www.eprawisdom.com e-ISSN : 2347 - 9671, p- ISSN : 2349 - 0187
EPRA International Journal of Economic and Business Review | Vol - 4, Issue- 9, September 2016
Inno Space (SJIF) Impact Factor : 5.509(Morocco) ISI Impact Factor : 1.259 (Dubai, UAE)

RESEARCH METHODS TO ASSESS THE IMPACT OF CLIMATE CHANGE ON FISHERIES

Dr.I.Sundar[1]
[1]Associate Professor and Economics Wing Head, Directorate of Distance Education, Annamalai University, Annamalai Nagar, Tamil Nadu, India.

ABSTRACT

Some of the fisheries resources that may be most affected by climate change include fisheries stocks that are currently heavily or over-exploited, and species with narrowly defined physiological tolerances to environmental conditions such as high water temperatures or low levels of dissolved oxygen. This paper deals with research methods to assess the impact of climate change on fisheries. It outlines the Potential Climate Change Impacts on Fisheries Resources. This paper makes a comprehensive discussion on empirical modeling with respect to effects of precipitation changes on fish yields, effects of precipitation changes on catch on riverine systems, effects of temperature changes on fish yield, effects of precipitation changes on yield in marine systems, effects of temperature changes on yield in marine systems, effects of precipitation changes on habitat availability, effects of sea level rise on habitat availability, effects of temperature on habitat suitability, effects of multiple stressors on habitat suitability, evaluating physiological and life history constraints on growth and reproduction, effects of temperature changes on mortality, effects of temperature change on growth using bioenergetics modeling and effects of temperature change on physiological processes. This paper makes a specific discussion on application of historical analogy, socio-economic considerations, autonomous adaptation and planned adaptation towards identifying the impact of climate change on fisheries sector. This paper concludes with some interesting findings along with policy suggestions.

KEYWORDS: *Fisheries resources, Climate Change, human population, tourism economies*

INTRODUCTION

Fisheries resources provide a considerable amount of protein in diets around the world, and in some countries provide the majority of the animal protein consumed by local human populations. In addition, fisheries resources may support significant recreational and tourism economies at a local or regional scale, and the export of fisheries products contributes considerably to the economies of a number of countries. Thus, maintaining healthy and sustainable fisheries resources is of major importance. Regardless of the nature of the stress in terms of overfishing, pollution and climate change, fisheries will continue to be important to subsistence, recreational, and commercial fishers on both a local and regional scale.

POTENTIAL CLIMATE CHANGE IMPACTS IN THE FISHERIES RESOURCES SECTOR

Potential loss of coastal wetlands and estuarine habitats due to altered currents, limnology and sea level. Changes in the quality and availability of suitable habitat, loss of thermal habitat due to increased water temperatures, change in habitat availability due to shifts in major ocean currents and disruption of areas of upwelling, reduction in habitat quality due to changes in water quality parameters such as nutrients, dissolved oxygen or pollutant levels, loss of habitat due to changes in the duration, magnitude and distribution of total precipitation affecting water availability and volume annual or seasonal, changes in the distribution of habitats for particular species, resulting in shifts in the fish community structure and function, alteration of food webs resulting in shifts in species composition, inflow of other species resulting in altered competition and predation, increased habitat fragmentation due to changes in water quality and availability, loss or shifts in location of fishing grounds with direct consequences on jobs, loss or shifts in location of fishing grounds with direct consequences on jobs, loss of jobs due to collapse of fishery, establishment or expansion of fishery industry with development of new fishing grounds and increased expenses related to migration of fishing grounds to more distant locations.

Empirical Modelling:-

In this approach, models are developed by regression and correlation from historical data. The principle is to identify a sufficiently accurate quantitative relationship between yield or abundance and a climatological parameter in terms of temperature or precipitation to estimate future yields under different climate scenarios. The overall approach is similar between freshwater and marine systems, differing primarily in the species of interest pollock, king crab, walleye and the climate variable of interest temperature or precipitation or both.

The largest obstacle for using this approach is the availability of sufficient historical climatological and fisheries data to permit development of acceptable models. Data needs for these models may include historical time-series precipitation, temperature, surface water area, surface water runoff, floodplain area, stream flow and discharge, and catch data, as well as water depth, dissolved solids, and estimated precipitation and temperature data. Potential impacts are assessed by comparing recorded yield or catch under historical climate conditions with the yield or catch estimated for future climate conditions. This approach also does not consider potential impacts associated with changes in water temperature, water quality, biotic interactions, or fishing effort, gear, or success.

Effects of Precipitation Changes on Fish Yields:-

Changes in local or regional precipitation patterns or precipitation magnitude are likely to affect inflows to lakes and reservoirs, thereby affecting surface water area or water depth. Empirical models that estimate potential annual fish yield from lakes and reservoirs as a function of the surface area of the water body may be developed which permit estimation of fish yield as a function of precipitation-related limnological or hydrological parameters. In this context, Crul (1992) employed regression analysis to develop an empirical model for estimating total annual fish yield as a function of surface water area for lakes and reservoirs in Africa. If appropriate limnological and fish yield data are available, similar empirical models could be developed using regression analyses for lakes and reservoirs of interest.

Effects of Precipitation Changes on Catch on Riverine Systems:-

Welcomme et al., (1976) have reported on the relationships between catch and discharge or floodplain area, and discharge and floodplain area are directly related to precipitation. As described for lacustrine systems, empirical models for estimating catch as a function of discharge or floodplain area can be developed using regression analyses and historical catch, discharge, and floodplain data. Discharge and floodplain area can be estimated for various precipitation scenarios. Total annual catch is estimated by inputting the estimated floodplain area or discharge to the appropriate empirical model.

Effects of Temperature Changes on Fish Yield:-

This method employs empirical models to estimate maximum sustainable yield in lakes as a function of mean annual air temperature and morphoedaphic index (MEI). The MEI is calculated as the total dissolved solids divided by the mean depth. A similar approach was used by Schlesinger and Regier (1983) to evaluate effects of environmental temperatures on the yields of subarctic and temperate fishes in North America.

Effects of Precipitation Changes on Yield in Marine Systems:-

Numerous studies have investigated potential climate effects on marine fisheries using time-series data and regression analysis, and these studies show good correlations between fishery yield and environmental conditions. It could be noted Megrey et al. (1995) used time-series data to develop models relating age-0 pollock abundance in the Gulf of Alaska to precipitation. Garcia and Le Reste (1981) conducted study in the United States, Senegal, the Gulf of Mexico, and Australia have demonstrated the influence of rainfall on shrimp production. Particularly good correlations between total annual shrimp catch and the previous two years of total annual rainfall have been identified; both positive and negative relationships have been found, depending on the specific area or the species. This approach only indirectly assesses the effects of continental discharge or variability in salinity.

Effects of Temperature Changes on Yield in Marine Systems:-

According to Beamish (1995), most studies evaluating climate impacts in marine systems have focused on the effects of temperature change. Many have evaluated time-series yield and climate data to develop empirical models that permit estimation of yield as a function of environmental temperature. It could be noted that Regier et al. (1990) used empirical data from several sources to develop a model of the Arrhenius form for estimating the stabilized commercial penaeid shrimp yield (kilogram/ hectare of intertidal vegetation) as a function of mean annual air temperature. The Arrhenius form of an exponential relationship may be given as $\log_e k = a - b (1/T)$, where k is the rate constant, T is the absolute temperature (K), and a and b are coefficients estimated by regression analysis. This same approach could be used to develop models for other fisheries.

Effects of Precipitation Changes on Habitat Availability:-

River and stream hydrographs are graphical representations of changes in stream flow over time with minimum flows in late summer, maximum flows during spring. Welcomme (1976) Lowe-McConnell (1987) Poff and Allan (1995) and Galat and Frazier (1996) reported from their studies that the shape of the yearly hydrograph and the magnitude, timing, and duration of flood events have been shown to play an important role in the maintenance of riverine fish stocks. Similar importance has been attributed to seasonal changes in lacustrine conditions such as depth and shoreline inundation.

Effects of Sea Level Rise on Habitat Availability:-

Turner, (1977) and Turner and Boesch (1988) have shown positive relationships between habitat availability and the growth, recruitment, or annual yield of a fishery. For habitats that are directly linked to sea level, such as coastal and estuarine areas and coral reefs, the loss or gain of habitat due to changes in sea level should reflect similar changes in the fishery resource. For some habitats, the rate of sea level rise may also be important. It could be noted that if sea level rises at a rate that exceeds the capacity of coral to grow upward and remain in the photic zone, the corals may die. The suggested approach uses regression analysis to develop models of the relationship between habitat availability and sea level. Depending on the fishery of concern, these habitats could include submerged aquatic vegetation, coral reefs, mangrove stands, mud flats, and others. The changes in habitat availability that could result from changes in sea level are estimated using map and image analyses.

Effects of Temperature on Habitat Suitability:-

This species-specific approach compares projected water temperatures to species specific thermal habitat in terms of thermal limits and preferences, and can be applied to a particular habitat or for multiple habitats within a large geographic area. It could be noted that Meisner (1990) estimated loss of thermal habitat in two southern Ontario streams, and Eaton and Scheller (1996) estimated thermal habitat loss for the continental United States. In this approach, maximum temperature profiles can be developed for selected aquatic habitats. Water temperatures for different climate scenarios can be obtained directly from climate models.

Effects of Multiple Stressors on Habitat Suitability:-

This species-specific approach includes the development of habitat suitability index (HSI) models for individual species of concern. Habitat suitability modelling was developed by the US Fish and Wildlife Service to aid in impact assessment and habitat management, and habitat suitability index models have been developed for more than 100 species of North American terrestrial, freshwater, and marine biota. The models incorporate environmental variables such as water temperature, water depth, dissolved oxygen (DO) concentrations, and substrate composition. These variables are measured on continuous scales, and individual suitability curves are developed for each variable. These individual variable curves are then combined to produce an index of habitat suitability that is also continuous, ranging from 0 unsuitable habitat to 1.0 optimally suitable habitat. Because of the flexibility in incorporating variables, these models can be useful for species with complex life cycles, such as anadromous species.

The strength of any habitat suitability index model is a direct function of the availability of the ecological and physiological data for each species of concern as well as the availability of habitat data. In the absence of such data, professional judgment may be used to develop some components of the models, although this will lessen the strength of the suitability estimation. If species interactions in terms of competition and predation are known, these parameters can be incorporated into the models. Following construction of species-specific habitat suitability index model, habitat suitability can be estimated for specific habitats using historical or current climatic, hydrological and ecological data. Suitability values can then be calculated for climatic and hydrological conditions associated with future climate scenarios.

Evaluating Physiological and Life History Constraints on Growth and Reproduction:-

This approach considers the potential effects of climate change on the growth and reproduction of target fish species as a function of species-specific physiological constraints. Specifically, the methods link climate parameters with specific physiological aspects of thermal tolerance, growth rates, mortality rates parameters to infer species specific responses to estimated changes in climate. Data requirements may include historical and estimated climatic parameters and species-specific physiological data. Impacts to the fishery are assessed by comparing species-specific physiological responses under historical and estimated climate conditions.

Effects of Temperature Changes on Mortality:-

This species-specific method used the empirical relationships between natural mortality, asymptotic length or weight, a species-specific growth coefficient, and mean annual water temperature developed by Pauly (1980) to estimate the exponential coefficient of natural mortality under historical and estimated air temperatures. All else being equal, the higher the estimated coefficient of natural mortality, the greater the mortality of a particular fish stock.

Effects of Temperature Change on Growth Using Bioenergetics Modelling:-

This species-specific method uses a bioenergetics simulation model originally developed by Kitchell et al. (1977). It is applicable to riverine and lacustrine systems and may be especially useful for well-controlled aquaculture systems. The model processes data on fish physiology, diet composition, energy density and water temperature and generates consumption and growth estimates. Climate change impacts on fisheries resources are inferred by putting historical and projected water temperatures into the model and estimating growth and feeding rates under those temperature conditions. This model is data intensive. Data requirements include historical and projected water temperatures for the habitats of concern and species-specific physiological data for each species of interest, including consumption, respiration, and digestion/excretion data.

Effects of Temperature Change on Physiological Processes:-

Because fish are poikilotherms, the rates of all their physiological functions are directly dependent on environmental temperature, and any climate-related changes in temperature may dramatically affect the biological processes controlling growth, reproduction, development and other physiological parameters. Wood and McDonald (1997) offer a review of the effects of temperature on the physiology of marine and freshwater fishes.

Using Historical Analogy:-

According to Glantz (1990), historical analogy can be used to estimate potential impacts to fisheries resources for areas for which extensive fisheries and oceanographic time-series data are available. In this approach, the status and the response of fisheries resources to past environmental conditions are assessed and used to estimate the nature and direction of responses to future climate conditions.

It is evident from the works of Meisner et al., (1987) Christie and Regier (1988) and Kennedy (1990) that to assess the vulnerability of the fisheries to climate change, estimated atmospheric climate changes must be translated into changes in environmental variables that are directly important to fisheries resources, such as lake and sea levels, ocean currents, stream flow and water temperatures. Only when these climate-induced hydrologic changes are estimated can the responses of the fishery resource towards reduced growth rates or reproductive success, increased mortality, and altered distribution be identified and evaluated. The assessment of fisheries impacts will depend critically on the analyses from the water resource and coastal resource sectors and their associated hydrologic models. Multisectoral, multidisciplinary teams will be necessary, and fisheries specialists will have to interact with technical specialists from other resource areas when developing riverine hydrographs; estimating sea and lake levels, water temperatures, and salinity; estimating the timing and extent of floodplain inundation and the fate of wetlands; and estimating the distribution of oceanic currents and upwelling zones under different climate change scenarios.

SOCIO-ECONOMIC CONSIDERATIONS

Changes in abundance of specific fisheries will have direct social and economic effects. Changes in commercial fisheries will have very direct economic impacts, either beneficial or negative. These economic impacts can be measured directly through changes in total monetary value of the catch and can be used in a cost-benefit analysis. Changes to recreational fisheries may also incur socio-economic impacts. Decreases or increases in abundance of key recreational species will affect the likelihood of people travelling to a specific place to fish and thus directly affect the livelihood of that sector of the population employed supporting the recreational fishery. This in turn can affect local or regional economies.

These same impacts to fisheries can affect subsistence activities. Areas that are highly dependent on fish as a daily food source may be significantly affected by climate change impacts to fisheries resources. Reduced subsistence catches may result in direct local or regional impacts on human health. In extreme cases the drying of a tropical water body could lead to entire villages having to move. In other cases it may require people to migrate on at least a seasonal basis to other fishing grounds. So it is important to look at socio-economic impacts outside of the formal economy.

AUTONOMOUS ADAPTATION

Given any set of effects of climate change, certain changes in fishery populations and in the human social and economic systems that depend on them will happen without purposeful intervention. One of the more obvious examples will be the likely poleward redistribution of marine fisheries. There will not be significant barriers to this process occurring naturally. Other changes in fish distributions, including freshwater fisheries, are also likely without human management and intervention. The changes estimated in the assessments will provide a guide for these adjustments, and monitoring programs can confirm these changes. Some social and economic responses to climate change are likely to be virtually autonomous also. It would be expected that subsistence fishers will switch to other available species, and some groups may migrate to stay with favoured fish species or to find new fishing grounds. Stocking of at least some species better adapted to the changed conditions is likely, even without major public programs.

PLANNED ADAPTATION

Global warming is expected to on average to higher air temperatures and changes in the geographic distribution, temporal pattern, and magnitude of precipitation. These changes in temperature and precipitation in turn affect marine and freshwater habitats and eventually lead to changes in the distribution, composition, and abundance of fisheries species around the world. However, specific estimations of effects to habitats and fisheries resources are difficult to develop given the uncertainty associated with the overall accuracy of estimations of climate change, and the very difficult problem of providing regional- or finer-scale estimations of climate changes.

CONCLUSION

It could be seen clearly from the above discussion that the potential impact of climate change on fisheries is very clear from the focus of this paper. There is an urgent need to protect the fisheries from the negative impact of climate change. Through conducting research on impact of climate change on fisheries enables the fisheries department, marine scientist, planners and policy makers to develop mitigation measures and coping mechanism to overcome the negative impact of climate change on fisheries sector. In order to overcome the negative impact of climate change on fisheries sector, the following policy suggestions can be considered

1. The government should allocate more funds for research on impact of climate change on fisheries sector and publishing its results
2. The government should motivate the researcher towards identifying the climate change scenario and its impact on fisheries sector in different regions in India through geographical information system and remote sensing technique
3. The government should promote inter disciplinary and multi disciplinary research to assess the impact of climate change on fisheries sector by the way of developing research team and research infrastructural facilities.
4. The government should give liberal research grants and subsidies towards promoting research on impact of climate change on fisheries sector.
5. The government should motivate the private institutions and NGOs towards conducting the research on developing climate change impact

mitigation measures and coping mechanism to overcome the negative impact of climate change on fisheries sector.

6. The government should encourage the researchers to develop safe fishing practices

REFERENCES

1. *Crul, R.C.M. 1992. Models for Estimating Potential Fish Yields of African Inland Waters.*
2. *Welcomme, R.L. 1976. Some general and theoretical considerations on the fish yield of African rivers. Journal of Fish Biology 8, 351-364.*
3. *Schlesinger, D.A. and H.A. Regier. 1983. Relationship between environmental temperature and yields of subarctic and temperate zone fish species. Canadian Journal of Fisheries and Aquatic Science 40, 1829-1837.*
4. *Megrey, B.A., S.J. Bogard, W.C. Rugen, A.B. Hollowed, P.J. Stabeno, S.A. Macklin, J.D. Schumacher, and W.J. Ingraham, Jr. 1995. An exploratory analysis of associations between biotic and abiotic factors and year-class strength of Gulf of Alaska walleye pollock (Theragra chalcograma). In Climate Change and Northern Fish Populations, R.J. Beamish (ed). Canadian Special Publications of Fisheries and Aquatic Sciences No. 121, National Research Council of Canada, Ottawa, pp. 227-243.*
5. *Garcia, S. and L. Le Reste. 1981. Life Cycles, Dynamics, Exploitation, and Management of Coastal Penaeid Shrimp Stocks, FAO Technical Paper No. 203, Food and Agriculture Organization of the United Nations, Rome.*
6. *Beamish, R.J. (ed). 1995. Climate Change and Northern Fish Populations. Canadian Special Publication of Fisheries and Aquatic Sciences, No. 121, National Research Council of Canada, Ottawa.*
7. *Lowe-McConnell, R.H. 1987. Ecological Studies in Tropical Fish Communities. Cambridge University Press, Cambridge.*
8. *Poff, N.L. and J.D. Allan. 1995. Functional organization of stream fish assemblages in relation to hydrological variability. Ecology 76, 606-627.*
9. *Turner, R.E. 1977. Intertidal vegetation and commercial yields of penaeid shrimp. Transactions of the American Fisheries Society 106(5), 411-416.*
10. *Turner, R.E. and D.F. Boesch. 1988. Aquatic animal production and wetland relationships: Insights gleaned following wetland loss or gain. In The Ecology and Management of Wetlands. Vol. 1, Ecology of Wetlands, D.D. Hook et al. (eds). Timber Press, Portland, Oregon, USA, pp. 25-39.*
11. *Meisner, J.D. 1990. Potential loss of thermal habitat for brook trout, due to climatic warming, in two southern Ontario streams. Transactions of the American Fisheries Society 119, 282-291.*
12. *Eaton, J.G. and R.M. Scheller. 1996. Effects of climate warming on fish thermal habitat in streams of the United States. Limnology and Oceanography 41, 1109-1115.*
13. *Pauly, D. 1980. Some Simple Methods for the Assessment of Tropical Fish Stocks. FAO Fisheries Technical Paper No. 234. Food and Agriculture Organization of the United Nations, Rome.*
14. *Kitchell, J.F., D.J. Stewart, and D. Weininger. 1977. Applications of a bioenergetics model to yellow perch (Perca flavescens) and walleye (Stizostedion vitreum vitreum). Journal of the Fisheries Research Board of Canada 34, 1922-1935.*
15. *Wood, C.M., and D.G. McDonald (eds). 1997. Global Warming: Implications for Freshwater and Marine Fish. Cambridge University Press, Cambridge, UK.*
16. *Glantz, M.H. 1990. Does history have a future? Forecasting climate change effects on fisheries by analogy. Fisheries 15(6), 39-44.*
17. *Kennedy, V.S. 1990. Anticipated effects of climate change on estuarine and coastal fisheries. Fisheries 15(6), 16-24.*