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## Hilsa fishery management in Bangladesh

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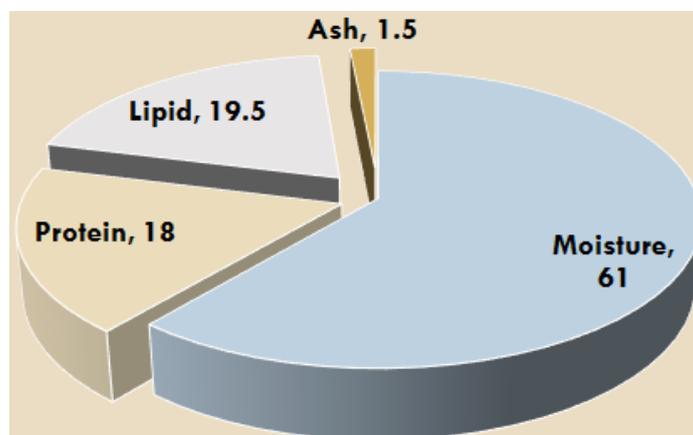
**Abstract.** Hilsa shad (*Tenualosa ilisha*), is a biologically, nutritionally, economically, socially and culturally important species in the Bay of Bengal and Persian Gulf regions, but Bangladesh enjoys the major share wherein it contributes about 517,000 tons/year. However, this important fishery declined in the late 1990's that led the Government to formulate the Hilsa Fishery Management Action Plan (HFMAP) and started its implementation from 2005. Since then, hilsa production increased @5%/year till 2015. To improve the annual incremental production further, Department of Fisheries (DoF) and WorldFish have jointly been implementing "Enhanced Coastal Fisheries in Bangladesh (ECOFISH-Bangladesh)", a USAID supported project (2014-2019). The project supports the DoF and local communities to establish a science-based "adaptive co-management" that focuses on the brood hilsa protection, juvenile conservation, illegal gears control, and overall ecosystem resilience involving all stakeholders. As a synergistic impact of all the initiatives taken and the proactive supports of the law enforcing agencies, the declined hilsa fishery from both inland and marine habitats revived @ 11% annual incremental total hilsa catch. The increased hilsa production and average size (from 510 g to 915 g) resulted in increased household income of fishers by 52%. The interventions additionally improved catfish abundance and other fish biodiversity.

**Keywords:** Bay of Bengal; ECOFISH; fisheries management; hilsa.

### 1. Introduction

Hilsa shad (*Tenualosa ilisha*, Clupeidae), is a biologically, nutritionally, economically and socio-culturally important species in the Bay of Bengal and Persian Gulf regions. Its biological importance among the aquatic biologists derived from the unique migratory nature of the fish. It is an anadromous migratory fish that migrates from the sea to freshwater rivers and estuaries for spawning, but also follow amphidromous nature of migration, i.e. frequently moves between freshwaters and marine waters for feeding and swimming purposes following tidal rhythms [1]. In addition, the species contributes to trophic cycle as it feeds at the lower trophic levels, the primary consumer. Nutritionally, it is a high-protein (18%) and high-lipid (19.5%) fish and rich in essential micronutrients, especially phosphorus, calcium, zinc, vitamins A & E, polyunsaturated fatty acids (PUFA) and Omega-3 fatty acid (Figure 1).





**Figure 1.** Proximate composition of hilsa [2-4].

Due to the nutritional value as well as its attractive shiny appearance, high palatability and awesome taste, flavor and mouth feel, about 260 million Bengali people, living in Bangladesh, India and all over the world, cherish hilsa and love to have it. However, some people do not enjoy its taste due to the presence of 138 intermuscular pin-bones. To solve this problem, some initiatives have already been taken to prepare boneless products like hilsa soup, hilsa noodles, hilsa balls and those initiatives will be continued.

Globally, hilsa is the most important commercial transboundary species of the Bay of Bengal, but Bangladesh enjoys the major share (86%), followed by India (8%), Myanmar (4%) and the rest by other countries [1]. In Bangladesh, it is the national fish and geographical indication (GI) product and also known as iconic flagship species contributing 517,198 tons/year (12% of total fish production) that worth about US\$ 4 billion of which 232,698 tons (6% of inland catch) harvest from inland waters and the rest 284,500 tons (44% of marine catch) harvest from marine waters [5]. Hilsa has also socio-cultural and religious values and its non-consumptive value estimated approximately US\$0.36 billion per annum [6]. The fishery directly employs 0.5 million fishers and another 2.5 million actors are associated in its value chain.

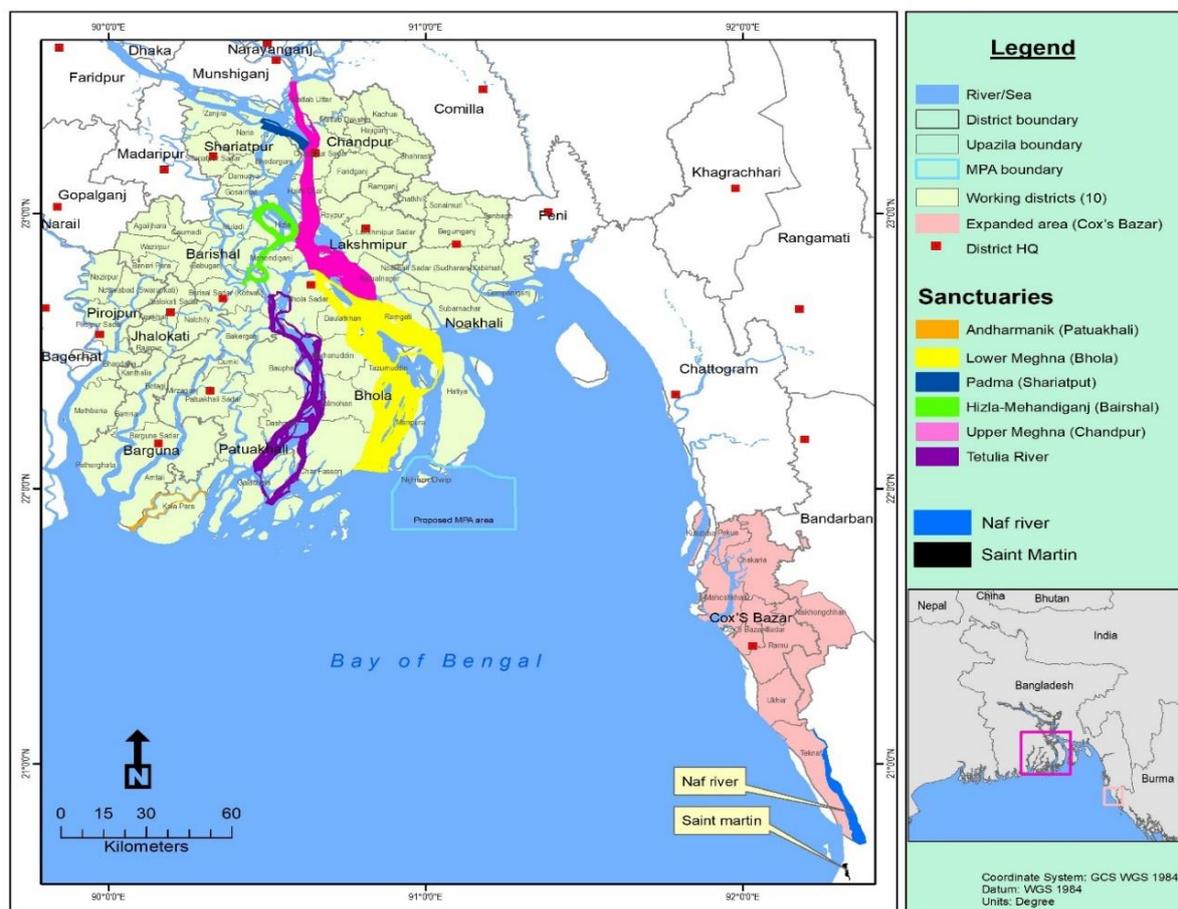
Considering the enormous importance of the small scale hilsa fishery in Bangladesh, the country took the lead in managing the fishery for reviving the fishery from its past declining trend. During 2002-03, the fishery declined sharply and the production gone down to below 0.2 million tons. Then the Government of Bangladesh formulated Hilsa Fishery Management Action Plan (HFMAP) to revive the fishery. The focused areas of the HFMAP were the establishment of sanctuaries to protect juvenile in the peak season, protection of brood hilsa in the peak spawning season, eradication of harmful gears, protection of migratory routes, controlling overfishing, providing food incentives (presently @40 kg rice/fisher for almost 7 months, covering all the ban periods) and some AIGA supports. From 2005, the HFMAP implementation started and since then, hilsa production increased @5%/year till 2015. To improve the annual incremental production further, Department of Fisheries and WorldFish have jointly been implementing a project entitled “Enhanced Coastal Fisheries in Bangladesh (ECOFISH-Bangladesh)”, a USAID funded five-year initiative (2014-2019). The project supports the Department of Fisheries (DoF) and local communities to establish a collaborative science-based adaptive co-management that focuses on the reduction of overfishing, conservation of juveniles in the nursery ground and protection of brood hilsa in the peak spawning season through involving all stakeholders. The initiative also contributed in improving community empowerment focusing on women’s access to resources and technologies for livelihood diversification and community resilience improvement to endure compliance during fishing ban periods. This article describes the impact of the adaptive co-management and relevant livelihood support activities on the hilsa and other important coastal fisheries in Bangladesh. The contribution of the impacts to achieve

the SDGs has also been evaluated briefly. Finally, some regional initiatives in hilsa management has been pointed out.

## 2. Materials and methods

### 2.1. Intervened areas

The main co-management intervened areas were the designated six hilsa sanctuaries, the main nursery grounds of hilsa. These sanctuaries comprise important catchment areas of important rivers. In the Meghna river, there are three sanctuaries and one sanctuary located in each of the Tentulia, the Padma and the Andharmanik rivers covering a total length of about 400 km river stretches (Figure 2). The complete fishing ban in the Andharmanik sanctuary imposes from November to January and for all other sanctuaries, the ban period imposes in March and April each year.



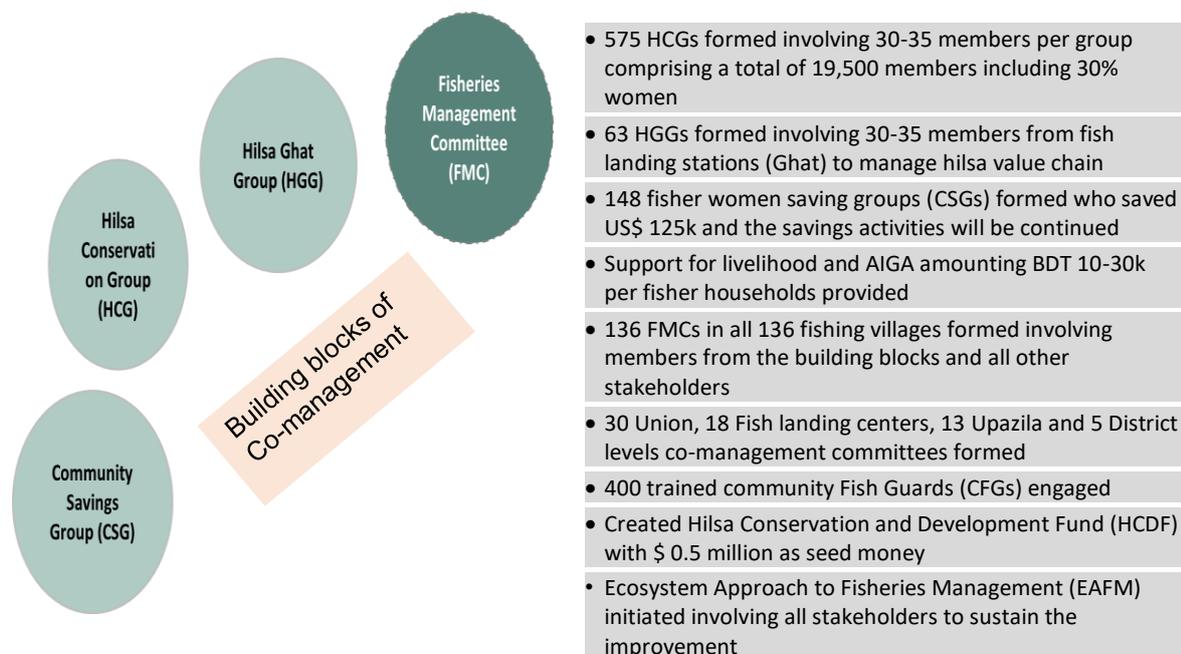
**Figure 2.** Co-management intervened areas to manage coastal fisheries in Bangladesh.

### 2.2. Generation of science-based information

At the initial stage of the interventions, science-based information relevant to support the adaptive co-management were generated. The production target was set at the maximum sustainable yield (MSY = 0.526 million tons) level that was estimated through year-long stock assessment. Peak spawning season, month and week were identified to optimize the most effective brood hilsa ban period. Fish species diversity and trophic levels, sub-species or races in the hilsa population were identified to understand the species interactions and life strategy.

### 2.3. Adoption of co-management in major river sanctuaries

Adaptive co-management approach was first ever introduced through the ECOFISH-Bangladesh project to manage the large river ecosystems encompassing the six hilsa sanctuaries as stated before. In order to establish the co-management in river sanctuaries, three types of building blocks such as Hilsa Conservation Group (HCG), Hilsa Ghat Group (HGG) and Community Saving Groups (CSG), each having 30-35 members, including an executive committee were established at the community levels (Figure 3). These HCG in the village levels comprise 70% men and 30% women, HGG in fish landing stations with all men as women are not available, and CSG with all women members in the village level were formed after thorough community profiling. Then taking representatives from all of these groups together with other broader stakeholders in the village level, a Fisheries Management Committee (FMC) were formed to formulate, coordinate, and implement local fisheries management action plan (Figure 3). Taking representatives from all those groups and other stakeholders, co-management committees at different higher tiers like Union, Upazila and District levels have been formed. In addition, 400 Community Fish Guards (CFGs) along the 400 km sanctuaries, i.e. 1 CFG in every km have been selected through participatory approach and deployed to oversee the compliance and assist the law enforcing agencies and Department of Fisheries, especially during ban periods.



**Figure 3.** Building blocks of co-management and its current status.

The collective action of all those groups and committees and government agencies is the principal essence of co-management that ensures the proactive engagement of all stakeholders for hilsa and other coastal fisheries management, and thus, improve the resilience of the relevant fishery, river ecosystems, and fishing communities. Both **carrot and stick** strategies have been followed as implementation tools. As the ‘carrot’, Govt. provides food incentives @ 40 kg rice/fishers for 4 months during the juvenile conservation period and almost another 3 months covering brood hilsa and marine ban periods. In addition, AIGA supports regularly provide through ECOFISH-Bangladesh project in 136 coastal fishing communities along the six sanctuaries to improve the resilience of fishers, so that they can comply with the fishing ban periods. The ‘stick’ strategy includes surveillance of law enforcing agencies along with the CFGs and implementation of instant penalty as imprisonment and fine through mobile court for non-compliance of the fishing ban periods. Awareness building activities and involvement of all stakeholders through the central coordination by the Ministry of Fisheries & Livestock as well as enhanced supports from ECOFISH-Bangladesh through

consolidation and coordination among all actors in the platform of co-management, largely contributed to the revival of hilsa fishery.

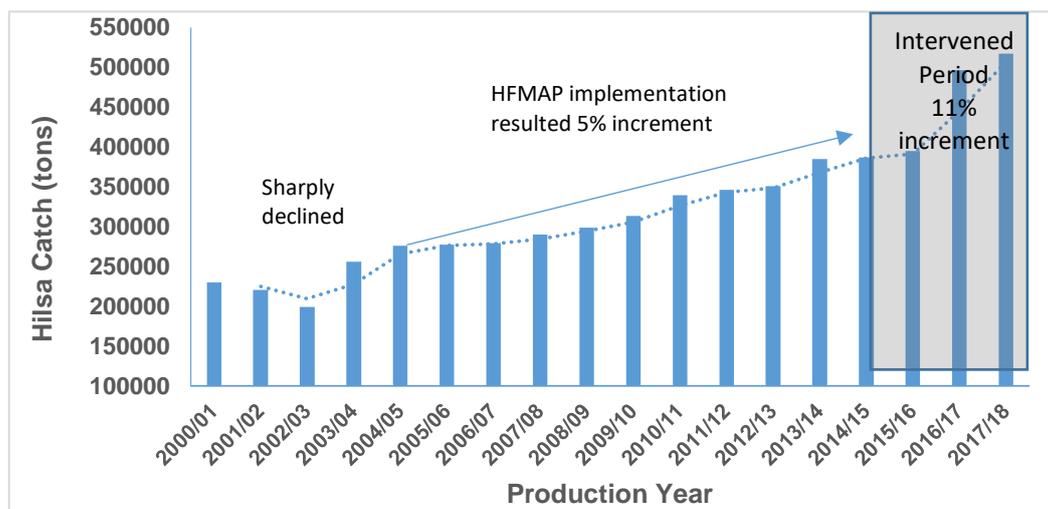
#### *2.4. Impacts assessment*

The impacts of the co-management related interventions on four fisheries related indicators like hilsa production, hilsa size, catfish catch and fishers' households' income were assessed in different ways depending on the nature and availability of comparable data. The past and present annual hilsa production data are readily available in the FAO database as well as in the Annual Fish Week Compendium of Department of Fisheries (DoF), Bangladesh. So, the annual hilsa production data before and after the interventions were compared. The average individual hilsa size data was available in DoF for 2014 and for 2015, 2016 and 2019, the size data were collected through monthly sampling. All the collected the data were then compared. The size composition data, i.e. proportion of different size groups of hilsa was collected through sampling in the peak season in 2017, 2018 and 2019 and compared. Baseline and end-line average catfish catch was estimated in 2016 and 2019, respectively through conducting a survey. Average households' income in 2016 and 2018 were also estimated through a quick survey among 400 beneficiaries and compared the differences. For all the baseline and end-line survey data, statistical t-test were used to evaluate the significance levels of the differences. Finally, improvement in women's access to finance was evaluated directly comparing the total savings to provide credits among themselves as their initial savings was literally zero.

### **3. Results and discussion**

#### *3.1. Total hilsa production increased*

Total annual hilsa production showed a sharp decline in 2002/03, but after 2005, due to the implementation of HFMAP, hilsa fishery production increased @5%/year till 2015 (Figure 4). As a synergistic impact of the general management activities of the government and the additional inputs from ECOFISH-Bangladesh project through science-based adaptive co-management, the annual incremental total hilsa catch increased from 5% to 11% after 2015, resulting annual total hilsa production of 0.517 million tons in 2018, which is almost equal to the estimated MSY level (0.526 million tons). In fact, due to the co-management intervention, fishers' awareness and engagement have remarkably improved, their resilience also improved after getting livelihood and AIGA supports from government and ECOFISH-Bangladesh project and as a result, compliance to size ban for Jatka protection (<25 cm TL), complete fishing ban in all six sanctuaries (2 months) and brood hilsa (22-day) ban periods have been improved tremendously that resulted the improved production. The co-management interventions helped in producing 6% extra annual incremental production, that comprised about 130,000 tons hilsa over the last 3 years, worthing about US\$1,040 million (hilsa price @US\$8/kg). This extra benefit improved the livelihoods of fishers and traders and improved the nutrition of the consumers throughout the country. Now, it is essential to keep the momentum of the increasing production trend until it reached to the carrying capacity of the ecosystem.

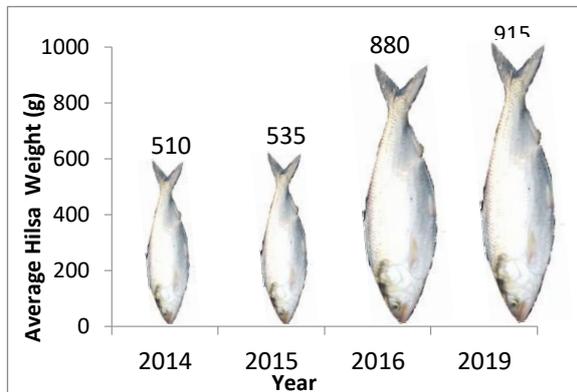


**Figure 4.** Annual hilsa production trends in Bangladesh before and after adoption of co-management.

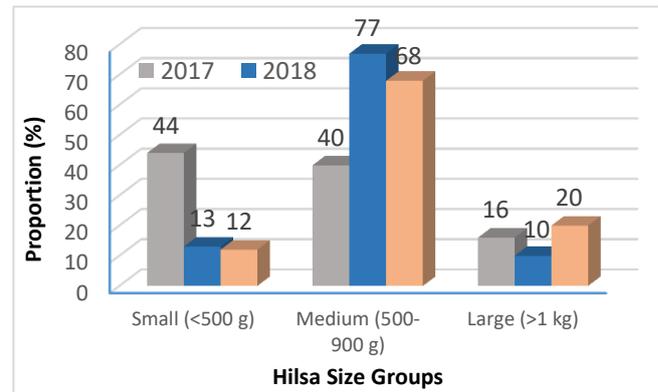
### 3.2. Hilsa size increased

Individual hilsa size has increased remarkably from an average of 535 g in 2015 to 915 g in 2019, i.e. size increased by 400 g over 5-year project period (Figure 5). This size increment indicates that the fishery has revived and improved remarkably. The most desirable size that fetch premium market price is >1 kg sized hilsa. The present average hilsa size is very close to the premium size. In fact, a very large proportion of hilsa (20%, Figure 6) has already been exceeded the benchmark, and fishers are happily getting higher price and consumers are enjoying the large hilsa after over a two decades. The individual size increment resulted in a remarkable shift in the size group compositions from smaller to larger (Figure 6). In 2017, the small size (<500 g) hilsa dominated the catch, followed by medium size hilsa (500-900 g) and the large size hilsa constituted only small portion over the last two years (10-16%). In 2019, the proportion of large size hilsa (20%) and along with the medium size (88%) hilsa exceeded the small size hilsa (Figure 6).

The gradual shifting of the smaller size groups to the larger size groups indicate better fisheries status through improved fisheries management and fetch higher income for the fishers. In the previous year, the remarkable improvement was the shift from smaller to medium and this year the higher proportion of medium size hilsa shifted and grown to large size hilsa. When individual hilsa grows to around a kg size in 3-4-year period, its taste and flavor increase remarkably due to the cumulative deposition of lipid contents in its body muscle. The taste and flavor together, increase the palatability of hilsa by the consumers that led to higher market demand and higher price. Therefore, individual size improvement is a key indicator, that not only indicate fishery improvement through better management, but also enhance the consumer satisfaction having better taste and flavor and higher income of fishers. Nevertheless, the measurement of the individual sizes depends on the proper representatives of the hilsa population in the sample. Though the same technique was followed every year to minimize the sampling error and bias, sampling from a huge population cannot be guaranteed fully representative of the hilsa population available round the year. Therefore, the measurement undoubtedly indicated the size improvement, but the numerical may vary time to time and sample to sample.



**Figure 5.** Average individual hilsa size increased by 400 g through co-management intervention.



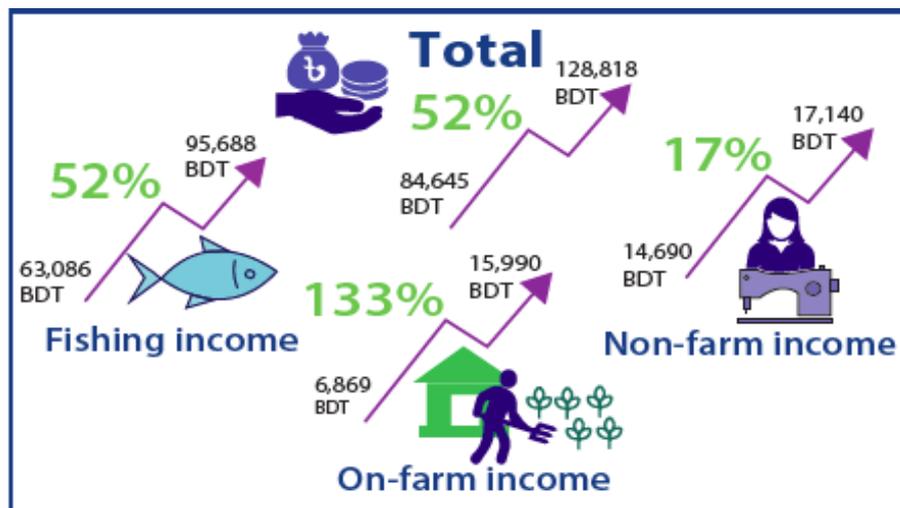
**Figure 6.** Hilsa size compositions during 2017-2019 in Bangladesh waters.

### 3.3. Catfish abundance increased

As a result of implementation of hilsa management, the abundance of large river catfish, like Pangas (*Pangasius pangasius*), Ayr (*Sperata aor*), Rita (*Rita rita*) and Baghair (*Bagarius bagarius*) have also been remarkably increased. In 2016 (baseline), the catfish bycatch by hilsa nets was about a kg/boat/day and during the end-line survey in 2019, the catch was found to be about 1.5 kg/boat/day, i.e. the riverine catfish bycatch increased by 50% over the two years and the change is highly significant ( $p < 0.001$ ). Though the bycatch/boat/day is very small, considering the 20,000 small fishing boats that catches it, the total amount would be about 30 tons/day. The reasons of this increase might be due to two reasons: firstly, the increased juvenile hilsa (Jatka) production facilitated increased predation by catfishes, and secondly, through the protection of hilsa brood and juveniles, concurrently cat fish brood and juveniles have also been conserved. As the major riverine catfish are very high priced fish and may weigh up to 40 kg/individual fish, improvement of this fishery remarkably increase the income of fishers and improve consumer satisfaction as well as nutritional requirement. In future, more details impact of the improvement of hilsa on each of the catfish species as well as related other species and fishers' livelihood need to be assessed.

### 3.4. Fishers' households income increased

As a result of the increased hilsa and catfish production and improved hilsa size, the total household fishers' income as well as income from fishing activities have been increased by 52% during the 3-year period from 2016 to 2019 (Figure 7). In addition, due to the AIGA support provided from ECOFISH-Bangladesh project as well as the Government of Bangladesh support to improve the resilience to comply the ban periods, other agricultural income (on-farm) and small business (non-farm) income have also been increased remarkably. All the changes in income were found to be highly significant ( $p < 0.001$ ). The increase in income will lead to improve the livelihood of the fishing communities. As the increase of income may be directly or indirectly influenced by other minor socio-economic factors that were not measured through the survey. Therefore, the increased income may not be truly influenced by the project alone. However, whatever the numerical figure of the income increment, no doubt the fishers' income improved remarkably due to the project intervention. Now, the sustainability of this improving trend is the main challenge, and the future focus of the project activities should be concentrated on the sustainability issues of the fishers' livelihood improvement.



**Figure 7.** Info-graphical presentation of annual households' income increment from baseline (2016) to end-line (2018) due to co-management in Bangladesh.

### 3.5. Women's access to finance increased

As a part of livelihood resilience improvement through co-management focusing on women, especially to improve access to finance for women, a total of 148 community savings groups (CSGs) were formed involving 30-35 women in each fishing village that comprises a total of 5,000 women who saved US\$ 125k, so far. The savings activities will be continued to increase the amount further. From this fund, about 1,000 women had received credit about US\$75,000 to do different small businesses like tailoring, goat rearing, cow rearing, commercial gardening, grocery business and poultry rearing. Each loan recipient is expected to repay his or her loan in 10 installments over a period of 10 months. All CSG members have been provided training through Business Literacy Schools (BLS), an innovation of ECOFISH-Bangladesh project. Through the savings and loan management, women's access to fund increased, power in decision-making improved, control over resources and participation in income generating activities visibly improved at the poor fishing communities. These has increased the resilience of the vulnerable fishing households in the face of climate changes impacts and disasters as well as helping withstand shocks and stresses during the fishing ban periods. If the savings activities can be continued on a long term basis and credit system with low interest rate could be continued, fishers' women access to finance would be improved in a sustainable way. The future efforts of the project should focus on supporting the long term practice of the savings activities of the communities.

### 3.6. ECOFISH-Bangladesh interventions supported SDGs

The outcomes of the incentive based co-management interventions for the hilsa fishery management in Bangladesh, broadly support various sustainable development goals (SDGs) of the country in various ways [7]. The most focus area is the SDG 14 for Bangladesh: Conserve and sustainably use the oceans, seas and marine resources for sustainable development. Through the sustainable management of the hilsa fishery, the main anadromous marine species, greatly support the SDG 14. More specifically, to support the SDG 14a (increase scientific knowledge, develop research capacity and transfer marine technology), the interventions generated scientific information necessary for management, trained about 20k stakeholders to support management and through adaptive co-management, hilsa production increased at sustainable level and biodiversity improved to achieve SDG 14 focusing on SDG 14a. To achieve the SDG 14b (provide access for small-scale artisanal fishers to marine resources and markets), the interventions contributed to improve hilsa production

that comprise 51% of small-scale artisanal fishery, so, increase access to this sea fish supporting SDG 14b.

The outcomes also indirectly supported SDG 1 (end poverty in all its forms everywhere) as fishers' households' income increased by 52%, this will reduce poverty significantly. It also supported SDG 2 (end hunger, achieve food security and improved nutrition) as annual hilsa production increased by 11%, instead of previous 5%, this is contributing in improving nutrition & food security. The outcomes also supported SDG 3 (ensure healthy lives and promote well-being for all at all ages) through improved production of high protein- high lipid and Omega-3 rich as well as PUFA rich fish ensuring healthy life. Finally, SDG 5 (achieve gender equality and empower all women and girls) has been supported by improving the accesses to finance through CSGs that empowered women and increased resilience of the coastal fishing communities.

### 3.7. *Opened doors for regional initiatives*

The success of the hilsa management in Bangladesh attracted two other neighboring countries, India and Myanmar to adapt the incentive-based management in their own countries taking lessons from Bangladesh. India has taken initiatives to conserve juvenile and brood hilsa following lessons from Bangladesh. The Darwin Initiative of UK, supported scientific hilsa research and awareness building activities in Bangladesh and taken steps to replicate those in Myanmar focusing on the incentive-based fisheries management. The activities have already been introduced to protect fish stocks in the Ayeyarwady Delta, safeguard biodiversity and improve the livelihoods of local fishing communities. Under this activity, a knowledge sharing workshop between Bangladesh and Myanmar was organized in Dhaka in collaboration with WorldFish, Bangladesh that may lead to improve national level management as well as regional transboundary management of the species in near future.

## 4. Conclusion

As a synergistic impact of science-based adaptive co-management of hilsa fisheries in Bangladesh through the ECOFISH-Bangladesh project and other Government and non-government initiatives involving all stakeholders, the hilsa production increased remarkably and approached to MSY level. The fish size also increased remarkably indicating improvement of the fishery and as a result, fishers' income and livelihoods also improved. For sustaining the improvement, precautionary measures to avoid over-harvest through continuous monitoring and maintenance of the resilience of the river and fishers through implementing EAFM, institutionalization and mainstreaming of the co-management and /or EAFM efforts focusing on the CSGs, CFGs and HCDF are highly recommended. The case of the hilsa fishery improvement in Bangladesh may be followed regionally and globally for the improvement of hilsa and similar small scale fisheries.

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