Age gr. 0–14 yrs.	−0.170	1.000	0.200
Natural	Fish and Tiger pawn collection	Percentage of population possess no land	−1.000	1.000	2.500
-	Crab collection	Percentage of population possess <1 bigha (<0.133 hectare) land	0.117	1.000	0.408
Financial	Fishing	Monthly income >10000	0.208	1.000	0.002

Source: Computed by Authors.

The models were prepared according the following equation as proposed by Dranove in 2012.

$$Y = \beta_0 + \beta_1\chi_1 + \beta_2\chi_2 + \beta_3\chi_3 + \ldots\ldots + \beta_n\chi_n + \varepsilon i \quad (1)$$

here, Y= contribution of the livelihood capitals for accessing PS; β_0 =intercept of the regression equation; $\beta_1, \beta_2, \beta_3 \ldots\ldots \beta_n$ = regression co-efficient; and $X_1, X_2, X_3, \ldots\ldots, X_n$ = independent variables; ε = the regression residual; i = 1, 2, 3, ..., n.

A Variation Inflation Factor (VIF) identified multi-collinearity among the independent variables and it is acceptable as the value will be less than 5 [50–53]. The composite effect measurement is calculated by using descriptive statistics based on the effect size of two or more variables, which are related to one another. Composite effect

size' of a set of predictor variables on an outcome variable computed from a single regression model that uses an arithmetic mean of standardized regression coefficients [54–56]. In this study arithmetic mean of unstandardized regression coefficients have been used as the unit of variables remain identical.

$$\text{Composite effect} = \sum_{i=1}^{N} bi/N \quad (2)$$

here, bi = unstandardized co-efficient value of i-th variable, N = number of significant variables of the respective capital.

2.2.2. Sustainability of rural livelihoods capitals

The sustainability of livelihood capitals was measured by carrying out following steps:

Step 1: An aggregate index based on standardization of each section of the livelihood capitals was carried out using Equation (1). This index was constructed following UNDP (United Nations Development Programmer) Human Development Index where the standardized indicators ranged between 0 and 1.

$$\text{Standardization score} = rij = \frac{X_{ij-xjmin}}{x_{jmax} - x_{jmin}} \quad (3)$$

X_{ij}: The value of the i index; $xjmin$: The minimum i, $xjmax$: The maximum i. i: The index, j: The location X_{ij} is the standardized value of the rural livelihoods capitals related to the j-th entity of the Bijoynagar, Birajnagar, Pakhiralay, and Pathankhali village. X_{ij} is the value of the variable representing the i-th component of rural livelihoods capitals related to the j-th entity.

Step 2: The average values of the standardized data (Appendix A1) for each of the five capitals was considered to get the resulting score as the sustainability index for each capital.

Step 3: For analysis of the status of sustainability of livelihood capitals Prescott-Allen five categories of sustainability levels were executed [57]. Based on the sustainability score from 0 to 1; Prescott-Allen categorized sustainability levels into the following four groups:

Unsustainable where calculated score ranges between 0 and 0.20

Potentially unsustainable (Weak) where calculated score ranges between 0.20 and 0.40

Moderate where calculated score ranges between 0.40 and 0.60

Potentially sustainable (strong) where calculated score ranges between 0.60 and 0.80

Sustainable where calculated score ranges between 0.80 and 1.00

Data were statistically analyzed using SPSS (PASW Statistics 18.0.0) software.

2.2.3. Livelihood capitals based sustainability for accessing PS

Village level sustainability for accessing PS based on livelihood capitals were analyzed by computing the average values of the standardized data (Appendix A1) for each of the four capitals, which were taken into consideration for this study. The geometric mean of different sustainability ($S1$, $S2 \ldots Sn$) classes with rank has been derived to assess composite effect of village level Sustainability Index (SI). This

concept of this methodology was taken from Composite Vulnerability Index (CVI) formulation based on the square root of geometric mean of the ranked variables as adopted by Hajra et al. [58].

$$SI = 4\sqrt{(S1 \times S2 \times S3 \times S4)} \quad (4)$$

Prescott-Allen categorization of sustainability levels has been applied for analyzing the status of village level Sustainability Index (SI).

3. Results and discussion

3.1. Livelihood capitals and provisioning services (PS)

3.1.1. Human capitals

Multiple Regression analysis by stepwise method was performed to investigate the variables that can be significantly related to livelihood services. For analysis of human capital Average number of family members engaged in particular ESS, Age group, Level of Education are taken as variables and different score has been assigned. For Average number of family members of 1 to 5 and 6 to 10 engaged in particular ESS, score 1 and 2 have been assigned respectively. For Age group of 0–14 years, 15 to 59 years and 60 and above years score 1, 2 and 3 have been assigned respectively. For the level of education such as Primary, secondary, higher secondary, graduation and illiterate score 1 to 5 have assigned (**Table 1**). As shown in **Table 2**, human capital is included as the livelihood capitals for accessing the Provisioning Services (PS) after performing the Multiple Regression analysis. Livelihood services, which included under this capital, are Fishing, Fish and Tiger Pawn collection, Crab collection, Crab and Fishing, Daily labor. Average numbers of family members are significantly related to livelihood services such as Fishing, Fish and Tiger pawn collection, Crab collection, Crab and fishing, and Daily Labor. Age group of 0–14 years are significantly related to business only.

Table 2 shows that Average number of family members are positively highly significantly related to Fish and Tiger prawn collection (Unstandardized coefficient 3.125), followed by Crab and fishing (Unstandardized coefficient 2.840), Crab collection (Unstandardized coefficient 1.136), and Fishing (Unstandardized coefficient 0.947) as these jobs are least risk prone. Villagers did not require any formal permissions in case of Tiger pawn collection so that more people could engage in the activity at low risk. They need to stay at forest for a fortnight, which requires work force and catching crab and crab fishing is very lucrative. Contrary to this, Average number of family members and Age group of 0–14 years are significantly negatively related to Daily Labor and business. An increase in the level of education sometimes significantly reduced PS extraction as the new generation want to divert themselves from their ancestral job.

No autocorrelation exists among the livelihood services, which was included after performing multiple regression by stepwise method. Composite effects of livelihood capitals on the access to livelihood services are depicted as positive and negative effect simultaneously (**Figure 2**). Composite scores of effect size suggest that human capital had a positive effect on most of the PS collection except Daily Labor (−4.167). The highest positive effect was found in Fish and Tiger prawn collection

3.125) followed by Crab and fishing (2.840), Crab collection (1.136) and Fishing (0.947) (**Figure 2**).

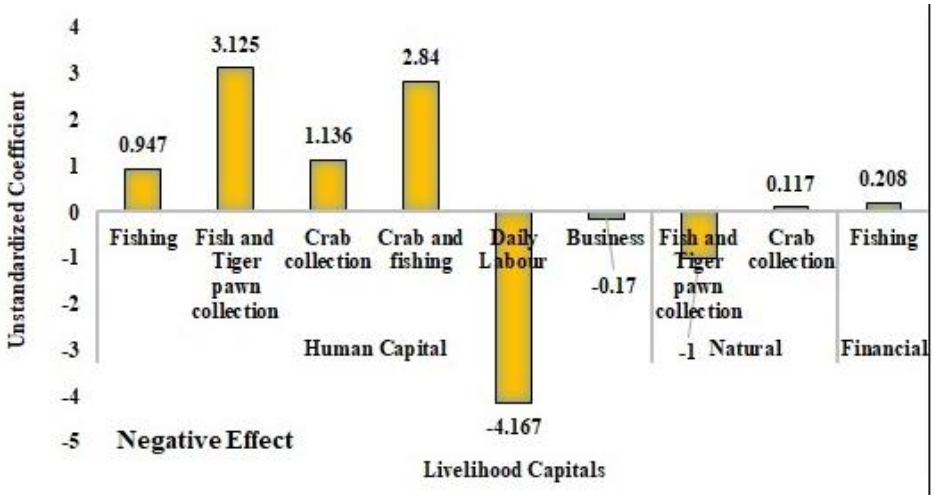

Figure 2. Composite effects of livelihood capitals on the access to livelihood services.

3.1.2. Natural capitals

Livelihood services, which included under this capital, are Fish and Tiger prawn collection and Crab collection. Land ownership was the only natural capital to have significant impact on access to PS. For analysis of Natural capital Percentage of population possess no land and Percentage of population possess <1 bigha (< 0.133 hectare), 1–5 bigha (0.133 to 0.668 hectare), 6 to 10 bigha (0.802 to 1.33 hectare) land are taken as variables and 0 to 3 score have been assigned (**Table 1**). Percentage of population possesses no land and percentage of population possesses less than 1 bigha (0.133 hectares) are significantly related to Fish and Tiger prawn collection and Crab collection respectively. Owned or rented land size consistently influences the livelihood strategy of marginalized people around natural ecosystems [59]. In fact, total land area had a significant and positive relationship with access to PS collection. Percentage of population possess <1 bigha (< 0.133 hectare) land is positively significantly related to crab collection (Unstandardized coefficient 0.117). However, percentage of population possess no land is negatively significantly related to Fish and Tiger prawn collection (Unstandardized coefficient −0.1000) as this PS could easily generate income and does not require lofty amount of lands. If villagers had enough land, they would also use it for commercial purposes. Composite scores of effect size suggest that natural capital had a positive effect on most of the PS collection except Fish and Tiger pawn collection (−1.000). The positive effect was found in Crab collection 0.117) (**Figure 2**).

3.1.3. Financial capitals

Financial capital is included as the livelihood capitals for accessing the Provisioning Services (PS) **Table 2** shows people with monthly income above 10000 is significantly related to Fishing. Financial capital played significant roles in all PS extraction. Households with higher financial capital has the capability to invest more, which resulted in larger income from PS extraction. This concept was supported by

the research work done by Uberhuaga et al. in 2012 in lowland Bolivia. In our study monthly income less than Rs.3000, Rs.3000–10000 and more than Rs.10000 are taken as variables and 0 to 3 score have been assigned (**Table 1**). Financial capital to have a strong positive impact on Fishing (Unstandardized coefficient 0.208). The composite effects of financial capital showed the positive and significant impact on the collection of Fishing 0.208) (**Figure 2**).

3.2. The status of sustainability of livelihood capitals

The sustainability of livelihood capitals in the studied villages **(Table 3)** revealed that human capitals of the villages Pakhiralay and Pathankhali was less than average (0.5, according to Prescott-Allen five categories of sustainability levels). However, villages Bijaynagar and Birajnagar was sustainable and potentially sustainable respectively in terms of human capital. The standardized scores of physical capital exhibited that, in all studied villages, the physical capital score was less than 0.5. Therefore, the sustainability of the studied villages in terms of physical capital is weak and unsustainable. In addition, the natural capital scores of the studied villages represented that villages are either weak or unsustainable (standardized score less than 0.5). In terms of the financial capital the studied villages are completely unsustainable. The social capitals of the studied villages are also weak and unsustainable. Therefore, in general it might be concluded that human capital (except Pakhiralay and Pathankhali) of the studied villages were close to above average, while the physical, natural, financial, social as well as the total capital of these villages was less than average. The overall status of sustainability of livelihood capitals of the villages Bijoynagar, Birajnagar, Pakhiralay and Pathankhali are moderate, week and unsustainable respectively.

Table 3. The scores and sustainability of livelihood capitals in the studied villages.

Village	Human capital	Sustainability	Physical capital	Sustainability	Natural capital	Sustainability	Financial capital	Sustainability	Social capital	Sustainability	Total capital	Sustainability
Bijoynagar	0.882	Sustainable	0.312	Weak	0.065	Unsus-tainable	0.168	Unsustainable	0.286	Weak	0.434	Moderate
Birajnagar	0.717	Potentially sustainable	0.230	Weak	0.203	Weak	0.163	Unsustainable	0.143	Unsustainable	0.360	Weak
Pakhiralay	0.471	Moderate	0.062	Unsus-tainable	0.033	Unsus-tainable	0.062	Unsus tainable	0.286	Weak	0.242	Weak
Pathankhali	0.282	Weak	0.043	Unsus-tainable	0.028	Unsus-tainable	0.028	Unsustainable	0.286	Weak	0.182	Unsus-tainable

Source: computed by authors.

One-Sample *t* test of livelihood capitals **(Table 4)** was performed to analyze whether the mean score of livelihood capitals is statistically different from average value (0.5) or not. As per the mean score and significant level, it is established that except human capitals, all other livelihood capitals as well as total capital were statistically different from average value (0.5) in the studied villages. Natural, financial, social and physical, total capitals were significantly below average at 99%

and 95% confidence level respectively. Indeed, human capitals are not statistically different from average value (0.5).

Table 4. One-sample t test of livelihood capitals (Test value = 0.5).

Livelihood capital	Mean	*t*	Sig.(2-tailed)	Mean difference	95% confidence interval of the difference	
-	-	-	-	-	Lower	Upper
Human	0.588	0.665	0.554	0.088	−0.333	0.509
Physical	0.162	−5.174	0.014	−0.338	−0.546	−0.130
Natural	0.082	−10.170	0.002	−0.418	−0.548	−0.287
Financial	0.105	−11.124	0.002	−0.395	−0.508	−0.282
Social	0.250	−6.986	0.006	−0.250	−0.364	−0.136
Total	0.305	−3.440	0.041	−0.196	−0.376	−0.015

Source: computed by authors.

3.3. The status of livelihood capitals based sustainability for accessing PS

Access required people to use their human, natural, financial, physical and social capital. Computation of village level Sustainability Rank (SR) revealed that village Birajnagar stood as rank 1 followed by Bijoynagar, Pakhiralay and Pathankhali in terms of human, physical, natural and financial capital for accessing PS (**Table 5**). Sustainability status based on Prescott-Allen categorization of sustainability levels revealed that villages Bijoynagar, and Birajnagar are potentially unsustainable or weak, followed by the villages Pakhiralay and Pathankhali, which are completely unsustainable. Sustainable livelihood capitals are expressed in the light of pre-existing physical, natural, financial, social and human resources that possessed by a community or have access to it [60]. Therefore, a society that is incapable of attaining the basic needs of livelihood capital (natural, financial, physical, human, and social capital) becomes unsustainable [61].

Table 5. Village level Livelihood capital based Sustainability Index (SI) for accessing PS.

Village	Human Capital	Rank*	Physical Capital	Rank	Natural Capital	Rank	Financial capital	Rank	Capital based sustainability	Rank of SI (based on geometric mean of different sustainability	SI status (based on Prescott-Allen categorization)
Bijoynagar	0.882	1	0.312	2	0.065	4	0.168	3	0.219	2	Potentially unsustainable/weak
Birajnagar	0.717	1	0.230	2	0.203	3	0.163	4	0.295	1	Potentially unsustainable/weak
Pakhiralay	0.471	1	0.062	2	0.033	4	0.061	3	0.031	3	unsustainable
Pathankhali	0.282	1	0.043	2	0.028	3	0.027	4	0.012	4	unsustainable

Source: computed by authors.

3.4. Diminishing of forest based provisioning services

Access to PS requires not only livelihood capitals but also involvement of villagers, merchants, pirates, forest department (FD), police, rapid action battalion (RAB), and the coast guard is equally significant [24]. In 1973, after the formation of

Sundarban Tiger Reserve (STR), more restrictions were implemented for the fishing communities such as complete ban on fishing in the core area of STR [62]. FD, which falls under the Ministry of Environment and Forest, is in charge of issuing and monitoring Boat License Certificates (BLC) that allows access to the forest based provisioning services. Patrolling along the coastline coast guard was mainly engaged in prevention of illegal activities while RAB occasionally runs operation for capturing the forest-pirates hiding inside the forest. Because of that confrontation between the forest guards and local residents area regular phenomenon [24,63–65]. Villagers had to buy a permit from the FD for entering forest, which costs US $ 2.70 for 7 to 10 days per persons. In reality, however, marginal people often by compulsion enter the forest without permits to avoid paying the fees. If they were caught by FD.officials while entering the core areas they have to pay US $67.42 as penalty. Due to dearth of land holdings and capital assets banks often refuse to give them loan, therefore the villagers should depend on local merchants for money and physical capitals including boats, nets. Because of that, they would either sell the forest-based products to the merchants or share benefits with them as per their agreement. Marginal PS collecting groups also had to buy a permit from a pirate group to maintain their security while collecting PS. However, they would be at the receiving end if they caught by a group other than their permit issuing group and had to pay a lofty amount may be of US $130–US $380 to the pirates [24]. (adopted from Das [66]).

On the other hand, informal sources complains collecting forest based PS would be restricted if the Forest minister visit the forest fringe areas at least for a fortnight. River pollution compels forest fishers to enter the prohibited core area, leading to human tiger conflicts, and human killings by tigers [67]. The man-animal conflicts are incumbent upon socio-economic and political landscapes [68]. Moreover, due to lack of integration with the forest department, federal income generated scheme, such as Mahatma Gandhi National Rural Employment Guarantee Act, 2005 or NREGA, has failed to either provide livelihood security or provide ecosystem benefits [69,70]. Arbitrary boundary between the core and the buffer areas often causes man-animal conflict while the victims entering the core areas by violating laws. Frequently occurring disasters because of rapid climatic changes causes livelihood challenges to the maximum extent [65,71], which in turn forces people to depend on the forest resources merely. However, many of the villagers are gradually trying to switch over their PS due to administrative entanglements as well as autocracy of pirates and local merchants, moneylenders.

Village level sustainability in terms of livelihood capitals revealed that human capital is quite satisfactory, however physical capitals or asset level related to forest based PS such possession of number of boats, fishnet, Boat License Certificate (BLC) should be enhanced with the help of the local administration. For maintaining these possessions, financial capital is required. If the villagers have adequate amount of financial capital in their hands, they should not become reliant on the wealthy merchants who could exploit them by providing the physical items [72]. If the marginal villagers have natural capitals such as landownership they could farm shrimp, crab or poultry had less need to be engaged in risky activities (fishing, honey collection) to survive. The social capitals of the studied villages are also unsustainable; therefore, it requires building up high level of social trust, social cohesion, social participation

and other components of social capital within the community level. Diffusion of social learning and sharing can greatly influence access into the PS within a socio-ecological context [73].

For being a transboundary biodiversity region, the Sudarban faces challenges through the several federal ministries and the state government departments. On the other hand, environmental concerns become a burning issue of mainstream political dispute and action now a days [74]. Therefore, disentanglements regarding forest related administrative issues should be sorted out. Fast issuing of Biometric Fisherman card for entering forest, ease of borrowing and repayment of loan to the marginal people, participatory management, ecotourism by involving local villagers must be encouraged for the enhancement of forest based provisioning services in the near future.

4. Conclusion

'Ability to benefit' from PS is indispensable for the welfare of the forest based ecosystem dependent communities. Components of each livelihood capital influences households' access to specific PS in different levels. Composite scores of effect size of the present study reveals that human capital had a positive effect on most of the PS collection. With the enhancement of human capital villagers can easily access the forest based resources. The survey of the status of the livelihood capitals in the studied villages indicated that except human capital, all other capitals associated with accessing PS, show deprived performance. Therefore, the village Bijoynagar and Birajnagar become potentially unsustainable followed by village Pakhiralay and Pathankhali. Amplified human capital and improved physical, financial and social capital help the collectors to strengthen their activities into the profitable PS. Natural capital had positively associated with cultivation in household premises. Composite scores of effect size recommend that natural capital had a positive effect on most of the PS collection except Fish and Tiger pawn collection (−1.000). Financial capital eased the extraction of PS except those where higher investment of other capitals would not be required. In terms of village level sustainability of livelihood capitals based on five capital analysis village Bijoynagar was in moderate state, followed by the village Birajnagar, Pakhiralay and Pathankhali which are weak and unsustainable respectively. It seems to be the high time to keep the attention for policy makers, planners, and administration for promoting human, physical, social capital in the studied area that would be vital in changing the access to the PS. To protect a certain PS vibrant understanding of the access-livelihood capital nexuses as well as disentanglements regarding forest related administrative issues is extremely important which might protect forest based ecosystem services from over exploitation by ensuring sustainable local wellbeing.

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Appendix

Table A1. Standardized Data for Livelihood Capitals and Sustainability Index Calculation.

Capitals	ESS	Village	Total Score obtained based on variables taken for different ecosystem services	Standardized Score	Average of standardized score for each capital
Human	Fishing	Bijoynagar	17	1.000	
		Birajnagar	17	1.000	
		Pakhiralay	0	0	
		Pathankhali	0	0	
-	Fish and Tiger Pawn collection	Bijoynagar	15	0.600	
		Birajnagar	20	0.826	
		Pakhiralay	15	0.826	
		Pathankhali	24	1.000	
-	Crab collection	Bijoynagar	17	1.000	Bijoynagar
		Birajnagar	15	0.882	0.882
		Pakhiralay	0	0	Birajnagar
		Pathankhali	0	0	0.717
-	Crab and Fishing	Bijoynagar	20	1.000	Pakhiralay
		Birajnagar	18	0.900	0.471
		Pakhiralay	0	0	Pathankhali
		Pathankhali	0	0	0.282
-	Daily labour	Bijoynagar	17	0.695	
		Birajnagar	17	0.695	
		Pakhiralay	24	1.000	
		Pathankhali	17	0.695	
-	Business	Bijoynagar	15	1.000	
		Birajnagar	0	0	
		Pakhiralay	15	1.000	
		Pathankhali	0	0	
Physical	Fishing	Bijoynagar	7	0.411	
		Birajnagar	6	0.352	
		Pakhiralay	0	0	Bijoynagar
		Pathankhali	0	0	0.312
-	Fish and Tiger Pawn collection	Bijoynagar	7	0.260	Birajnagar
		Birajnagar	6	0.217	0.230
		Pakhiralay	3	0.086	Pakhiralay
		Pathankhali	5	0.173	0.062
-	Crab collection	Bijoynagar	6	0.352	Pathankhali
		Birajnagar	5	0.294	0.043
		Pakhiralay	0	0	
		Pathankhali	0	0	
-	Crab and Fishing	Bijoynagar	6	0.300	
		Birajnagar	6	0.300	
		Pakhiralay	0	0	
		Pathankhali	0	0	
-	Daily labour	Bijoynagar	3	0.086	
		Birajnagar	6	0.217	
		Pakhiralay	3	0.086	-
		Pathankhali	3	0.086	
-	Business	Bijoynagar	7	0.466	
		Birajnagar	0	0	
		Pakhiralay	3	0.200	
		Pathankhali	0	0	

Table A1. (*Continued*).

Capitals	ESS	Village	Total Score obtained based on variables taken for different ecosystem services	Standardized Score	Average of standardized score for each capital
Natural	Fishing	Bijoynagar	3	0.176	
		Birajnagar	2	0.117	
		Pakhiralay	0	0	
		Pathankhali	0	0	
-	Fish and Tiger Pawn collection	Bijoynagar	2	0.043	
		Birajnagar	2	0.043	
		Pakhiralay	1	0	
		Pathankhali	3	0.086	
-	Crab collection	Bijoynagar	1	0.058	Bijoynagar
		Birajnagar	1	0.058	0.065
		Pakhiralay	0	0	Birajnagar
		Pathankhali	0	0	0.203
-	Crab and Fishing	Bijoynagar	1	0.050	Pakhiralay
		Birajnagar	2	0.100	0.033
		Pakhiralay	0	0	Pathankhali
		Pathankhali	0	0	0.028
-	Daily labour	Bijoynagar	1	0	
		Birajnagar	1	0	
		Pakhiralay	1	0	
		Pathankhali	3	0.086	
-	Business	Bijoynagar	1	0.066	
		Birajnagar	0	0	
		Pakhiralay	3	0.200	
		Pathankhali	0	0	
Financial	Fishing	Bijoynagar	5	0.294	Bijoynagar
		Birajnagar	6	0.352	0.168
		Pakhiralay	0	0	Birajnagar
		Pathankhali	0	0	0.163
-	Fish and Tiger Pawn collection	Bijoynagar	3	0.086	Pakhiralay
		Birajnagar	3	0.086	0.061
		Pakhiralay	3	0.086	Pathankhali
		Pathankhali	3	0.086	0.027
-	Crab collection	Bijoynagar	3	0.176	
		Birajnagar	3	0.176	
		Pakhiralay	0	0	
		Pathankhali	0	0	
-	Crab and Fishing	Bijoynagar	2	0.100	
		Birajnagar	3	0.150	
		Pakhiralay	0	0	
		Pathankhali	0	0	-
-	Daily labour	Bijoynagar	3	0.086	
		Birajnagar	6	0.217	
		Pakhiralay	3	0.086	
		Pathankhali	3	0.086	
-	Business	Bijoynagar	4	0.266	
		Birajnagar	0	0	
		Pakhiralay	3	0.200	
		Pathankhali	0	0	

Source: primary survey.