Novelty Journals

ISSN 2394-9716

International Journal of Novel Research in Interdisciplinary Studies
Vol. 4, Issue 1, pp: (1-5), Month: January – February 2017, Available at: www.noveltyjournals.com

Review on Regional Impact of Climate Change on Fisheries Sector

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Abstract: **Fish is considered as a staple protein in human dietary intake and the fisheries sector serves as a source of employment and economic benefit. The fisheries sector is one of the climate sensitive areas affecting the productivity and diversity of fish species through the changes in distribution, abundance, size, habitat, and condition. Therefore, the scientists all over the world has paid enormous concern for the impact of climate change on fisheries sector. However, the information is still inadequate and detailed study is needed to adapt the treat of climate change as well for the sustainable fisheries sector. This paper attempts to give information about the impact of climate change on fisheries sector in different areas of the world and thus to contribute to the future research by serving as a background information.**

Keywords: **Adaptation, Aquaculture, Climate, Fisheries, Impact, Vulnerability.**

I. INTRODUCTION

In the current world, climate change has become one of the biggest threats to ecosystems due to the well-established evidences. Based on the definition of the Intergovernmental Panel for Climate Change (IPCC) climate change refers as a change in climate that is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and that is in addition to natural climate variability observed over comparable time periods [1]. The scientists has identified that human activities are increasingly influencing the climate and the earth's temperature by burning fossil fuels, cutting down rainforests and farming livestock.

However, the climate change is already having a reflective effect on the life in the water body. Thus, the fisheries sector became one of the climate sensitive areas with noticeable impact. Globally, 3 billion people rely on fish as their major source of protein. At the same time, this sector assure the livelihoods of 12% of the world's population, creating economic benefits of US$ 2.9 trillion per year [2]. The elevated amount of carbon dioxide may acidify the ocean which can affect many fish and shell fish species. On the other hand, changes in temperature can destroy local fishing community due to the changes is fisheries habitat. Similarly, rising sea level can destroy the breeding ground and nurseries of many fish species. However, the climate change is not universal and thus the impact can be varied region to region. The aim of this review is to present the impacts of climate change on fisheries sector at a global scale. This review can be served as a background information for future research on climate change and fisheries.

II. FISHERIES SECTOR IN CHANGING CLIMATE

Climate Change in Bangladesh has become an extremely crucial issue due to its geographical location, flat and low-lying landscape, population density, poverty, illiteracy, lack of institutional setup etc. [3]. The vulnerability of fisheries sector linking with climate change in Bangladesh is also obvious because of its economics (3.69% in national GDP), diets (60% animal protein supply) and social dependencies on fisheries sector (17.80 million full time employment) [4]. Based on the fisheries statistics published on 2016, the total fish production from inland closed water (culture), inland open water

(capture) and marine fisheries was 3.548 mMT in the year 2013-14 [4]. Nevertheless, In Asia, Bangladesh including Pakistan, Laos PDR and Nepal has the lowest adaptive capacity for climate change in fisheries [5]. The degree of sea level rise has been identified as a critical variable for the vulnerability of climate change in Bangladesh which directly affect the fisheries sector. Bangladesh is well known for its high quality shrimp culture and in the coastal zone of Bangladesh approximately 60 shrimp hatcheries and 120 shrimp processing plants are operating. Even though, the sea level rise can be helpful for the shrimp farming for maintaining the salinity of coastal area, it can destroy the shrimp pond by causing flood. At the same time, the dry fish industry is also affected by the sea level rise [6]. Another impact of climate change on fisheries sector is the alteration of marine ecosystems which influences the reproduction, migration and survival of fish species and the indication has been observed in case of Hilsa (*Tenualosa ilisha*) fish in Bangladesh. During the last two decades Hilsa production from inland waters declined about 20 percent, whereas marine water yield increased threefold. Major Hilsa catch has gradually shifted from inland to marine water [6]. Another study has been carried out to assess the vulnerability and adaptation to the impacts of climate variability and change, in three small-scale coastal fishing communities in Bangladesh. The study identified that the level of livelihood vulnerability not only differs between communities but also between different household groups within a community, depending on their level of exposure, sensitivity and adaptive capacity [7]. However, Billah [8] has conducted a research to understand climatic variables those have adverse effects on freshwater aquaculture, to identify possible impacts of climate change on freshwater aquaculture practices and to recommend for adaptation to climate change. The study utilized survey, interview and Focus Group Discussion method to collect data from 50 fish farmers, 30 hatchery operators, and 20 key informants. The study identified flood, drought, rainfall variation, fluctuation of temperature and cyclone as the common climatic variables affecting the freshwater aquaculture in Bangladesh those frequently occur in freshwater aquaculture in Bangladesh. These variables reduce spawning rate, hatchling rate and growth rate of fingerlings in hatcheries as well as affect fish feed production, deteriorate feed quality and also less availability in market.

India has been ranked 20th on Climate Change Performance Index 2017 and thus the fisheries sector of India is not free from the risk. A study on the impact of sea level rise has been conducted at Vellare Coleroon estuarine region of the southeast coast of India in the Tamil Nadu State. The study utilized Digital Elevation Model (DEM) derived from SRTM 90M (Shuttle Radar Topographic Mission) data, along with GIS (Geographic Information System) techniques to categorize the range of inundation and the projected SLR scenarios of 0.5 m and 1 m was utilized to estimate the vulnerability. The findings of the study revealed that about 1570 ha of the LULC (Land use and Land cover) of the study area would be permanently inundated to 0.5 m and 2407 ha for 1 m SLR and has also resulted in the loss of three major coastal natural resources like coastal agriculture, mangroves and aquaculture. At the same time, the study identified six villages to be vulnerable at 0.5 m SLR and twelve villages at 1 m SLR. However, the study proposed mainstreaming adaptation options to SLR as a sustainable adaptation measure [9].

Aquaculture is an important sector of Canada providing a remarkable amount of revenue for the Canadian economy as well as job opportunities. At the same time, Canada is the seventh largest seafood exporter in the world exporting 85% of seafood production. British Columbia is an ideal place for aquaculture because of its climate, water quality and sheltered bays and therefore this area has been identified as the fourth largest producer of salmon in the world and is Canada's leader in aquaculture production. About 740 aquaculture operations in B.C. produce salmon, other finfish and shellfish year-round, with a total harvested value of nearly $534 million. British Columbia's aquaculture industry also creates close to 6,000 jobs, which results in $224 million in wages for British Columbians [10]. A study investigated the impact of climate change on Manila Clams and Pacific Oysters bottom culture in British Columbia. The findings of the study indicated that the annual average projections of SST of open ocean adjacent waters of BC's coast will increase approximately 10C between 2012 and 2050 at a rate of 0.1110C/year, and between 2051 and 2100 the SST will increase approximately 20C at a rate of 0.0330C/year. The annual average projections of SSS of open ocean adjacent waters of BC's coast will decrease approximately 0.2 ppt between iv 2012 and 2050 at a rate of 0.0055 ppt/year. Furthermore, projections from 2051 to 2100 indicate that SST will decrease approximately 0.5 ppt at a rate of 0.0088 ppt/year. The results also indicated that an increase of 1.2 m in sea level will inundate 121 ha of Buckley Bay and Fanny Bay combined and 37 ha of Henry Bay. An increase of 2 m in sea level will inundate 195.2 ha of Buckley Bay and Fanny Bay, and, 51.4 ha of Henry Bay. Capability indices' classes defined and mapped in this study for Manila Clams bottom culture are: Not advisable, Poor, Medium and Good; and Not Advisable, Medium and Good for Pacific Oysters [11]. Another study used traditional environmental knowledge (TEK) to assess the impacts of climate change on food security for First Nations

communities located in the western James Bay region of northern Ontario, Canada [12]. The result could not observe climatic-related effects on fish species (i.e., distributional change) except the fish die-offs of July 2005.

Mathis [13] used a risk assessment framework based on the Intergovernmental Panel on Climate Change to analyze earth-system global ocean model hindcasts and projections of ocean chemistry, fisheries harvest data, and demographic information in case of Alaska's fishery sector. The analysis indicated that regions in southeast and southwest Alaska that are highly reliant on fishery harvests and have relatively lower incomes and employment alternatives likely face the highest risk from ocean acidification. Similarly, Shenker [14] stated that fishery species in Florida are under threat due to climate change especially for the sea level rise, changes in hurricanes and precipitation levels. On the other hand, another study has been conducted to assess the climate vulnerability on 82 fish and invertebrate species in the Northeast U.S. shelf including exploited, forage, and protected species. The findings revealed that the majority of species included in the assessment had a high potential for a change in distribution in response to projected changes in climate [15].

The adverse effect of climate change on fisheries sector can be reduced through increasing fishers' access to educational, physical, financial and livelihood opportunities [16]. An inverse correlation between sea surface temperature and fish catches and a positive correlation between fish catches and rainfall has been observed in Kenya's coastline. No significant association observed between gear type and education level. At the same time the education level and period in fishing were not significant determinants influencing migration as a coping strategy to climate variability. However, small-scale fisher-folk in the developing countries are more vulnerable to climate variability because of their high reliance on fisheries and poor adaptive capacity. A study recommended that the government and other stakeholders should help enhance resilience of fishing communities by supporting existing adaptive livelihood strategies and management institutions that are designed to support adaptation to climate change and variability [17]

Taking into account the importance of fish habitat for a sustainable fisheries, the Fisheries Queensland has carried out a project with the aim of auditing and mapping the vulnerability of marine vegetation communities (fish habitats) to the physical impacts of sea level rise [18]. The result demonstrated a marked difference in mangrove community extent between the southern and northern parts of Moreton Bay, with the gains in fish habitats occurring mostly on the undeveloped floodplains of the estuaries of the Caboolture River region. For evaluating the risk of climate change on aquaculture industries, a qualitative screening-level risk assessment was developed applying 7 major industries in the temperate south-east region of Australia [19]. The assessment specified that oysters farmed from wild spat (Sydney rock oysters *Saccostrea glomerata*) were at most risk to climate change, with warm temperate hatchery-based finfish species (yellowtail kingfish *Seriola lalandi*) being the least at risk.

A value orientation approach was used to investigate the relation between climate change and trout fishing in Georgia. The study revealed protection orientation, knowledge of current impact of climate change on trout, belief about climate change, perceived quality of trout fishing, specialization, importance of catching many trout, and source of climate information as significant predictors of trout anglers' concern about risk of climate change. At the same time protection orientation, concern, specialization, importance of catching many trout, trout substitutes, and importance of nature and scenery were identified as significant predictors of behavioral intentions of adjusting fishing trips to affected sites [20].

Fisheries resources are among the most significant natural benefactions of Uganda, which has about 20% of surface area covered by water, produces up to 15 000 tonnes of fish from aquaculture, including production from small-scale fish farmers, emerging commercial fish farmers and stocked community water reservoirs and minor lakes [21]. Besides the magnitude and diversity, the fisheries sector also plays significant role in terms of employment and income for over 1 million people. A study has conducted to on fishers' perceptions of climate change, impacts on their livelihoods and adaptation strategies in environmental change hotspots in the area of Lake Wamala, Uganda. Utilizing quantitative and qualitative methods, the study observed that fishers were aware of changes in climate conditions exhibited by irregular seasons, floods and droughts. The study also identified fishing remained the main livelihood activity. Besides that, the dominance of fishes had changed from Nile tilapia (*Oreochromis niloticus*) to the African catfish (*Clarias gariepinus Burchell*) in the study area [22].

Malaysia is blessed with a massive area of coastline which is 4,809 km in length and 329,750 km^2 in area. Peninsular Malaysia consists of 2,031 km coastline whereas Sabah and Sarawak consists of 2,778 km coastline. There are 72 fish landing spots are available all over Malaysia including East and West Malaysia [23]. Therefore, the fishery sector has

been playing an important role as a major supplier of animal protein to the Malaysian population. According to the Food and Agriculture Organisation (FAO), Malaysia is one of the top fish-consuming countries in Asia (above 40kg/capita/year), almost double the average in Thailand and China. Total food fish production in Malaysia Increased from: 1.42 million MT (2005) to 1.74 million MT (2013). Even though the fisheries sector of Malaysia is not free from the impact of climate change, the research in this sector is still lacking. A study carried out with the aim of estimating the influence of selected environmental parameters on the fish larval distribution and abundance between October 2012 and September 2013 in the mangrove estuarine area of Marudu bay, Sabah, Malaysia (Rezagholinejad 2016). The study recorded total 3,879 larvae from 20 families with a mean abundance of 118 larvae per 100 m3. The result identified a weak overall correlation between larval assemblage and environmental parameters in the estuary of Marudu Bay [24].

III. CONCLUSION

Climate change is a truly global alarm and there is no doubt that it will influence the fisheries sector. This fisheries sector is a blessing for many communities for acting as a source of food, animal protein and earning. Therefore, understanding the fish response of climate change is imperative for formulating adaptation measures. The work presented herein compiled the research relating climate change impact on fisheries sector. In case of Bangladesh, the sea level rise and alteration of marine ecosystem have been identified as most significant factor of climate change affecting fisheries sector. Similarly India is also vulnerable for sea level rise. Whereas the aquaculture industry of Canada can be influence by sea surface temperature, salinity and sea level rise. The research on the fisheries sector of US indicated that the fisheries species are highly vulnerable for changes in climate and the limiting factors are identified as ocean acidification, sea level rise, changes in hurricanes and precipitation levels. However, the sea surface temperature and rainfall pattern are concerned for the fisheries sector of Kenya. In case of Australia, oysters farmed from wild spat has been identified at risk level. Moreover, some significant predictors has been found for the trout anglers in Georgia such as protection orientation, knowledge of current impact of climate change on trout, belief about climate change, perceived quality of trout fishing, specialization, importance of catching many trout, and source of climate information. At the same time the fishers of Uganda were conscious about the changing climate revealed by irregular seasons, floods and droughts. However, in case of Malaysia weak correlation between larval assemblage and environmental parameters in the estuary of Marudu Bay has been observed. As a whole, the review indicated the world wide concern of the climate change issue and identified sea level rise, ocean acidification, sea surface temperature and salinity are the most distressed climate variables. Additionally, many studies has been conducted on the fishermen community to find out the impact on their livelihood. The review has also revealed that the climate change can affect both the culture and capture fisheries. Even though the important of this area, the research on climate change and fisheries sector is still a lacking and thus more study is recommended for a sustainable fisheries in changing climate.

ACKNOWLEDGEMENT

The research has been carried out under the research project TRGS/1/2015/UKM/02/5/2 provided by Ministry of Higher Education of Malaysia.

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