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RESEARCH ARTICLE

Climate Change and Its Impact on Fisheries and Aquatic Ecosystem in Bihar

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Abstract

Climate change is the most important global change phenomenon which has attracted the attention of all community across the globe. With the signs of climate change becoming increasingly tangible with each passing year, concern about its possible implications for various sectors of life on the Earth is also intensifying. Intergovernmental Panel on Climate Change (IPCC, 2007a), average global temperature increased by 0.74±0.18°C during the last 100 years. It is estimated (IPCC, 2007b)that in 21st Century global surface temperature will likely to rise further 1.1 to 6.4°C. On account of its close association with climatic variables such as temperature and precipitation, fisheries is indisputably the most climate-sensitive sector, and thus, the possible impact of climate change on this sector of utmost importance to millions of peoples who are directly or indirectly associated with the sector.

Introduction

Human's relentless pursuit of material comfort and 'luxurious life' has engendered an irreversible harm to the environment , In a country like India where seventy percent of the population is dependent on agriculture and allied sectors, it is imperative that the effects of such drastic changes in environment are studied. Also, it is equally important that we rely more on scientifically proven facts about global climate changes rather than mere conjectures and exaggerations. Over the past two decades, climate change has evolved from a subject of future speculation to an inconvenient reality of the present. Climate change is arguably the most important global change phenomenon which has attracted the attention of scientific community across the globe. With the signs of climate change becoming increasingly tangible with each passing year, concern about its possible implications for various sectors of life on the Earth is also intensifying. Intergovernmental Panel on Climate Change (IPCC, 2007a), average global temperature increased by 0.74±0.18°C during the last 100 years. It is estimated (IPCC, 2007b)that in 21st Century global surface temperature will likely to rise further 1.1 to 6.4°C. On account of its close association with climatic variables such as temperature and precipitation, fisheries is indisputably the most climate-sensitive sector, and thus, the possible impact of climate change on this sector of utmost importance to millions of peoples who are directly or indirectly associated with the sector. In recent years, possible impact of climate change on fisheries has been the most intensively debated,yet neglected topic. This article explores the possible impact of climate change on fisheries and aquatic ecosystem, with special reference to Bihar.

How fisheries will be affected

In general, fishes cannot maintain a constant body temperature like mammals do. Their body is exactly the same temperature as the water they are living in. Surprisingly, fishes can live in very cold or very hot water, but each species has a range of temperatures that it prefers, and fish can't survive in temperatures too far (increase or decrease) out of this range. When fish encounter water that is too cold for them, their metabolism slows down and they become lethargic. Contrary, as the surrounding water warms up, their metabolism speeds up and they digest food more rapidly, grow more quickly, and eventually have more energy for reproduction. But fish need more food and more oxygen to support this higher metabolism. Warmer fish tend to mature more quickly, but the cost of this speedy lifestyle is often a smaller body size (Pottinger 1998). Ninety percent of aquatic animals raised in warm water end up smaller than their peers raised at cooler temperatures (Wedemeyer*et al.,* 1999). For instance, Southern calamari grow more quickly at higher temperatures, but they also hatch much earlier, and reach sexual maturity earlier, so they can't catch up in size to Squid who have more time to grow in cool water(Beitinger*et al.*, 2000). Many fish will also have less offspring as temperatures rise, and some may not be able to reproduce at all and become permanently sterile.

Tropical fish like Guppies produce smaller broods, and Chocolate mahseer ovulate less frequently in warm water (Majhi et al., 2011). In eastern region of India climate change will threaten the sustainability of riverine and stream fishes due to rising water temperature, and reduced river flow. So many of the native fish species found in the major river system of the region will depicts a migratory behavior or may tends to become weaker in terms of reproductive performance. Nevertheless, such declines in fisheries will have massive impacts on the region's commercial fisheries (both capture and culture), tourism, and rich biodiversity. For instance, warmer temperatures will likely to cause economically important species such as *Chacachaca*, *Chitalachitala* and and *Nangranangra*to disperse and shift the range in which they live. They may be unable to survive in low or mid riverine flow conditions. In fact, if there is not enough food, the available energy of fish will go to fuelling its high metabolism, and less energy will be available for growth and reproduction (Monica and Ferando2002). Rainbow trout grow significantly more slowly when the water temperature is raised only 2°C and food is limited, and fish such as Salmon is expected to grow more slowly if food supply does not increase as temperatures rise (Kubb*et al.*, 1980). Even if there is more food to eat, it may not be enough to satisfy the rapacious appetites of warmed-up fish. Experiments in Toolik Lake, Alaska (US), suggest that a warming of 3°C will double the food supply for Arctic trout, but their metabolism will increase so much that young trout are expected to starve by the end of their first year. This lake has in fact warmed by several degrees during the last few decades, and young fish have begun to lose weight during August, the month when they normally grow the most. So, arctic trout may already be suffering the effects of climate change (Allison et al. 2007).

To make matters worse, fish may not have enough oxygen to breathe as the water grows warmer. Fish filter oxygen from the water, but the amount of oxygen dissolved in water decreases as temperatures rise. So many fish will experience an "oxygen squeeze" as the aquatic environment warms (Diaz et al., 2004). They will need more oxygen to support their elevated metabolisms, but may not be able to get it from the warmer, oxygen-poor water around them. Many tropical species those already suffer near-lethal temperatures during the hottest part of the day. A sudden and abrupt change in temperature even 2-3°C can lead to mass mortality, especially in aquaculture ponds or shallow pools.

As global temperatures rise, some fish may be able to shift locally by moving deeper or by heading upriver towards cool water. Forty years of data from the Great Lakes (US and Canada) suggested that warm water species such as Smallmouth bass will become 14 times more abundant than species like Northern pike and lake trout if temperatures rise by 2°C, and the fish that stick around are already living in warmer water will also have to deal with new species showing up on their ecosystem (Brander 2007). Many areas have been colonized by new species as water has warmed in the last few decades, and invasions are likely to increase. Introduced tropical fish Tilapia, a freshwater fish from Africa, competes with native fish for food and spawning habitat, and gobbles up eggs and juveniles, while larger predators prey on native adults (Allison et al., 2009). In India existing favourable higher temperature condition, tilapia is increasingly becoming menace for their indiscriminate breeding behaviour. Many ponds and lakes of India have been choked with large number of smaller size tilapia consequently endemic and native species are under severe threat.

Impact on environment and ecosystem

As our water bodies are warming up, many parasites and microbes that cause fetal fish diseases will grow faster and become more virulent (Kuwahara et al., 2006). Similarly, parasites in cooler climates will more likely survive the winter and produce multiple generations of offspring each year, so more fishes will become infected (Gale et al., 2009). If harmful microbes and parasites become stronger and more numerous, fish whose immune systems are already stressed by warm water, low oxygen, and crowding, will become even more susceptible to diseases and parasites. Consequently fishes will die massively everywhere (Gale et al., 2009). Further, warmer water increases the concentration of toxicity released from pollutants, and as fish pump more water through their gills to meet increased metabolic needs, virtually they collect more toxins (Guéguen et al., 2011). While warmer fish can flush out the extra load of some types of toxins like cadmium and lead (remain higher in the high temperatures) but fishes will accumulate mercury more rapidly, even if present in trace quantity. Mercury poisoning is already a major economic problem for fisheries in US, Canada and Japan, and poses a significant public health risk (Guéguen et al., 2011).

Impact on fish production of Bihar

The state of Bihar is producing around 3.69 lakh tone of fish (2012-13) at a growth rate of 5.58%, contributing around 4.5 % to the total fish production and 7.52% of Inland production of India (2000- 01 to 2010-11) . With 60-65 % of the population of Bihar eating fish (Bansil, 2011), the present fish production from the region provides about 4.81 kg/capita of fish against the standard nutritional requirement of 11.0 kg/capita. To bridge the gap between requirement and availability of fishes, additional 3.85lakh tonnes of fishes will be required The State is endowed with rich aquatic and fisheries resources in the form of rivers, flood plains, wetlands (*chaurs*), ox-bow lakes (*mauns*), reservoirs, tanks and ponds (Anon 2008).The state is having 361 thousand hectares of water area constituting around 3.9% of the total geographical area.Flood plains and other wetlands locally known as *chaurs* are major fisheries resources and measure about 45,978 ha. Ox-bow lakes, locally known as mauns, are the discarded loops of meandering rivers which got cut off from the main rivers and is estimated to be about 9,000 ha. State is also having a total of 25 thousand ha of reservoirs, 1.34 lakh ha wet land, 3200 km long riverine stretchand78 thousand ha of tanks and ponds (Directorate of Fisheries, Patna). There are around 49.59 lakh fishermen population (Bansil, 2011) getting substances from these vast water bodies. The average annual rainfall in Bihar for the last decade (2000-09) was estimated to be1091.08 mms. But, in 2005, the rainfall was 897.40 mms and in 2009 it was 868.61 mms. This indicates severe drought situation in 2005 and 2009. Drought occurred due to shortfall in south west monsoon in both these years (Anon 2011).These vast water bodies are experiencing drastic change in rainfall patters, rise in temperature, habitat destruction, overfishing, pollution etc. and thereby natural water bodies are increasingly threatened by climate change scenario. This will have direct implications on natural stock of fish populations as well as will have direct implication to livelihood option of fisher folk.

Table. Temperature tolerances of selected, cultured species of different climatic distribution.

Species	**Lower**	**Higher**	**Optimal range (ºC)**	Remarks
Redbelly tilapia (*Tilapia zillii*)	7	42	28.8-31.4	Tropical
Guinean tilapia (*Tilapiaguineensis*)	14	34	18-32	Tropical
European eel (*Anguilla Anguilla*)	0	39	22-23	Subtropical
Channel catfish (*Ictalurus punctatus*)	0	14	20-25	Subtropical
Arctic charr (*Salvelinus alpinus*)	0	19.7	06-15	Temperate/Polar
Rainbow trout (*Oncorhynchus mykis*s)	0	27	09-14	Temperate/Polar
Atlantic salmon (*Salmo salar*)	-0.5	25	13-17	Temperate/Polar
Indian major carps (IMC’s)	15	37	19-35	Subtropical

Impacts on diseases

An increase in the incidence of disease outbreaks in corals and marine mammals, together with the incidence of new diseases has been reported (Harvell *et al.*, 1999). Coral bleaching was linked to the high El Niño temperatures in 1997 to 1998.It is not difficult to predict a general impact of water warming on the spread of diseases such as bacterial diseases in aquaculture because in most cases, the incidence and persistence of these diseases are related to fish stress. Increased water temperatures usually stress the fish and facilitate various diseases process. Very recently it has been reported that ocean acidification could impact on the immune response of mussels, specifically shown for the blue mussel, *Mytilus edulis*, a popular aquaculture species. It has been suggested that the impacts are brought through changes in the physiological condition and functionality of haemocytes which in turn are caused by calcium carbonate shell dissolution. Examples of disease related catastrophes in the aquaculture industry include the spread of the white spot disease in shrimp farming in India and other countries (Sharma k, et al., 2010), the issue must be made a priority for aquaculture considering relevant biosecurity measures as a main adaptation.

Impacts on biodiversity

In the wake of the global climatic change induced phenomena, would impact adversely on disease transmission as well as on biodiversity. The balance of evidence suggests that global climate change will not enhance impacts on biodiversity through aquaculture *per se.* However, in view of the changes in temperature regimes and so forth, particularly in the temperate region, the possibilities of diseases occurring amongst filter feeding molluscs and fish, for example, could be higher. The decline of coral reefs, from bleaching, weakening of coral skeletons and reduced accretion of reefs are estimated to be as high as 60 percent by year 2030 (Dalvi, R. S *et al*., 2009).

Potential impacts of aquaculture on climate change

Aquaculture, on a global scale becomes a significant contributor to the human food basket. The aquaculture sector has experienced very strong growth over the last two decades, making it the fastest growing primary production industry (FAO, 2004b). Foremost among these has been the use of fish meal and fish oil, obtained through reduction processes of raw material supposedly suitable for direct human consumption. Another target has been that of mangrove clearing during the shrimp farming boom. In the past, mangrove clearing was a major issue with respect to shrimp farming but the practice no longer takes place. In fact, it has been estimated that less than five percent of mangrove areas have been lost due to shrimp farming, most losses occurring due to population pressures and clearing for agriculture, urban development, logging and fuel. Consequently, an attempt is made below to outline the positive contributions of aquaculture towards the global problem of climate change.

Carbon emissions, viz. Greenhouse gases, in one form or the other, driven by anthropogenic activities, are a root cause of climate change (IPCC, 2007) and all mitigating measures revolve around reducing the carbon emissions. It is therefore relevant to consider the degree of carbon emissions of the various animal food production sectors with a view to gauging the degree to which aquaculture contributes to this primary cause. The United States Environmental Protection Agency (EPA) recognised 14 major sources responsible for methane emissions in the USA and ranked enteric fermentation and manure management from animal husbandry as the third and fifth highest emitters respectively. Domesticated livestock, the ruminant animals (cattle, buffalo, sheep, goats, etc.) produce significant amounts of methane in the rumen in the normal course of food digestion, through microbial fermentation, that is discharged in the atmosphere. Equally, the solid waste produced manure needs to be managed and this process results in the emission of significant amounts of methane. It has been suggested that the world’s livestock accounts for 18 percent of greenhouse gases emitted, more than all transport modes put together, and most of this is contributed by 1.5 billion cattle . Overall, the livestock sector is estimated to account for 37 percent of all human-induced methane emissions. The global warming potential (GWP) of methane is estimated to be 23 times that of carbon dioxide. Farmed aquatic organisms do not emit methane and therefore are not direct contributors to the causative problems. Surprisingly and unfortunately this has not been taken into account, particularly by those who tend to advocate the view that aquaculture is polluting and non-sustainable.

Adaptive measures

It is suggested that successes in aquaculture depend on relevant institutional policy and planning changes or adaptations. In terms of institutional and policy measures the following are priority areas for development of the sector is to be taken into account:

- to implement an Ecosystem Approach to Aquaculture (EAA) as a global strategy;
- to prioritize and enhance mariculture and specially non-fed aquaculture (filter feeders, algae);
- To enhance the use of suitable inland water bodies through culture-based fisheries and appropriate stock enhancement practices.
- Farm management practices and breeding season could be modified to minimize the effect of climate change on aquaculture productivity.
- development of remediation strategies of soil and water of aquaculture ponds
- Improved training and general education of populations dependent on agriculture
- Identification of the present vulnerabilities of aquaculture systems
- Food programs and other social security programs to provide insurance of culture ponds against supply changes or any natural calamity
- Transportation, distribution and market integration to provide the infrastructure to supply food during crop short falls.

Conclusion

Fisheries and aquaculture needs to be blended into national climate change adaptation strategies. Without careful planning, aquatic ecosystems, fisheries and aquaculture can potentially suffer as a result of adaptation measures applied by other sectors, such as increased use of dams and hydropower in catchments with high rainfall, construction of artificial coastal defenses or marine wind farms. Mitigation solutions are not at all well known and require in innovative approaches such as the recent inclusion of mangrove conservation. The Ecosystem Approach to Aquaculture (EAA) aims to integrate aquaculture within the wider ecosystem as with any system approach to management; EAA encompasses a complete range of stakeholders, their influences, and other interlinked processes. In addition to the above improvements, it is imperative that the developed countries and the rapidly developing countries formulate strategies to curb green house gas emissions. Developing countries like India should also look at adopting new energy-saving technologies and planting of more trees. The emphasis should also be laid on increasing the use of renewable energy sources like solar and wind. The above facts emphasize the need not only to study in detail the climate change vulnerability of fisheries & aquaculture but also the methods of improving the adaptive capacity of aquaculture to climate variability and extremes.

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