Fishers' livelihood diversification in Bhagirathi–Hooghly stretch of Ganga River in India

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For the resource-poor fishers, livelihood diversification is a strategy to cope with the uncertainties and inadequateness of fisheries as a profession. The present study is an attempt to assess the socio-economic conditions together with livelihood diversification of fishermen households of the Bhagirathi–Hooghly stretch of Ganga River. Data were collected by personally interviewing 500 fishermen from Sagar to Farakka (560 km stretch) in West Bengal using survey schedules in 2016. Analysis of data indicated that the socio-economic conditions of fishermen households were not encouraging. Fishing is the main occupation of around 88.60% of fishers and overall, fishing contributes about 70.30% to the total income of the family. Average number of income-generating activities per household ranged from 1.43 in the lower stretch to 1.79 in the upper stretch. Further, it was found that not only the average household income and number of income sources were limited, their level of diversification was also quite low. The monthly income of a household was found to be Rs 9391. The income is higher in the lower stretch because of higher catch and high value fish in the catch. Fishery as an only profession is unable to provide a decent life. The study also revealed that among other factors, the Simpson index contributes positively and significantly towards per capita income of the fisher households. However, in the absence of suitable alternative opportunities, the resource is under pressure. Government needs to develop appropriate strategies to facilitate successful livelihood diversification. Facilities may be created for non-fishing activities like fish marketing kiosks, cloth weaving facilities, agro-processing in fruit orchard areas, e-rickshaws and so on. Fishers may be trained in other income-generating activities like carpentry, embroidery, dress making, driving, etc. for better livelihood.

Keywords: Diversification, Ganga, India, occupation, riverine fisher.

THE Ganga River system is a rich ecosystem which supports about 10–13 million riverine fisher folk and about 300 freshwater fish species[1]. The system provides livelihood and nutritional security to millions of people, however, post independence, the river has been mainly equated to irrigation, water supply and hydro power only. Riverine fisheries are completely being ignored[1]. The report further says that large dams, barrages and hydropower projects adversely affected the river flow and impacted hydrological connectivity between rivers and wetlands. In addition to this, alarming levels of pollution, riverfront encroachment, rampant sand mining and unregulated overexploitation of fish resources are causing its fishery resources to rapidly decline. Fisheries is a good indicator of the biophysical, ecological and social integrity of the river basin. Thus, declining fisheries in the Ganga river system show its poor ecological and social integrity.

Livelihood diversification is a process by which households engage in multiple income-generating activities. It is widely seen in the academic literature and international development arena as a strategy for mitigating risk and reducing vulnerability[2]. It is an important strategy to help the rural people to come out of poverty. A study of Food and Agriculture Organization (FAO) on farming systems and poverty has suggested that diversification is the most important source of poverty reduction for small farmers in South and South-East Asia[3]. Some of the studies available on fishers livelihood diversification are from Kenya[4], Ghana[5], Brazil[6], Nigeria[7,8] and Laos[9]. However, such studies are scarce in India. In the Bhagirathi–Hooghly stretch of the Ganga River, a sizeable population of fishers depend on fishing for their livelihood and daily sustenance. But, due to declining fisheries they are facing hardships in managing their livelihood. Against this backdrop, this study examined the socio-economic conditions and nature and extent of livelihood diversification of fishers' households in Bhagirathi–Hooghly stretch of Ganga River across different stretches.

Primary data were collected by personally interviewing the fishermen using open ended survey schedules. The study was conducted during the month of March–May and September–October 2016 covering a total of 500 fishers from 32 sampling sites of a 560 km stretch from Sagar to Farakka in West Bengal. Multi-stage stratified random sampling design was adopted to select the fishermen from all the three stretches.

The study area was divided into three stretches depending upon the width of the river and intensity of fishery activities (Table 1). The lower stretch is from Sagar to Dakshineswar. Here the river is wide and fishing activity is quite intense. The upper stretch is from Nabadwip to Farakka, where the river is comparatively narrower. The middle stretch is from Dakshineswar to Nabadwip, where the width of the river and fishing intensity is medium.

The extent of livelihood diversification was analysed from three points of view: (i) number of sources of income, (ii) shares of fisheries and non-fisheries income in the total household incomes, and (iii) constructing appropriate diversification indices. Level of diversification is measured by various types of concentration and

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Table 1. Sampling sites in the three designated zones

Stretch	Distance (km)	No. of sampling sites	Name of the sites	Number of households
Lower stretch	0–154	8	Sagar light house, Diamond Harbour, Hanrar Khal, Noorpur/Roy Chak, Burul, Godakhali, Jagannathpur 11 No. Lockgate (Uluberia), Baranagar/ Bally/Barendrapara	100
Middle stretch	154–278	10	Barrackpore/Nawabganj/Debitala, Halisahar (Acharjeepally, Lalkuthi, Sarkarpara), Sannyalchar, Medgachi, Hatathpally (Kalyani), Shamsundarighat, Khasbati, Hooghly ghat, Tribeni, Balagarh	200
Upper stretch	278–560	14	Katwa/Moraghat, Rajachar, Palassey (Ramnagar), Sundarpur Reach, Hotnagar, Chowrigachha, Lalbagh, Jiaganj, Jangipur, Raghunathganj, Sarala Kishorepur, Hasipur, Putimari, Farakka	200
Total	560	32		500

diversification indices[10,11]. Five different measures of diversification used in the study are described below.

$$\text{Herfindahl Hirschman index } = \sum_{i=1}^{N} P_i^2,$$

where N is the number of economic activities and P_i is the share of ith activity in total household income.

The Herfindahl Hirschman index (HHI), is a widely used measure of income/livelihood concentration mentioned in the literature[12]. This index denotes the extent to which a particular household's income is obtained from a few or more number of activities. The index varies from 0 (perfect diversification) to 1 (perfect concentration). Thus, a lower index signifies higher diversification.

$$\text{Simpson index, } D = 1 - \sum_{i=1}^{N} P_i^2.$$

Simpson index (SI) is a measure of diversification and most widely used[13]. It is inverse of HHI. This index also varies from 0 to 1, however, 1 indicates perfect diversification and 0 indicates perfect concentration. Thus, an increase in the index signifies higher diversification

$$\text{Ogive index (OI)} = \sum_{i}^{N} \frac{\left(P - \frac{1}{N}\right)^2}{1/N}.$$

The diversity of a household would be higher when its economic activities are more equally distributed among its sectors[14]. With an equal distribution, the Ogive index (OI) equals 0 as P_i is equal to $1/N$. This implies that the household has got perfect diversity. A higher value indicates more unequal distribution. However, the measure is sensitive to the level of sectoral aggregation (i.e. the chosen number of sectors, N) used to organize the data[15]. The value of N defines a household's economic structure being either diverse or specialized, both relative to other households' over time[16,17]. Both Ogive and entropy indices yield similar diversity rankings.

$$\text{Entropy index (EI)} = \sum_{i=1}^{N} P_i \log_n \left(\frac{1}{P_i}\right) = -\sum_{1}^{n} \log_N P_i,$$

where log is natural logarithm.

The entropy measure compares the existing income distributions among the income-generating activities to an equi-proportional distribution. Higher entropy index values indicate higher relative diversification, while lower values indicate relatively more specialization[15]. The minimum value of 0 (maximum specialization) would occur if household gets the total income from one activity. On the other hand, if income is distributed equally among the N sectors, the index would be highest. If the index is maximum there exists perfect diversity.

$$\text{Composite entropy index (CEI)} = \text{EI} \times \left(1 - \frac{1}{N}\right).$$

Since $-\log_N P_i$ is used as weights, it assigns more weight to lower values and less weight to higher values of P_i. The index 0 indicates perfect concentration.

A multiple linear regression analysis was employed to identify the factors affecting the per capita income of the fisher households. For this, data of the upper stretch were utilized. At the lower stretch the river is quite wide leading to more fishing area and both fresh water and estuarine fishes are available in this stretch. Moreover, high value fishes like mullets, sea bass, hilsa, prawns and shrimps are available in large quantities here. Thus, the fishermen of this stretch get more income from fisheries itself and their per capita income is more than that of the upper and middle stretches although the diversification is less. Therefore the effect of independent variables including livelihood diversification will be masked in this stretch. Some of the conditions of lower stretch also prevail in middle stretch. Hence, regression analysis was

Table 2. Factors affecting per capita income

Variables	Coefficients	Standard error	*t* Stat	*P*-value
Intercept	7.781749	0.186662	41.68896	6.8E-164
Simpson index	0.137143	0.060452	2.268612	0.023723
Family size	–0.17352	0.011183	–15.5161	1.62E-44
Age_respondent	0.016798	0.007899	2.126606	0.033948
Age_respondent^2	–8.9E-05	8.24E-05	–1.07936	0.280952
Education_respondent	0.019651	0.004706	4.176143	3.51E-05

$R^2 = 0.63$, $N = 200$.

Table 3. Socio-economic status of the respondent fishermen

Parameters	Lower stretch (100)	Middle stretch (200)	Upper stretch (200)	Entire stretch[#] (500)
Average age (years)	42.13	50.24	44.77	46.43
Average family size (numbers)	4.04	3.91	4.21	4.06
Illiteracy (%)	50.00	36.00	40.00	40.40
Can read and write (%)	9	17	9.5	12.4
Average years of schooling	2.39	1.39	1.58	1.66

Figures in the parentheses indicate the number of family surveyed. [#]Weighted average of three stretches.

Table 4. Average number of income sources of the fishermen households in different stretches*

Lower stretch	Middle stretch	Upper stretch	Entire stretch[#]
1.43	1.57	1.79	1.63

*Taking into account all the family members. [#]Weighted average of three stretches.

done taking data from the upper stretch only. The following model was selected

$$Y = a + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + u,$$

where Y is the per capita income in rupees; a the constant term; b_i's the regression coefficients; X_1 the Simpson index; X_2 the family size in numbers; X_3 the age of the respondent in years; X_4 the square of X_3; X_5 the education of the respondent (years of schooling) and U is the random term assumed to follow normal distribution with zero mean and constant variance σ_e^2.

Results of this multiple linear regression analysis are reported in Table 2.

Nearly every village along the sides of the river has fishermen earning their livelihood through fishing. There is no census data available regarding fishers specifically involved in capture fisheries in the entire studied stretch. However, there are some earlier data related to specific gear employed by the fishers. Hilsa fishery is the most important one in the studied stretch. It is reported that an estimated 20,390 fishermen are involved in hilsa fishery in lower stretch below Dakshineswar, whereas there are about 5600 hilsa fishermen in the stretch of Dakshineswar to Farakka in the middle and upper stretches[18].

Analysis of our study data indicated that the socio-economic conditions of the fishermen households are not encouraging (Table 3). The years of schooling as an indicator of education level of the head of the household, is only around 2 (1.66) and majority of them are illiterate (40.40%). The average size of the family is around 4. To the 89% respondent fishermen, fishing was the primary occupation. The figure ranged from 84.5% in the upper stretch to 92% in the lower stretch. Fish vending, ferry service, tourism, driving, labour, petty business and rickshaw van pulling were the other sectors of primary occupation.

Overall, contribution of fishing occupation in the total income was estimated to be 70.30%. Generally one member of the family is engaged in fishing and in the lower zone, fisherwomen also play an active role in fishing. The fishermen do fishing for 5–12 h daily, depending upon the season.

Table 4 shows that fishermen of all the stretches have diversified income sources, but the extent varies. Average number of income-generating activities per household ranged from 1.43 in the lower stretch to 1.79 in the upper stretch. In the upper stretch, the number of income sources was highest (1.79), followed by the middle (1.57) and lower stretch (1.43). In the upper stretch, more number of fishermen households were involved in non-fishing activities. At this stretch, fisheries alone could not provide sufficient livelihood, hence, fishermen are engaged in other income-generating activities. In general, in the lower stretch fisheries provided sufficient income which discouraged the fishermen to diversify their portfolio.

The magnitude and proportion of farm and non-farm incomes in the total income by households of each stretch are presented in Table 5. Fisheries remain the most important source of livelihood across all the stretches. The

Table 5. Contribution of fisheries towards household income*

	Lower stretch	Middle stretch	Upper stretch	Entire stretch#
Total monthly income (Rs)	10,226	9,380	8,984	9,391
Income from fishing (Rs)	7,759	6,758	5,868	6,602
Contribution of fishing (%)	75.88	72.04	65.32	70.30

*Taking into account all the family members. #Weighted average of three stretches.

Table 6. Different non-fishing sources of livelihood of the fishermen household*

Economic diversification (% of household)	Lower stretch	Middle stretch	Upper stretch	Entire stretch#
Labour	17.00	24.00	25.00	23.00
Driver	2.00	1.00	2.50	1.80
Self employed	7.00	8.00	20.50	12.80
Service	9.00	4.50	7.50	6.60
Business	3.00	6.00	10.50	7.20
Fish vending	2.00	7.50	3.00	4.60
Rickshaw puller	3.00	2.50	3.00	2.80
Others	0.00	3.50	4.50	3.20

*Taking into account all the family members. #Weighted average of three stretches.

study revealed that on an average, 30% of the total household income is derived from non-fisheries sources. However, these proportions varied widely across different sectors. In the lower and middle stretches, contribution of fishing in the total income of the household was found to be 75.88% and 72.04% respectively. In the upper stretch, fisheries contribution was 65.32%. Overall, fishing's contribution to the total income was estimated to be 70.30%.

A small amount of income comes from labour wages, service, petty business, etc. In the season of less catch, youth generally engage themselves in labour wage works or rickshaw van pulling to earn their livelihood. Members of 20.5% of the households are found to be engaged in self employed activities in the upper stretch and overall the figure is 12.8%. Table 6 shows that in the upper stretch, more number of fishermen households are involved in non-fishing activities as fishing alone could not suffice as a livelihood option. In the upper stretch more number of households were engaged in labour work, self employment avenues and business. Reliance on non-fisheries sources of income, particularly by the labourers, in the upper stretch is also evident from Table 6.

Five types of diversification indices were used to measure the level of livelihood diversification in the study area. Values of all these indices are shown in Table 7. The table reveals that the level of diversification, measured by Simpson index (D), for all the stretches is low. Other indices also have more or less similar values.

The multiple linear regression analysis was employed to identify the factors affecting the per capita income of the fisher households. The results of the regression are provided in Table 2.

Table 2 reveals that Simpson index, family size, age of respondent, education of respondent are the factors which affect the per capita income significantly. Among them, Simpson index contributes positively, which implies that as the livelihood of the fisher is diversified, the per capita income increases. In the upper stretch, income from fisheries is less due to less catch and fishers have to go for other income sources. Hence fishermen households with more livelihood options are better off. Education of the respondent came out as a highly significant factor for variation of personal income. Age contributes positively up to a certain point, then it contributes negatively as evident through the negative coefficient of age^2. Therefore, over-aged respondent fishers could not contribute sufficiently towards family income.

The study showed that fishery was the only profession to a sizeable number of fisher folks. However, it is unable to provide a decent life. Several ICAR-CIFRI studies show that the fish catch from the river Ganges is declining[19]. ICAR-CIFRI recorded that the average catch per kilometer of the river at Allahabad, declined to 362 kg km^{-1} during the 2000s from 1344 kg km^{-1} during 1950s. There has also been a noticeable shift in species composition in catches. The catch of major carps declined drastically; hilsa catch also decreased. Exotic fishes like tilapia and common carp have started appearing in the 2000s. The IUCN report[20] also emphasized that overexploitation was one of the causes of dwindling of hilsa catch.

Vass *et al.*[21] also observed that the increased fishing pressure due to higher demand, followed by indiscriminate fishing methods, increased fishing effort leading to over exploitation, gradually led to a drop in the catch per unit effort. With the decreasing natural stocks, fishers had to increase fishing efforts for whatever species or size of fish available to support their livelihoods.

Therefore, in the absence of suitable alternate opportunities, fishing is under pressure. There is a need for

Table 7. Livelihood diversification indices

Stretch	Herfindahl Hirschman	Simpson	Ogive	Entropy	Composite entropy	Per capita monthly income (Rs)
Lower	0.7978	0.2022	2.1874	0.3825	0.2026	2893.8
Middle	0.7407	0.2593	1.9627	0.4964	0.2593	2576.3
Upper	0.6921	0.3079	1.7676	0.5427	0.3046	2328.7
Overall	0.7328	0.2672	1.93	0.4919	0.266	2541.4

shifting a sizeable chunk of fishers from fishing profession to non-fishing activities. However, without alternate livelihoods, any form of management plans will not succeed. Facilities may be provided for fish marketing kiosks, cloth weaving, agro-processing in fruit orchard areas, e-rickshaws and so on. They may also be trained in some other income-generating activities like carpentry, embroidery, dress making, driving, etc. Some more alternatives include working with river management authorities, conservation agencies, ecotourism, agriculture, etc.

The government should develop appropriate strategies, especially for the resource-poor fishers' households to facilitate successful livelihood diversification. Education being an effective tool for this purpose, providing education and skill development training for poor fishers would have a large impact on their ability to diversify livelihood options.

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