IMPACT OF GLOBAL CLIMATE CHANGE ON AQUATIC RESOURCES AND FOOD AND INCOME SECURITY OF FISHING DEPENDENT POPULATIONS

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ABSTRACT

Climate change and climate-induced changes are expected to increase in the future and are likely to cause adverse impacts, especially on aquatic resources and coastal communities, by affecting the productivity and distribution of fish stocks. This will have serious implications on future demand and supply of fish at the global level with consequent effects on trade and on poor households in fishing communities that depend on fishing for consumption and income. However, documented studies on the economic analysis of the impacts of climate change on fisheries has been limited and fragmented.

To address this gap, this paper consolidates existing knowledge and understanding related to the impacts of climate change on fisheries and coastal communities with a view of developing a research agenda that identifies priority research issues, provides a framework for collaborative research, and sets the future research direction based on the discussions arising from the "Consultation on the Impact of Global Climate Change on Aquatic Resources and Food and Income Security of Fishing Dependent Populations" held at the University of San Diego on August 24–25, 2005. Results of this study will provide a strong basis for formulating and prioritizing management strategies and policy options to better prepare and respond, as well as minimize the vulnerability of aquatic resources and the coastal population to the impacts of climate change.

Keywords:

Climate change, aquatic resources, fishing dependent populations

INTRODUCTION

Scientific evidence shows a steady rise in the earth's average surface temperature by 0.5–0.6ºC during the past 100 years with the highest rates of increase registered during the last two decades. This change in global climate pattern has been traced to the accumulation of greenhouse gases (e.g., carbon dioxide, methane, nitrous oxide, chlorofluourocarbons, and volatile organic compounds) that traps heat from the sun and causes a general warming of the earth's surface, primarily as a result of human activities, such as use of fossil fuels, agriculture, deforestation, industrial production, etc., which have intensified during the last 50 years [1,2,3]. Despite various initiatives to reduce greenhouse gas emissions (e.g., Kyoto Protocol), concentrations of these gases are expected to continue to increase in the future. Thus, projections from climate change models show a continuous warming trend of the earth's average atmospheric temperature by 1.4–5.8ºC within the next 100 years [4,1,5,3].

THE THREAT OF CLIMATE CHANGE

Climate change will inevitably cause direct biophysical impacts initially on the atmosphere and hydrosphere, such as rise in the average ocean surface temperature to ranges similar to those registered during El Niño weather patterns, shifts in precipitation and evaporation patterns, changes in the hydrological cycle (e.g., salinity, wave conditions, and oceanic circulation), and increase in weather and

short-term climate fluctuations, which in turn will impact on the marine environment, fisheries, and coastal communities by affecting the biological productivity of aquatic ecosystems [6,7,8,2,9,10]. Both gains (e.g., longer growing season and improved survival and growth rate of aquaculture and freshwater fish species in areas of mid to higher latitude, etc.) and losses (e.g., reduction in fish productivity in certain areas, damage to or loss of coastal resources, especially in low-lying island economies, reduction in commercial, recreational, and subsistence values of marine resources, coral bleaching, shorter fishing days, increased disease incidence, etc.) are expected to occur with temporal and spatial variation depending on exposure and vulnerability to climate change [11,12,13]. Overall, negative impacts are expected to outweigh the anticipated positive effects of climate change.

VULNERABILITY OF FISHERIES AND FISHING DEPENDENT POPULATIONS

The real threat of a prolonged and extensive climate change may yet be the biggest challenge of a historically resilient sector that is already faced with difficult problems related to a dwindling resource base and coastal areas, overfishing, pollution, rising conflicts among various resource users, and increasing competition from coastal zone development [14,15,16,10,13]. For most fish species, the additional stress caused by climate change can impose serious deleterious impacts on stock abundance, given their limited adaptive capability to temperature and environmental variation beyond a narrow range [17,2,18]. For the estimated 200 million fisherfolk worldwide and their dependents, majority of which are small scale or artisanal fishers in coastal areas, who depend on fisheries resources as the only remaining source of income and nutrition, increasing uncertainty over availability and access to resource stocks due to climate change may threaten the survival of this already vulnerable segment, who lack capital resources and access to opportunities outside of the fisheries sector [12,19,15]. Given the magnitude of the anticipated change in climate, coping strategies that have proven to work in the past may be inadequate to handle the challenges posed before the fisheries sector.

ISSUES

Research interest on climate change during the last decade beginning in the early 1990s was geared primarily towards providing a better understanding on a global scale and longer-term time horizon of the causes (particularly those related to human activities) and pattern; improving long-term projections; and developing countervailing strategies to reduce the emission of greenhouse gases. Although these initial studies have contributed to the substantial advancement of a general scientific knowledge and understanding of global climate change and its impacts, numerous uncertainties still prevail on the timing extent, and distribution of impacts, technological change, and human response, mainly due to the lack of understanding of the processes and interactions involved in climate change and limitations of current scientific models [20,1,5]. Some of the important fisheries-related issues that need to be addressed in order to develop effective and timely management response to climate change are discussed below.

Fluctuations vs. Long-term Impacts

Immediate impacts of climate change are least obvious and unrecognized compared to longer term impacts, which are expected to be profound on fisheries and low income people. Differentiating between them and finding the link between the two have yet to be fully explored.

Distinction between Artisanal and Large-Scale/Industrial Fishers

The threat of climate change exacerbates the vulnerability, particularly of artisanal fishers who depend largely on fisheries for food and income due to their limited response and adaptation options and because they are geographically located in areas with more extreme climatic conditions. Thus, shifts in the abundance of fish stocks away from nearshore zones for example will adversely impact artisanal

harvesters more than large-scale fishers because they do not have the needed resources and skills to fish further off the coast. On the other hand, migration of new fish species in shallow waters may entail substantial cost outlay on the part of artisanal fishers to purchase fishing equipment and to learn fishing techniques in order to reap the economic benefits from the impact of climate change [2]. To date however, documented analysis on the socio-economic impacts of climate change especially on small-scale fisheries in tropical areas and developing countries have received little attention [19].

Climate vs. Effort and Natural-Induced Changes

The literature establishes climate change as a factor that determines stock fluctuation in fisheries. The additional shock imposed by climate change in a sector that is already faced with formidable obstacles resulting from excessive fishing effort, increasing conflicts, competition from alternative uses, globalization, and pollution is likely to result in a lower equilibrium level and optimal amount of fishing effort [16,18]. However, since ecosystems are dynamic and their responses are often complex, especially in exploited stocks, the current knowledge base and climate models are not adequately equipped to separate the causes of stock fluctuation (i.e., climate, effort, natural-stock-induced changes).

Increased Complexity in Fisheries Management and Governance

Small Pelagic are More Prone to Short-Term Fluctuation

Small pelagic supply have been on a steady decline in Asia due mainly to excessive fishing effort estimated at 30 percent above the recommended sustainable level [21,22]. The corrosion of the resource stock for some of the important fish species (e.g., sardines, anchovies, scads, mackerel) is a concern that has been raised even for countries that have been experiencing an increase in fish catch, such as China, Philippines, Indonesia, and Thailand [23,22]. Thus, given the uncertainty surrounding small pelagic fish stocks in the region, the additional stress imposed by climate change and its unfavorable effect on planktons, on which pelagics feed, may have serious economic and welfare implications, particularly on consumers in developing countries, where most of the consumption and income source of low-income and poor consumers is concentrated [24,22].

Spatial Distribution and Transboundary Issues

Existing studies on climate-induced changes are predominantly related to the northern hemisphere (e.g., salmon in the Northern Pacific Ocean, herring of the Atlanto-Scandinavian stock). We know less about impacts of climate change on the southern hemisphere (i.e., Where are the populations? How are they moving? How does this movement affect the productivity of fishing fleets?) Studies indicate that as ocean temperatures rise, some species will migrate north or will move into more open waters, changing resource allocations and management arrangements between countries. This may lead to increased conflicts between neighboring states (e.g., issues with distant water fleets due to stock movements offshore) and overfishing as nations rush to exploit resources over shortened time horizons. Potential repercussions of transboundary movement of fish stocks include agreements, international laws and cooperative arrangements that are in place among countries in whose economic zones these resources are located may work for a while but may eventually become strained or collapse as the situation becomes a race to fish [25].

Short-Term Issues

Climate change could increase the intensity, frequency, duration of short-term extreme climate-related events (e.g., El Niño, La Niña, storms, tropical cyclones) and the switching from one climate condition to another. This will impact on the productivity of fisheries and distribution of fish stocks, which in turn

will have wide-ranging consequences on ecosystems, industry, communities, and institutions, depending on their vulnerability to climate change [26]. Thus, coping strategies will be required in order to maximize the benefits and minimize the costs from fluctuating fisheries. In the case of tuna for example, higher ocean temperature is anticipated to cause geographic relocation of resources from the principal producing regions located in the central and eastern Pacific to areas of higher latitude and those situated in the western Pacific near the equator. This implies that a country, such as Kiribati, that is more vulnerable to the adverse effects of climate change because of its location and high dependence on tuna will have to work closely with other coastal nations in devising contingency measures to address this problem [27].

Long-Term Issues

Some of the long-term issues on climate change include the dynamic nature of institutions and the uncertainty surrounding their response to changing conditions increases the risks from climate change. On the other hand, mitigation decision making on climate change involves three crucial issues: When should it be undertaken? What is the manner in which it is should be carried out? and To what extent should it be implemented? Answers to these basic questions has hardly been explored in the literature with a few exceptions [28] and involve consideration of accompanying costs and benefits for each mitigation option, resource endowments and constraints, technological capability, and inter and intra-equity issues between nations/regions and among generations. For example, given the state of information and knowledge on climate change and our expectations on the future, the decision on the timing of mitigation action is a matter of comparing whether we will be better off undertaking action now to reduce greenhouse gas emissions or to postpone action to a later period when there is more certainty on the likely impacts of climate change (i.e., Will the expected stream of benefits from mitigation today exceed the cost? Or will the payoff in putting off mitigation efforts to some future time period be higher?) Costs on reducing carbon buildup show lower values in tropical countries with estimates ranging from US$0.1/tC–US$20/tC compared to US$20/tC–US$100/tC elsewhere. However, these estimates usually underestimate the true value of mitigation by excluding certain cost components (e.g., project implementation, monitoring and evaluation costs, opportunity cost of land). On the other hand, benefits from carbon mitigation efforts include both tangible and non-tangible impacts, however, current research studies exclude amenity and other social costs, which are more difficult to value [29].

NEEDS

In light of the issues discussed in the preceding section and our current limitations on climate impact assessment, it is apparent that certain research needs will have to be addressed as a way forward. First, a basic problem that has seriously hampered economic modeling efforts is lack/paucity of baseline information on needed biological, environmental, and economic (e.g., fishing effort) variables. In cases where data is available, there are problems involving the manner in which data is collected data and the difficulty of matching them with other existing data sets;

Second, is the need for models and case studies to increase comparability across northern and southern fisheries. In the case of economic models, focus should be given towards improving or developing dynamic fisheries stock assessment models that incorporate climate change variables along with the economic, social, political, and management environment in which they occur, and their socio-economic impacts on the productivity and movement of fisheries resources under extreme climate conditions never before experienced [30]. In this regard, development of game theoretic and biogeographic-bioeconomic models under conditions of uncertainty and risk may be highly useful in exploring transboundary and intergenerational issues and other economic impacts of climate change, respectively. Also, international market models with price as an endogenous variable may prove helpful in tracing the economic impacts of climate change on fisheries supply, demand, and trade. In addition, since current scientific models are

largely based on a global scale, which conceal geographic variations, the spatial dimension of these models will have to be downsized to a local or regional scale in order to improve its usefulness as a policymaking decision tool;

Third, is the problem on how to deal with uncertainties or the role of insurance and other institutions willing to share risks as a tool in enhancing security and reducing vulnerability of various groups/sectors to adverse climate change impacts. In particular, how can insurance be utilized as an adaptive tool for dealing with climate-induced uncertainty? What types of insurance services/arrangements can be offered to manage the risks from climate change? Other relevant insurance-related questions include the following: What are the limitations to which uncertainty can be introduced? What is needed to overcome these limitations (e.g., market-based approaches);

Fourth, the challenge posed by climate change highlights the need for more effective local and national policies to ensure sustained fish stocks across regions and generations;

Fifth, under conditions of risk and uncertainty that characterize climate change, a precautionary approach to managing fisheries resources may be optimal; and

Sixth, side payments may be necessary in order to compensate those who have been adversely affected by the impacts of climate change.

RESEARCH PRIORITIES

Existing knowledge gaps and uncertainties on the risks and socio-economic impacts of climate change present opportunities for extensive interdisciplinary collaboration in research to improve our understanding on the fundamental ecosystem processes and their interlinkages as well as the risks and implications of climate change as input to informed and effective decision making. Among the priority issues proposed for collaborative research include: a) inter-annual and inter-decadal changes in spatial distribution and migration patterns of fish populations over time; b) case studies on the changes in interaction between harvesters and managers; c) where fish populations are and where they move; d) resource conflicts that may arise or exacerbate between communities and nations due to changes and movement of fish stocks, particularly in Southeast Asia and South Asia, and how might they be addressed (e.g., negotiations, cooperation, treaties, adaptation alternatives, relief, etc); e) impact of climate change on aquaculture, focusing on the changes in the linkage between capture and culture fish; f) spatial analysis on the impacts of climate change; and g) probability vs. cost of extreme events (short-term and long-term) and the link between fluctuations and long-term impacts.

ACTION PLAN

To ensure the continuation of efforts to build capacity in developing win-win fisheries management measures and policies through research, several basic strategies will be utilized to operationalize the research agenda identified above within a time period of three years:

> Information Dissemination will be carried out initially through the publication of a Policy Brief by the WorldFish Center on the proceedings of the 2005 workshop. A webpage will also be maintained to provide a forum for continuous communication, exchange, interaction, and involvement among various stakeholders on research and other initiatives, issues and answers related to the socio-economic impacts of climate change.

Networking will be carried out with agencies with ongoing research initiatives on climate change (e.g., NOAA, GLOBEC, IRD (France), IOC) in order to foster interdisciplinary research partnerships, improve synergy, and raise the visibility of the research community.

Research proposals will be solicited from the scientific community to expand the current state of knowledge on climate change impacts and to encourage innovative research, particularly on the areas that address the research needs identified above.

Fund raising activities will be organized to sustain research initiatives and other climate change-related efforts. Government and private sectors, as well as the international community will be tapped to provide much-needed financial support.

Other activities (e.g., workshops) may be also sponsored as the need arises.

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