Ecological and Socio-economic Impacts of Climate Change on Fisheries

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ABSTRACT

Nowadays, climate change has become a severe issue for aquatic dweller. As the climate is changing gradually, it's affecting all types of terrestrial and aquatic creatures. Ocean lives are not out of the danger of the climate change. Many researches warned about this a few years back, and it's demonstrating now. The total population of the fishes is decreasing day by day because of changing climate. Climate changing is affecting the habitat, environment, foods of various fish species. As a result, those species are being disappeared slowly due to sudden change in environment. This reduction of the fish population has many impacts. As the fish population is decreasing, it directly or indirectly affecting those people who are dependent on the fisheries industry. As discussed, some adaptation and mitigation measures can change present condition of global fisheries. If we fail to take some initiatives now, it will significantly harm the social status of the fisherman. To sum up, climate changing will mainly affect the economic sector. So, we may adopt possible ways to reduce the climate change effects on the fish industry.

Keywords: *Ecological impact; Socio-economic; Fisheries; Climate change; Adaptation;*

More than 500 million people in the world depend on fisheries and aquaculture sectors. Also, it is noted that about 540 million people are somewhat or entirely reliant on the fisheries for their income (*Allison, 2011*). Therefore, it is one of the most essential areas of employment. Besides, fish is highly nutritious, which contains protein, oils, minerals, and vitamins (*FAO, 2005; FAO, 2007; Mohanty et al., 2010*). The requirement for aquaculture is increasing gradually because of population expansion, rising incomes, and growing urbanization. Global consumption of fish becomes multiplied since 1973 because of its increasing demand (*Christopher et al., 2003*). Along with this, fish is also frequently applying in animal feed industries. Nearly one-third of the world's wild-caught fish is "decreased" due to preparing fishmeal and fish oil. These fishmeal and fish oil are using in feeds for livestock, poultry and pigs. Along with this, fishmeal and fish oil for the feeds of farmed carnivorous fish, are also required (*Christopher et al., 2003*).

Climate change is one of the most talked topics all over the world, which has a direct and indirect effect on fish stocks. The ocean and the atmosphere are closely interrelated with each other. The sea absorbs approximately 93 per cent of the excess heat caused by the CO_2 (*Rhein et al., 2013*). It is affecting the marine lives slowly. Anthropogenic greenhouse gas (GHGs) emissions and continuous rising of global mean temperatures are significantly changing the earth's climate and the marine ecosystems. Anthropogenic greenhouse gas (GHG) emissions is playing significant role to increase their concentrations in atmosphere. The ocean has been compelled to swallow about 30 per cent of the emitted anthropogenic CO_2 (*IPCC, 2014*). Therefore, the potency of local fisheries and the health of marine life has changed negatively, and ocean acidification has elevated (*Stocker et al., 2013; Gattuso et al., 2015; Weatherd on et al., 2016*). Thus,

climate change is damaging the entire ecosystem in alarming ways. Besides, affected coral reefs, and mangroves are also leading the loss of fisheries biodiversity. Marine environmental changes are severely and increasingly stressing coral reefs. These marine hazards are sedimentation, nutrient loading, physical destruction, pollution and overfishing (*Wilkinson and Buddemeier, 1994*). The main factors of climate change are affecting the coastal communities by destroying the fisheries resources. Finally, socio-economic benefits are being reduced due to the overall impacts of climate change. By considering this, it is essential to review the potential environmental and socio-economic damage of climate change.

METHODOLOGY

Information from different secondary sources was used to carry out this research work. Published scientific research articles and gray literatures were considered to procure data to complete the review. The principal sources of information were the documents related to 'climate change,' 'fisheries resources,' 'inland fisheries,' 'marine fisheries resources,' 'ecological issues,' 'aquatic biology,' 'freshwater and marine environments' etc. Besides, these were the keywords for searching the information. Further information were also collected through visiting official websites of different relevant institutes, e.g., The Food and Agriculture Organization (FAO), World Fish Center etc. for getting an updated approach to address climate change for taking an adaptive measure. Furthermore, present condition, barriers, and preparation against climate change were observed in different stations of the Department of Fisheries in Bangladesh Government. All of these gathered data were reviewed, synthesized, and relevant information was used.

RESULTS AND DISCUSSION

Geo-physical impacts:Highsea level: Sea level is rising with the each degree increase of the global temperature, which may lead to salinization of the groundwater. The effect of sea-level rising means that coastal fishing communities are on the leading line of climate change. That means, if any hazardous issue occurs because of the climate change, the coastal fishing communities will become the first victim of it. Changing in the rainfall patterns and water use has an impact on the inland (fresh water) fisheries and on the aquaculture (*Harley et al., 2006*). Saline soil creates a detrimental effect on the freshwater fisheries and aquaculture. Therefore, intensifying sea level harms fish production, fish landing, processing, and as well as fish marketing facilities.

Alteration of annual monsoon: Climate change affects lots of environmental factors by altering rainfall patterns, drought, and the flooding season (*Goswami et al., 2006*). Thus, it creates additional pressure on loss of the habitat, pollution, introduction of the new species. Ocean productivity and circulation patterns are changing, which are creating an adverse effect on the food web. It is creating endanger to the inland fisheries and aquaculture (*Harley et al., 2006*).

Temperature: It may positively affect the maturity rate up to an optimum level and lower natural winter mortality in a temperate region. But temperature >30° C results in slow feeding and reduce the growth rate (*McCauley and Beitinger, 1992*). Besides, it reduces diffused oxygen levels and increases the metabolism rates of the fish. It is subsequently leading to raises in the fish deaths and reduction of the production. Moreover, the risk of spreading diseases is in raising state due to the high temperatures (*FAO, 2008a*).

Ocean acidification: Calcification of aquatic organisms such as shrimps, oysters, or the corals is more challenging in highly acidic water. Many primary animals, such as zooplankton, have calcium shells. These shells are getting hampered because of this acidification. As a result, alternation in the entire marine food web can happen. Oceans can absorb higher anthropogenic CO_2 emissions than the land's absorption (*Caldeira and Wickett, 2003*). CO_2 is hydrophilic, and it can reversibly convert to carbonic acid. This carbonic acid is responsible for the alarming rate of the ocean acidification (*Dupont and Thorndyke, 2009*). Ultimately it directly affects the whole-organism level, including the growth delay, increase of the predation and fatality, alteration in feeding rates and behavior, reduction in the immune competence, and decreased thermal tolerance. Indirectly it alters the amount of predator and prey, habitats of coral reefs, and as well as changes in nutrient recycling (*Le Quesne and Pinnegar, 2011*).

Alteration in supporting ecosystems: Changing in the climate also creates stresses on the mangroves, sea

grasses, and coral reefs. The acidification process has a consequence on the shell-forming aquatic animals. Besides, global warming is associated with the eutrophication process and the harmful algal blooms (*Peperzak, 2003*), which in turn intensifies the occurrence of the toxic tides. Therefore, different climate-changing elements affects supporting ecosystems of aquaculture.

Changes in the primary production: Climate change and ocean's primary production are interrelated with each other and are expected to be animportant limitation on fishes and fisheries production (*Dulvy et al., 2010*). The survival rate of the fish larvae depends on the availability of adequate and suitable food. Therefore, the distribution and phenology of the fish larvae and availability of their food affected severely (*Brander, 2006*).

Increasing surface temperature is a crucial factor which is affecting the primary production. (*O'Reilly et al.,2008)* predicted that the thermal stability would be increased, and the productivity will be decreased with the increase in air temperature by about 1.7 degrees. The rising ocean acidity speed up the acidification process, which makes it more difficult for aquatic organisms such as shrimps, oysters, or corals to form their shells. Zooplankton, which forms the base of the food chain, have a calcium shell. Zooplankton will be reduced as a result of the failure in making shells. As a result, the whole marine life will face a critical problem. The primary production of fish will be affected too.

*Variations in fish distribution: I*t is the most commonly recorded ecological reports of aquatic species (*Sumaila et al., 2011*). Shifting of the habitat due the increasing temperature and salinity is causing variation in fish distribution. The distribution of the juveniles of marine migrant species within estuarine ground results from the responses of individuals to various environmental variables or factors such as salinity, the water temperature, food availability or sediment variety such as the appearance of sea grass which is highly productive (*Stoner et al., 2001; Selleslagh et al., 2009*). The distribution of fish was strictly related to the physicochemical parameters. COND, TEMP, and TURB and inversely correlated to SAL and pH are strongly influencing most of the fish species (Mansor *et al.,* 2012).

Carbon sequestration: Carbon sequestration is one of the major causative factors of climate change. It is the process through which agriculture and forestry practices remove atmospheric carbon dioxide. The forestation process, reforestation process, and as well as forest preservation process is considered as favorable practices that can reduce carbon sequestration. These can also preserve carbon. These all can help to alleviate climate change by enhancing carbon storage (*Miller, 2008*). Changes in ocean flows as well as having a substantial influence on the world climate may have significant direct effects on aquaculture through changes in temperature, primary productivity. Therefore, food availability and the spread of diseased toxic algal blooms and predators (*Handisyde et al., 2006*). The vulnerability of fishery and aquaculture to climate change is complicated, which reflects a combination of all factors which are associated with production.

Down-warding socio-economic status: Fishing is an essential economic sector in South Asia as well as in the other parts of the world (*Srikanthan, 2013*). Especially in South Asia, it is vital as the agricultural sector (*Srikanthan, 2013*). Climate change is entirely affecting those people who are solely dependent on fishing. There are many consequences of Climate changes on fishermen's livelihood. The vulnerability of fishery-based livelihoods to climate variability and change is the degree to which a fishery-based livelihood system is susceptible to and weak to cope with adverse impacts of climate change, including climate variability and extremes (*IPCC, 2007*). In a small-scale fishing community, households are involved in various types of fishery-related activities such as fishing, post-harvest fish processing, fish trading, and making and mending of fishing materials (*OECD, 2001*). Fishing is a high-risk livelihood activity ''due to the fugitive characteristics of the resource, the unfriendly environment of the seas, and the perishability of the product" (*MRAG, 2011*). One direct impact of climatic shocks, such as cyclones and floods, is loss of many lives. Climatic shocks had killed more than hundred thousand people in the coastal region of many developing countries like Bangladesh. Many of them were fishermen or their household members, friends, or relatives (*IPCC, 2007*). Other impacts include physical injuries (*Badjeck et al., 2010*) and the health effects (*Kovats et al., 2003*) of the fishermen.

Cyclones and floods also damages boats, nets,

fishing gear, and fish landing centers, as well as educational, health, housing, and other community infrastructure (*Jallow et al., 1999; Adger et al., 2005; Westlund et al., 2007*). Fish productivity, abundance, and distribution are also likely to be impacted by climate change (*IPCC, 2007; Cheung et al., 2009; Brander, 2010; Drinkwater et al., 2010*), which may increase the cost of accessing fish catch (*Badjeck et al., 2010*). Fish processing costs may also increase due to the climate change.

Traditional fish drying is sensitive to variations in temperature and rainfall. Impacts on catch and processing of fish will ultimately influence employment, income, and nutrition of fishery-dependent households and communities through changes in the local institutions and resource management (*Badjeck et al., 2010*).

If, because of the climate change, the population of the fish becomes lower, it will significantly affect those people who are dependable on fishing for their livelihood. There will be some notable changes in their life:

1. Many of them don't know any work except fishing; they won't find any work to do. As a result, they will face an economic problem.
2. Their all equipment such as boats, nets, etc. will be damaged.
3. They won't get the basic needs of life: food, clothes, habitat, treatment, and education because of the lacking of the capability to buy them.

Besides this, when the population of fish will become lower, many people who are now depending on fishing for their livelihood, will try to find out another work to do. As a result, when people in any specific sector, such as "day labor" will rise, the price of the work of that sector will decrease. It won't be a good sign for that sector. The cost of work or the value of work is essential for any industry because if the value of work becomes lower in any industry, people will try to find out alternatives where they will get the proper value of their work. So, we can say that because of climate change, if the fish population becomes lower, it will create a fluctuation in the global economy too. Many sectors will lose their proper value of work.

Adaptation and mitigation: Making short-term decisions and long-term strategies in response to the impact of climate change is called adaptation. Therefore, adaptation is a continuous flow of activities, actions, choices, and approaches towards a problem to solve this (*Daw et al., 2009*). On the other, mitigation is the decreasing of the effect of climate change. The possible adaptation practices and recommendation are given below:

Pond aquaculture: This is an adaption tactic. This tactic is followed in many tropical and subtropical areas where aquaculture means finfish culture is done. Solar radiation, wind velocity, air temperature, water turbidity, humidity, and pond morphometry influences the pond water temperature. The overall rise in the global air temperature may not directly reflects in corresponding raises in inland aquaculture ponds. This suggests that there may be no need to make a plan of changing species or the modus operandi of the current aquaculture practices, particularly in the tropical and subtropical regions.

Integrated aquaculture: Integrated aquaculture is a very traditional practice. Especially in the small scale practice in the form of rice cum fish culture and/or aquaculture combination with animal husbandry. Combined aquaculture is still relatively traditional in rural China. This is also traditional in other tropical Asian countries and some temperate regions in Eastern Europe. The right production level of fish and other commodities from these practices is not accurately known. Still, they are essential to those rural communities where aquaculture is often practiced as the sole livelihood.

Cage culture: At present, globally cage aquaculture is becoming a frequently significant feature of the aquaculture expansion (*Halwart et al., 2007*). (*Ficke et al., 2007*) recommended that climatic changes could intensify eutrophication and stratification in the lentic systems and it could results in oxygen depletion. Tropics cage culture activities should be better-planned to avoid unwanted situations.

Aquaculture insurance: Insurance is an adaptive means that will help to limit the bankruptcies in the aquaculture business losses, which are currently in this condition because of any unwanted climatic damages. Proper insurance will cover at least a guarantee to restart the business correctly. Aquaculture insurance is well established for major commodities such as salmon and shrimp which are produced at industrial scales, but it is limited for small farmers. This is particularly important for Asia (*Secretan et al., 2007*), where the small-scale farming is usual. Governments should take some policies about aquaculture insurance considering specific size,

long term losses in the production, livelihoods, and as well as potential environmental damages.

Research and technology transfer: Relevant research and development concerning climate change and aquaculture are required. Technology transfer mechanisms must reach to the farmer level, especially to the small farmers. The occurrence of the disease, nutritional requirement, and the exact effect of climate change on specific species should be established through research and making awareness among the fish farmers by transferring the ultimate result of this research. For example, genetically improved strains of tilapia and the white legged shrimp culture have become successful under certain alien conditions. But there should be care based on the movement of the live organisms. This technology should be transferred to the small farmers so that they can try it and can adapt it if they want.

Aquaculture diversification: At present, in many countries and regions, there is a clear tendency to diversify farmed species and technologies (*FAO, 2006*). The speedy diversification process, which is "domestication of new species for aquaculture," is particularly mariculture. This process highlights the potential adaptive significance. In evolutionary terms, it is commonly understood that diversity provides the ground for natural selection and adaptation. Along with this, this type of proposal can be raise that, it is culturing more species that can submit a form of insurance and can offer better adaptation possibilities under different climate changing scenarios, especially unexpected issues such as diseases or market issues.

Aquaculture zoning and monitoring: Aquaculture is now become a significant and continuously growing food production sector (*FAO, 2006; 2007; 2009*). It provides income, employment and it can significantly offer to the stock of much-needed protein and along with this, food protection in general. Aquaculture is relatively a good system for the production of nutritious food. These nutritious foods can make an essential addition to global food security (*Brummett, 2013*). Sufficient site determination and aquaculture zoning can be necessary for adaptation actions to climate change. The availability of suitable areas for aquaculture in the Mediterranean region is becoming an important problem for the development and expansion of the activities related to aquaculture (*IUCN, 2009*). Site selection and site supervision are the most crucial issues for being successful in aquaculture, and it's needed to be carried out under sustainability and best practice guidelines (*IUCN, 2009*).

At the time of selecting aquaculture sites, it is required to determine possible threats by using risk assessment analysis. Decision-makers should be familiar with current production and technological methods so that they can ensure that aquaculture sites are appropriately selected and they can avoid any risk (*IUCN, 2009*).

At the time of choosing the best locations for aquaculture farms, particularly in coastal areas and in more exposed areas, weather-related dangers must be considered. As an example, coastal shrimp farms may need levies or other protective arrangements. Fish cages have to fasten to the bottom of a holding structure securely; submersible cages are that type of structure which can do this. Submersible cages are currently using in a few offshore sites. The result of using these cages is significantly good. They can withstand unfavorable weather conditions. Water warming and related low oxygen, potential eutrophication enhancement, etc. can be bypassed or minimized in the deeper locations with better circulation. For this purpose, tools like geographical information systems (GIS) should be used. By using GIS, it is possible to assess the spatial and ephemeral scales in the aquaculture site selection and site management process (*IUCN, 2009*).

However, there are always tradeoffs with the exposure to more extreme situations. Reduction in the likelihood of disease spread is possible by raising the minimum distance between farms and by executing tight bio-security plans for aquaculture clusters or zones. Implementing proper risk communication is also very important, but that communications have to be honest and quick, and the information also should be accurate. In this concern, weather information systems around the world are developing to prevent the consequential damages to the infrastructure and the biomass. For aquaculture, some of the most critical prevention systems must rely on the importance and active monitoring of water bodies and as well as aquatic organisms, such as bloom in the marine water, which indicates the condition of water bodies. If we can use them to identify the condition of the water, we can easily

monitor water bodies (*IUCN, 2009*).

A significant adaptation action at the local level and the water body/watershed system is the implementation of adequate multicultural monitoring systems. Such monitoring systems should provide sufficient information on physical and chemical status of the aquatic environments, early detection of diseases, and the presence of the pest species. It also includes information about the harmful algal blooms. Often, rural farmers may not have the terms and tools to execute such monitoring by them. However, some elementary measurements can be performed, such as water temperature and Secchi disk readings. The latter can give the early detection of algal blooms. Ideally, local authorities can support in executing this combined monitoring system with accompanying risk communication strategies and early warning systems to take steps and to notify the stakeholders. Some interesting examples of these monitoring systems are the monitoring programs for red tides in connection with mussel farming in the coastal inlets (rías) in Galicia, Spain, and the monitoring programs for salmon farming. In Galicia, the Technological Institute for The Control of The Marine Environment (INTECMAR) has a permanent monitoring program on the internet, which is easy to access for everyone. It provides alerts and early warnings about red tides and other water conditions which is relevant to mussel farming. The salmon farming industry in Chile, maintains a combined monitoring system through the Salmon Farmers Association. This monitoring system provides them the information about different water parameters by a permanent recording mechanism (automatic buoys plus manual samplings), and the information is delivered daily to the farmers through the web and also through local radio programs so that it can reach to the more remote areas.

CONCLUSION

The fisheries sector is a major source of income for many people in coastal communities. At present, because of climatic issues, marine life is facing several problems which are directly or indirectly affecting the people who are involved in the fish industry. But this condition can be solved by us. We can take some steps to improve the present ecosystem of marine life. Successful adaptation, including the survival of a population, species, or ecosystem, depending on the scale of the response. Population size, genetic variance, life span, reproduction, and dispersal are the factors affecting marine species (*Bell, 2009; Bernhardt, 2013; Hoffmann, 2011; Willi et al., 2006*). Improving the control of fisheries and aquaculture, as well as the sincerity and flexibility of aquatic ecosystems, are the best practices to decrease the climatic change effect. Besides, the sustainable use of fisheries biotechnologies, genetic diversity can reduce the impact of climate change soon. Enriched biodiversity gives higher production of fisheries product. In this case, the socio-economic status of fishermen will be upgraded indeed. So, it can be expected that coming days of aquatic life will change though some good marine governance policies.

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