Journal of Biology and Today's World 2023, Vol.12, Issue 01, 001-006

Research Article

Household-Level Economic Penalties Resulted from Climate Change-Induced Events among the Coastal Fishers of Bangladesh

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Received: 28-Nov-2022, Manuscript No. JBTW-22-81589; **Editor assigned:** 02-Dec-2022, PreQC No. JBTW-22-81589(PQ); **Reviewed:** 23-Dec-2022, QC No. JBTW-22-81589; **Revised:** 30-Dec-2022, Manuscript No. JBTW-22-81589(R); **Published:** 06-Jan-2023, DOI:10.35248/2322-3308-12.1.004.

Abstract

Climate Change Induced (CCI) calamities have immense negative impacts on coastal fishers' livelihoods by damaging their household and fishery-related assets, which triggers cyclic poverty among them. This study aimed to identify household level economic penalties due to CCI calamities among the coastal fishers of Bangladesh. A cross sectional study was conducted among 338 coastal fishers living in 11 coastal districts using a random sampling technique. Males outnumbered females (84.6% *vs.* 15.4%), with nearly all (99.1%) living below the poverty line. On average, coastal fishers had to struggle against at least three (3.12 ± 1.28) CCI catastrophes with considerable losses per incidence {Domestic Asset Loss (DAL): 38318 ± 33071; Loss in Fisheries (LIF): 19236 ± 20486} within the past five years. CCI incidences such as Severity of Disaster (SoD), Longevity of Disaster (LoD), Winter Cold Shock (WCS), and water flow were significantly associated with DAL (95% C.I., p<0.05). Similarly, SoD, WCS, water flow, and Sea Waves during Storms (SWDS) were also significantly associated with the impoverished status of coastal fishers in Bangladesh. Climate-resilient coastal management and livelihood improvement policies implemented by the relevant authorities could reduce impending economic penalties for coastal fishing communities.

Keywords: Climate change-induced events • Economic penalty • Coastal fishers

Introduction

Bangladesh has been identified as one of the 9th most vulnerable disasters affected and nearly 112 million people have directly affected by the Climate Change (CC) induced catastrophic calamities within the last two decades [1]. This region has been subjected to recurring hydro climatic disasters [2-4]. However, the frequency and severity of CC posed incidents have been assumed in growing and adversaries likewise [5-8]. The country has also been considered highly susceptible to sea level rise because of its low-laying geographic settings at the edge of the Bay of Bengal, coastal floodplain and low lying topography [7-13]. Trends analysis have been displayed a rising tendency of temperature [14,15] and rainfall with seasonal and spatial variabilities [14,16,17] have been deemed to have high surges, sea wave, high tidal bores and fluctuation, inundation of salinity intruded water on the coastline water bodies and flood plain [7,11,12,16,18,19]. The variability of climatic factors and its changes, impacts, and vulnerabilities, are causing widespread distress on coastal dwellers [8,20-24]. Recent studies show that the CCI events have much influence on the livelihood assets of Small Scale Fishers (SSF) and coastal fishers [20,25-29]. The fishers have suffered of extreme poverty and poverty influenced by different seasonal vulnerability and climatic induced shocks and hazards [20,25,27-30]. The above miseries and cruelty lead them to pushing and pulling into poverty [20,31]. CC induced extreme events such as sea level rise, temperature fluctuations, increased rainfall, cyclones, storms, coastal-bank erosion, inundation, and heavy flash floods adversely affected the coastal fisher's and non-fisher's livelihoods, especially in terms of economic losses [11,12,20,31-33]. Higher salinity intrusion levels have negative effects on coastal agriculture, cultivation, and aquaculture, as well as domestic and industrial water use, and overall production and development [13,34-38]. These disaster-originated incidences have also created severe vulnerability of losing domestic assets including standing cash crops, household's resources of the coastal extreme poor, poor and marginal inhabitants of the 16 coastal districts [7,8,12,14,20,22,23,39-41]. Extreme CC-induced events have a significant negative impact on their major livelihood elements, including damage of household assets, reduced agriculture production, extinction of livestock, and loss in fisheries, putting them into socio-economically impoverished status, health risks, and food insecure [12,14,20,22,37]. Every year CC-induced adversaries and events make them asset loss, jobless and income vulnerable by creating unfavorable environment for deep sea and off-shore fishing, consistently make coastal fishers paralyzed and inactive [8,11,22,42-45]. Notably, most studies have used different social, or policy-level perspectives and approaches to explore their ideas. The limited number of studies has been carried out showing coastal dwelling fishers' household-level economic penalties due to the severity and frequency of the CC induced disasters based on fishers' insights in relation to their impoverished livelihood status. Moreover, the household-specific livelihood approach of the coastal fisher communities living in about 710-kilometer-long coastline zones of Southern Bangladesh ranging from Cox's Bazar to Satkhira has not been explored together in the previous studies. In addition, coastal dwelling fisher communities have been evidently the frontline victims of CC-induced catastrophic disasters [7,8,11-13,21,23,24,33,36,38,40,41] and it has also been a government concern to manage coastal zones and to develop livelihood status by escaping them from the curse of poverty line. Therefore, it is necessary to identify the climatic factors responsible for the coastal fishers' household-level different assets' losses and other predictors that drive them into a vicious poverty cycle or interfere with their getting out of impoverished socio-economic status. The principal objective of this study was to identify financial penalties equivalent to the damages of households and fisheries assets resulting from Climate Change-Induced (CCI) calamities and adversities of environmental weather events among the coastal fishers of Bangladesh.

Materials and Methods

Sample size estimation and data collection

There were 32,115 registered male and female fishers living in the selected 74-Unions within the 6 kilometers coastal zones with nearly 30% prevalence [46]. Thus, a list of 9,526 registered fishers had obtained from the Department of Fisheries (DoF) to include the study participants. A national representative sample size was measured assuming a 30% prevalence, 5% precision at 95% confidence interval level using following formula [46,47]. n0= {(Zn/2)2P (1-P)}/(e2); and corrected formula used for resizing sample for finite population (N=9526) was, n= (n0-N)/(N + n0-1);

So, corrected sample size for finite population was 312. Allowing 10% non-response rate, the ultimate sample size was 343. After collecting all the estimated data, information of 5 filled-up questionnaires were removed due to valid reasons. Therefore, raw data gathered from 338 fishers were considered for statistical analysis as shown in Figure 1.

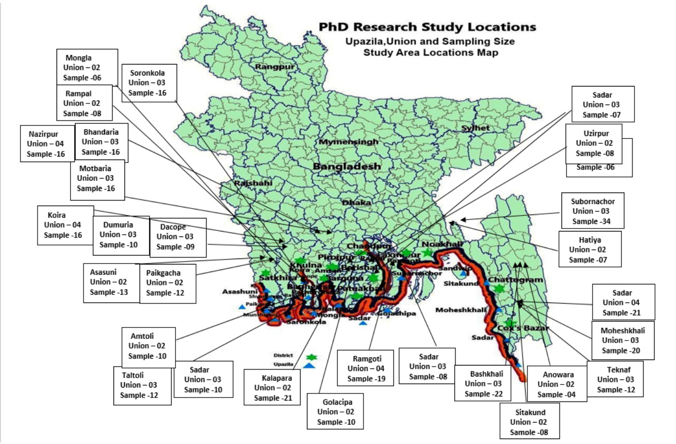

Figure 1. Study area.

Note: (▲) District; (✱) Sub-District; (■) Coastal area of Bangladesh.

The study data was collected using a pre-tested Bangla version semi-structured questionnaire. The study information was collected retrospectively (recall method) following face-to-face interview method for the past five years before the start of fieldwork. Verbal consent was obtained from the respondents before collecting data. However, the study participants were selected randomly using Probability Proportional Sampling (PPS) technique based on the aforesaid registered coastal fishers' measure. Every 24th male and/or female fisher was enrolled to obtain the estimated sample size. We assume that the population (fishers') living in the coastal zone is distinctly homogeneous among themselves but natured heterogeneous from others. The study data were collected between January-December, 2021. However, to overcome limitations, a checklist regarding the spatial distributions of CC-induced and environmental (adverse weather) events from the Meteorological Department (BMD) was also used during data collection.

Operational definition

The information used in this study was the coastal fishers' insights/ sensitivity on the CC-induced and environmental disastrous events went upon coastal dwellers (either fishers or non-fishers) in the past five-years before the onset of the research's fieldwork (retrospective). Predictor and outcome variables were categorized dichotomously that indicated the frequency and severity of climatic and environmental (adverse weather) incidences. Notably, household distance to coast, spatial distributions of the participants, low-laying geographic settings and topography, coastal floodplains, direct/indirect victimhood, and involved in primary or secondary-level fishery activity might be the causes of variability in describing (insights) the frequency and severity of climatic and environmental (negative weather) incidences and economic penalties. To explain all above things, we applied some practical definitions as mentioned below.

CC-induced and environmental (adverse weather) incidences: Indicate the disasters or disastrous events, including storm/cyclone, saline water intrusion or inundation, temperature fluctuations, unusual/heavy rainfall, unusual winter-cold shock, unusual water flow through the coast, unusual/ heavy sea wave, flood or flash flood, etc.

Domestic Asset Loss (DAL): Means the monetary equivalence to BDT (≥ 50,000 BDT and <50,000 BDT) of the damages of household resources including living home, farming equipment, utensils, reserve food-grains, cash money poultry, livestock, etc. due to CC-induced and environmental (negative weather) incidences;

Loss In Fisheries (LIF) : Indicates the monetary equivalence to BDT (≥ 50,000 BDT and < 50,000 BDT) of the damages of aquaculture farms(gher) and ponds, the explored sea deep fishes, matured harvestable fishes, fishing logistics including fishing gears (nets), crafts (fishing boats/ trawlers), fish trapes, etc. due to CC-induced and environmental (negative weather) incidences;

Socio-Economic Status (SES): Explains the category of the coastal fishers/non-fishers' population livelihoods based on economic status, e.g., extreme poor, poor, middle, and rich;

Other explanatory variables such as Household Proximity to Coast (HHPC): distance from home to sea-beach in kilometer, Number of Disasters (NoD): number of CC-induced and environmental (adverse weather) incidences has been seen and suffered by the respondents within the past 5-years, Severity of Disasters (SoD): scale-up disasters based on the magnitudes and intensity of damage/losses and/or areas covered and affected by the disasters, Longevity of Disasters (LoD): duration of disasters in days; unsteady temperature fluctuation, rainfall variability, cold wave shock, water overflow, and saline water intrusion/ inundation: categorically measured as increased or decreased as per respondents insights, Coastal Land Erosion Increase (CLEI): scale-up categorically as yes or no as per respondents insights and comprehensions; and sea wave during storm/cyclone: scale-up categorically as high, medium or low as per respondents insights and sentiment;.

Data analysis

The raw data were input into SPSS data-sheet using unique codes for each of the variables. The numeric variables were presented as mean (standard deviation), median, minimum, and maximum and categorical variables were as number and percentage. Chi-square or Fisher's Exact test was used in this study. Three outcome variables were used such as Domestic Asset Loss (DAL), Loss In Fisheries (LIF), and Socio-Economic Status (SES). The explanatory variables were also used as mentioned in operational definition section. Data was analyzed using SPSS version 25.0.

Results

Socio-demographic characteristics

Table 1 and Table 2 illustrate the demographic characteristics of the respondents. Three hundred and thirty-eight (338) coastal fishers and non-fishers were participated with male to female predominance {286 (84.6%) *vs.* 52 (15.4%)} and more than two-thirds of them were living within 1 kilometer proximity to coast {237 (70.1%); mean: 1.33 ± 1.80 km; Median: 0.65 km}. Mean age was 41 ± 12.97 (median: 42; Ranges: 18-89). Nearly one-fourth and two-thirds of the participants belong to ≤ 30 years and 31-59 years, respectively. In addition, nearly nine percent {30 (8.9%)} of the respondents were at their age of 60 and above years. In terms of occupation, more than three-fourths {286 (84.6%)} of the participants were involved in direct fishing either coastal or deep-sea and others were in non-fishing activities

Illiteracy comprised nearly fifteen percent {53 (15.7%)} while majority of the fishers had attended to primary level education {166 (49.1%)]}. Almost all the participants were impoverished either extreme poor {192 (56.8%)} or poor {143 (42.3%)}. Nearly two-thirds {234 (69.2%)} of the participating households have only one earning member while remaining households {104 (30.8)} belong to two. However, almost all the coastal dwelling fishers and non-fishers {324 (95.9%)} were living on less than 15,000 BDT monthly income while their average monthly income has remained within nine thousand {mean: 8567.46 ± 5770.19, median: 7250.0}.

However, the mean number of CC-induced catastrophes in the past 5-years before the start of the data collection period was 3.12 (SD: ± 1.28, median: 3.0, range: 1-8). The average longevity of each of the disasters was nearly seven days {mean: 7.18 ± 4.78, median: 6.0, range: 1-35}. Therefore, coastal fishers and non-fishers lost livelihood-related assets equivalent to financial penalties as a result of CC-induced catastrophic disasters, such as Domestic Asset Loss (DAL) and Loss-In-Fisheries (LIF), forcing them to participate in loan offerings offered by GO/NGOs, commercial banks, or local Mahajans at high interest to obtain a Loss Recovery Amount (LRA). This cyclic trap might be sustained for a longer period or even until the end of the fisher's life. However, the average amounts of DAL, LIF, and LRA were about BDT 38,318 (SD = ± 33071, median: 30,000.0), BDT 19,236 (SD = ± 20,486, median: 15,000.0), and BDT 33,048 (SD = ± 30,281, 25000.0), respectively

Table 1: Summary of observations.

Case	Age	Sex	Time of consultation	Clinical symptoms	Staging	Traitement	Evolution
1	25	M	12 months	Nasal Obstruction Exophtalmos low visual acquity Headaches	Stage C	Surgery radiation therapy	Full remission
2	30	M	8 months	Epistaxis, Nasal sinus pains Swelling of the hemiface	Stage D	Symptomatic traitement	Patient deliverad to family
3	21	M	2 months	Nasal Obstruction. Epistaxis, anosmia -Low visual acquity Nasal sinus pains -Headaches	Stage C	Surgery radiation therapy	Reccurence
4	64	F	3 months	Nasal obstruction Epistaxis anosmia exophtalmos cervical lymphadenopathy	Stage C	Surgery radiation therapy	Evolutionary pursuit
5	63	F	4 months	Nasal obstruction nasal sinus pains	Stage C	Palliative radiation therapy Palliative chemotherapy	Passed away
6	27	F	7 months	Nasal obstruction Epistaxis Low visual acquity	Stage C	Surgery radiation therapy	Full remission

Table 2: Means of Household characteristics and CC-related factors (n=338).

Variables	Mean ± SD	Median	Min-Max
Age (years)	41 ± 12.97	42	18-89
Education*	4.81 ± 3.24	5	0-11
HHEM	1.47 ± 0.94	1	01-Jul
HHPC (Km)	1.33 ± 1.80	0.65	0.1-6.0
MHHI (BDT)	8567 ± 5770	7250	15,000-80,000
NoD	3.12 ± 1.28	3	01-Aug
LoD	7.18 ± 4.78	6	Jan-35
DAL (BDT)	38318 ± 33071	30,000.00	0-240,000
LIF (BDT)	19236 ± 20486	15,000.00	0-170,000

Note: * Class attended

Fishers' insight on CC-induced and environmental (adverse weather) factors

According to Table 3, nearly one-third {108 (32.0%)} of participating households were located 500 meters' proximity to coast. More than two-thirds {234 (69.2%)} of the respondents were recalled ≥ 4 CC-induced ≥ 5 day long disasters {264 (78.1%)} with moderate-to-high severity {288 (85.2%)} within the past 5-years before the onset of the research's fieldwork. Similarly, greater than three-fourths of coastal fishers were claimed about the increased incidents of temperature {304 (89.9%)}, rainfall {302 (89.3%)}, coastal land erosion {P307 (90.8%)}, saline water intrusion {314 (92.9%)}, and sea-wave {324 (95.9%)} while majority of them had called for a rising trends of cold shock {210 (62.1%)} and water flow {170 (50.3%)} within the same time interval. However, spatial distributions, low-laying geographic settings at the edge of the Bay of Bengal, coastal floodplain and low-lying topography, level of dependency on fisheries and other infrastructural factors may influence the participant's variability in expressing their insights.

Demographic factors in relation to poverty status

Table 4 demonstrates the relationship between socio-demographic factors and poverty status of the coastal fishers of Southern Bangladesh. Among all the used socio-demographic factors, only the number of household earning member was significantly associated with the poverty status of the coastal dwelling fishers and non-fishers (95% C.I., $\chi2$ =9.68, p=0.002). However, other factors, including Domestic Asset Loss (DAL) and Loss-In-Fisheries (LIF) were not statistically significant over the poverty status (95% C.I., p ≥ 0.05)

Discussion

The current study mainly focused coastal fishers' insights [43,48] on the economic penalties due to CC-induced and environmental (adverse weather) catastrophes of Southern Bangladesh. The penalties are transformed into financial equivalence in BDT, including Domestic Asset Loss (DAL) and Loss-In-Fisheries (LIF) as shown in Table 5.

Table 3: Fishers' Insights on CC-induced and Environmental (Negative weather) Factors (n=338).

Variable name and category		Frequency	Percentage
HHPC	<0.5 km	108	32
	≥ 0.5 km	230	68
NoD	≥ 4 Ts	234	69.2
	≤ 3 Ts	104	30.8
SoD	MH	288	85.2
	Low	50	14.8
LoD	≥ 5 days	264	78.1
	≤ 4 days	74	21.9
Temperature	Increase	304	89.9
	Decrease	34	10.1
Rainfall	Increase	302	89.3
	Decrease	36	10.7
CLEI	Yes	307	90.8
	No	31	9.2
WCS	Increase	210	62.1
	Decrease	128	37.9
Inundation	Increase	314	92.9
	Decrease	24	7.1
Water Flow	Increase	170	50.3
	Decrease	168	49.7
SWDS	High	324	95.9
	Low	14	4.1

Table 4: Relationship between demographic factors and poverty status of coastal fishers.

Variable name and category		Poverty Status (n=338)			χ^2	p-value
		Extreme Poor	PTM	Total		
Sex	Male	157	129	286	2.76	0.128
	Female	35	17	52		
Age	≤ 30 years	54	31	85	5.03	0.082
	31-59 years	126	97	223		
	≥ 60 years	12	18	30		
HHEM	1 member	146	88	234	9.68	0.002
	≥ 2 member	46	58	104		
	Illiterate	29	24	53	0.66	0.731
Education	Primary	98	68	166		
	≥ High School	65	54	119		
Home Type	Kancha	182	131	313	3.11	0.094
	Semi or Pakka	10	15	25		
	≤ 6,999 BDT	76	56	132	1.16	0.61
Income	7-15,999 BD	110	82	192		
	≥ 16,000 BDT	6	8	14		
DAL	<50,000 BDT	129	99	228	0.02	0.907
	≥ 50,000 BDT	63	47	110		
LIF	<50,000 BDT	174	131	305	0.08	0.854
	≥ 50,000 BDT	18	15	33		

Table 5: Relationship between CC-induced and environmental (adverse weather) events and asset of losses and socio-economic status (n=338).

Variable name and category		Domestic asset loss		χ2	p-value	Loss in fisheries		χ2	p-value	Socio-economic status		χ2	p-value
		≥ 50 Thd.	<50 Thd.			≥ 50 Thd.	<50 Thd.			EP	PTM		
HHPC	<0.5 km	41	67	2.1	0.171	17	91	6.44	0.017	64	44	0.4	0.56
	≥ 0.5 km	69	161			16	214			128	102		
NoD	≥ 4 Ts	81	153	1.5	0.258	24	210	0.21	0.697	141	93	3.7	0.06
	≤ 3 Ts	29	75			9	95			51	53		
SoD	MH	101	187	5.7	0.021	32	256	4.01	0.041	171	117	5.2	0.03
	Low	9	41			1	49			21	29		
LoD	≥ 5 days	93	171	4	0.047	26	238	0.01	1	150	114	0	1
	≤ 4 days	17	57			7	67			42	32		
Temperature	Increase	94	210	3.6	0.809	24	280	12	0.002	175	129	0.7	0.47
	Decrease	16	18			9	25			17	17		
Rainfall	Increase	103	199	3.2	0.091	29	273	0.08	1	171	131	0	0.86
	Decrease	7	29			4	32			21	15		
CLEI	Yes	104	203	2.7	0.111	30	277	0	1	170	137	2.8	0.13
	No	6	25			3	28			22	9		
WCS	Increase	80	130	7.8	0.006	27	183	6.03	0.022	129	81	4.8	0.03
	Decrease	30	98			6	122			63	65		
Inundation	Increase	102	212	0	1	29	285	1.39	0.274	179	135	0.1	0.83
	Decrease	8	16			4	20			13	11		
Water Flow	Increase	45	125	5.8	0.02	10	160	5.85	0.017	87	83	4.4	0.04
	Decrease	65	103			23	145			105	63		
SWDS	High	108	216	2.2	0.159	33	291	1.58	0.377	180	144	5	0.03
	Low	2	12			0	14			12	2		

Male to female predominance was observed with impoverished socio-economic status and more than two-thirds of them have been living within 1 km proximity to coast and they had to struggle against at least three CC-induced and environmental (adverse weather) incidences with considerable losses within the last five years. Limited number of studies had highlighted the gender diversity among fishers' communities except some reports of the Department of Fisheries (DoF) with almost similar findings [31,46,49]. Similarly, the research findings also demonstrated that almost all the coastal population who are involved in fishing activities are impoverished, either extreme poor or poor and are rotating in the vicious cycle of poverty due to CC-induced and environmental (negative weather) events [7, 20,28,29,38,44,50]. The poverty rate found so far higher among direct/indirect fishing communities compared to overall coastal population according to the World Bank/WFP/BBS 2014 findings (54.8% vs 99.1%) in Chattogram and Barishal coastal belt [40]. These findings are also relevant to other studies [4,7,20,22,34,44,50]. In reality, fishing is a profession of low-wage earning source and a large group of fishers able to manage only $100-120/month which is too insignificant to afford their 4-5 membered families [28,29,34]. On the other hand, because of living very close to the coastline, the livelihood means like household assets, earning resources like aquaculture farms, standing cash crops, etc. of coastal dwellers, fishermen, or non-fishermen are damaged (economic loss) due to CC caused incidences such as unexpected storms/cyclones, flash floods, inundation, high tides, coastal land erosion, etc. [4,5,8,9,21-24,33,36,41]. However, considering predictors such as the Severity of Disasters (SoD), the Longevity of Disasters (LoD), cold wave shock, and water over flow found to have a significant effect on the Domestic Asset Loss (DAL) of the coastal fishers. In addition, taking into account of the predictors of CC-induced and environmental (adverse weather) catastrophes, including Household Proximity to the Coast (HHPC), the Severity of Disasters (SoD), temperature, cold shock, and water flow also observed to have a significant effect on the Losing Assets to Fisheries (LIF). Simultaneously, reductions in fish production [46,49], shrinkage of employment opportunities [22,44,45], fishing bans announced by the government [44,45], obviously persistent CC-induced and environmental (adverse weather) incidences, etc. have immense long-term direct or indirect negative impacts on the subsistence of coastal fishers and non-fishing dwellers [34,38,43]. Moreover, this study also revealed that the Severity Of Disasters (SoD), Winter Cold Shock (WCS) wave, water over flow, Sea-Wave rising During Storm/Cyclone (SWDS), and Household Earnings Member (HHEM) were also found to have a significant effect on the socio-economic status (poverty status) of coastal fishers living in Southern Bangladesh. Therefore, all these things force the coastal fishermen to seek loans, others' mercy dependency, and favors from others like moneylenders (GO/NGOs) or Mahajans, who compel them to sell/mortgage their land, imposing advanced labor selling, cash crops in exchange for returning the money borrowed or lent [28,29,42,44,45]. Ultimately, the fishermen always remain in debt and borrow money from various sources to replenish their financial crisis [28,29,44] and are trapped in a vicious cycle of poverty [42,44,51]

Conclusion and Recommendations

This research has revealed the financial equivalent household-level penalties regarding the livelihood assets (domestic and fishery resources) of the coastal dwelling fisher communities due to CC induced events. This study has also demonstrated that the fishermen living near the coast are exposed to significant economic penalties for almost all their survival or livelihood resources due to every climate change-induced or environmental (adverse weather) disaster that might trigger towards shaking coastal poverty. Therefore, it is evident that the coastal residing fisher communities are shut down in a vicious cycle of poverty of Bangladesh. The research findings have demanded the Government of Bangladesh (GoB) and concerned development agencies/allies to take medium and long-term strategies and steps to implement sustainable climate-resilient policy initiatives to uplift the impoverished livelihood status of coastal fisher communities, especially by getting rid of the economic penalties and other socio-environmental liabilities.

Conflict of Interest

The author(s) did not receive any funding, and they declare no competing interests.

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Cite this article: Islam Md, et al. Household-Level Economic Penalties Resulted from Climate Change-Induced Events among the Coastal Fishers of Bangladesh. J Biol Todays World, 12(1), 001-006