



Climate Change: Research to Meet the Challenges Facing Fisheries and Aquaculture

KEY MESSAGES

- Climate change poses new challenges to the sustainability of fisheries and aquaculture systems, with serious implications for the 520 million people who depend on them for their livelihoods and the nearly 3 billion people for whom fish is an important source of animal protein.
 - To help meet these challenges, climate change research at the WorldFish Center aims to work with partners to
 1. focus climate change responses where they are most needed by assessing and mapping the vulnerability of fishery- and aquaculture-dependent people and regions to the impacts of climate change;
 2. reduce people's vulnerability to these impacts by identifying appropriate adaptation strategies;
 3. contribute to climate change mitigation by identifying ways to reduce greenhouse gas emissions and sequester carbon in aquatic production systems; and
 4. build local, national and regional capacity to implement adaptation and mitigation strategies for fisheries and aquaculture by informing policy processes.
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THE CLIMATE CHANGE CHALLENGE

The Intergovernmental Panel on Climate Change projects that atmospheric temperatures will rise by 1.8-4.0°C globally by 2100 (IPCC 2007). This warming will be accompanied by rising sea temperatures, changing sea levels, increasing ocean acidification, altered rainfall patterns and river flows, and higher incidence of extreme weather events.

The productivity, distribution and seasonality of fisheries, and the quality and availability of the habitats that support them, are sensitive to these climate change effects. In addition, many fishery-dependent communities and aquaculture operations are in regions highly exposed to climate change. Researchers and policymakers now recognize that the climate change impacts on coastal and riparian environments, and on the

fisheries they support, will bring new challenges to these systems and to the people who depend on them. Coping with these challenges will require adaptation measures planned at multiple scales.

Climate change stresses will compound existing pressure on fisheries and aquaculture and threaten their capacity to provide food and livelihoods. Worldwide, fish products provide 15% or more of the protein consumed by nearly 3 billion people and support the livelihoods of 520 million people, many of them women (FAO 2009, WorldFish Center 2008). Many capture fisheries worldwide have declined sharply in recent decades or have already collapsed from overfishing, and major fishing grounds are concentrated in zones threatened by pollution, the mismanagement of freshwater, and habitat and coastal zone modification. Aquaculture needs to expand sustainably to fill supply shortfalls as demand for fish for human consumption continues to rise — but, even more than fisheries, aquaculture is concentrated in areas with intense competition for environmental services. Sustaining fisheries in the face of these challenges, and ensuring that they contribute to development as effectively as possible, will be more difficult as the climate changes. Similarly, realizing the potential of aquaculture will require careful attention to climate change impacts and the constraints and opportunities they bring.

Understanding these linkages between climate change, livelihoods and food security is critical for designing policies and management strategies for fisheries and aquaculture in the communities, nations and regions that depend on them. Doing so effectively will require sustained investment in research that informs policy, resource management and development. Key research questions and work being pursued by the WorldFish Center to address them is summarized below in four areas: (1) diagnosing vulnerability to climate change, (2) understanding current coping mechanisms and adaptive responses, (3)

contributing to mitigation, and (4) building the capacity to respond and adapt.

1. DIAGNOSING VULNERABILITY TO CLIMATE CHANGE

The vulnerability of fishery- and aquaculture-dependent communities and regions to climate change is complex, reflecting a combination of three key factors: the exposure of a particular system to climate change, the degree of sensitivity to climate impacts, and the adaptive capacity of the group or society experiencing those impacts. Vulnerability varies greatly across production systems, households, communities, nations and regions. It is influenced by changing demographics, the degree of market globalization and emerging agricultural development policy. Poor and marginalized groups, including women, are likely to be the most vulnerable because climate change will likely exacerbate the unequal access to natural resources, productive assets, information and technology that already exists.

Developing policies and strategies to address climate change impacts on fisheries and aquaculture depends on identifying vulnerable places and people and understanding what drives their vulnerability. This requires vulnerability assessment at multiple scales and taking into account multiple interacting drivers. Key questions that need to be addressed include the following:

- 1.1 What is the nature and extent of vulnerability among fishery- and aquaculture-dependent communities and regions to specific climate-related threats?
- 1.2 How do other drivers of change influence vulnerability to climate change?

Vulnerability: The degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes

Adaptive capacity: Abilities and resources to cope with climate-related changes. Adaptation may be anticipatory (before impacts), autonomous (spontaneous) or planned (the result of deliberate policy decisions) and can occur at different scales: individual, household, government institution, local and national.

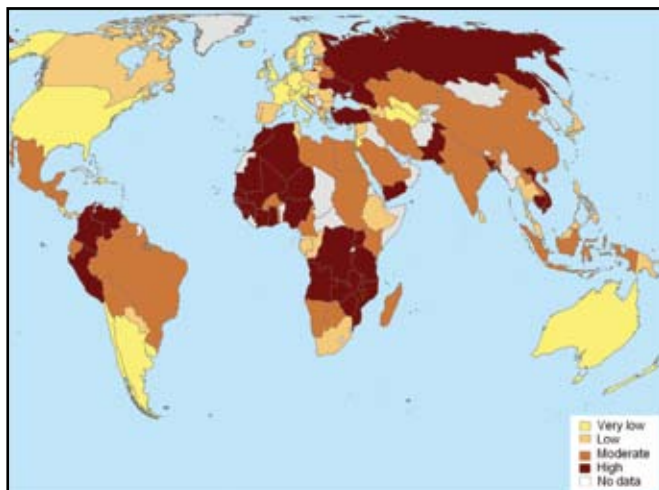
Mitigation: Human intervention to reduce the anthropogenic forcing of the climate system, including strategies to reduce greenhouse gas sources and emissions and enhance greenhouse gas sinks.

Adapted from IPCC (2007)

WORLD FISH RESEARCH: DIAGNOSING VULNERABILITY TO CLIMATE CHANGE

- WorldFish researchers and partners recently examined the vulnerability of 132 national economies to expected climate change impacts on their capture fisheries, using an indicator-based approach. Highly vulnerable nations are primarily in Asia, Africa and Latin America and include many least developed countries (Allison *et al.* 2009).
- Through QUEST-Fish, a consortium of leading British and international institutions dedicated to quantifying and understanding the earth system (QUEST), WorldFish combines indicator-based vulnerability assessments with a scenario-based framework to study how fisheries systems within nations across 20 large marine ecosystems may respond to climate change under different population, trade, economic and policy scenarios (<http://web.pml.ac.uk/quest-fish>).
- In the Coral Triangle spanning Indonesia, Malaysia, Papua New Guinea, Philippines, Solomon Islands and Timor-Leste, where climate change poses serious threats to coral reefs (Hoegh-Guldberg *et al.* 2009), WorldFish is assessing national and local dependence upon reefs and the implications for social vulnerability to climate change.

Two thirds of the nations most vulnerable to climate change are in Africa, where fish provides more than half of the animal protein consumed in some countries. Inland and coastal waters are highly sensitive to climatic variation, and adaptive capacity is low.



Source: Allison *et al.* 2009

The outputs of research to answer these questions will be vulnerability maps that identify 'hotspots' and most affected people. These maps can be used to guide investments in adaptation. Understanding climate vulnerability in the context of other drivers helps to prioritize climate-related actions and inform programs to mainstream climate change responses in other development policy and planning activities.

2. UNDERSTANDING CURRENT COPING MECHANISMS AND ADAPTIVE RESPONSES

Policies enabling adaptation to climate change can be guided by an understanding of the complex ways in which fisheries and aquaculture have responded to past climate variability as well as other 'shocks'. Examining the responses of fishing communities to natural disasters, in particular the responses of women and the poor, can aid understanding of which measures may reduce vulnerability and enhance resilience in the face of future climate impacts. Key research questions that need to be addressed include the following:

- 2.1 To what extent do current successful responses to climate variability confer resilience to future climate change?
- 2.2 What are the known limits to adaptation based on analysis of adaptation failures following natural disasters or multiple stresses?
- 2.3 Under what conditions do short-term coping mechanisms undermine long-term adaptive capacity?

Research addressing these questions will provide governments, communities and their development partners with a summary of the lessons that fishers and fish-farmers have learnt from past responses to climate variability and other disasters and 'shocks'.

WORLD FISH RESEARCH: COPING MECHANISMS AND ADAPTIVE RESPONSES

- WorldFish scientists have recently developed a participatory diagnostic and adaptive management framework for small-scale fisheries (Andrew *et al.* 2007). This is used to examine how fisherfolk are vulnerable to the compounding effects of multiple stresses in fishery systems, as well as exogenous

economic, social and environmental drivers, and how they cope with them. The framework is currently applied in two contexts where communities are especially vulnerable to climate change:

- o In tsunami-affected fishing communities in the Solomon Islands, fisheries are already under a range of stresses, including overfishing, and face new threats such as climate-mediated impacts on coral reefs.
- o The Niger River basin has a long history of vulnerability to drought and reduced river flow. Working through the Challenge Program on Water and Food of the Consultative Group on International Agricultural Research (CGIAR), WorldFish seeks to identify threats to fishing-dependent communities and help government partners design adaptive management strategies to strengthen livelihood resilience and improve water productivity (www.waterforfood.org).
- Through the CGIAR Challenge Program on Water and Food, WorldFish is studying the development of collective approaches to fish culture on seasonal floodplains in Bangladesh, Cambodia, China, Mali and Vietnam. This research seeks to understand how communities exposed to dramatic environmental variation adapt their livelihood strategies and design institutions that govern access to areas that are dry land in some seasons and under water in others. Developing locally appropriate fish-culture technologies and understanding the conditions for collective action to support them are possible approaches to enabling adaptive responses to climate variability and change on these floodplains.

3. CONTRIBUTING TO MITIGATION

Agriculture contributes 10-12% of global greenhouse gas emissions, with aquaculture contributing a small but unknown fraction of that. Fishing burns 1.2% of the fossil fuel used globally each year (Tyedmers *et al.* 2005). While the potential benefit of investing in fishing energy efficiency and emission reduction is minor, the sector does provide opportunities to improve livelihoods and environmental and resource management in ways that mitigate climate change. Market instruments for financing mitigation, such as the Clean Development Mechanism and voluntary carbon markets, may be used to fund work that contributes to the development of sustainable fisheries and aquaculture.

Mitigation strategies for fisheries include promoting the use of fuel-efficient fishing vessels and methods, removing such disincentives to energy efficiency as fuel subsidies, and reducing overcapacity in global fishing fleets, as there are too many boats burning too much fuel to chase too few fish. Aquaculture technologies that reduce energy consumption and optimize the potential for carbon sequestration provide opportunities for mitigation. Similarly, conserving and restoring mangroves sequesters carbon, protects coastlines, and enhances fisheries and livelihoods. Opportunities for funding adaptation through novel schemes that also contribute to mitigation, such as the Reduced Emissions from Deforestation and Degradation scheme for mangroves, should be promoted. In pursuing these mitigation opportunities, key research questions include the following:

- 3.1 How can fisheries and aquaculture contribute to reducing greenhouse gas sources and emissions?
- 3.2 What are the opportunities for using aquatic production systems as carbon sinks?
- 3.3 To what extent can mitigation strategies enhance the sustainability of fisheries and aquaculture?
- 3.4 What effects, good and bad, will mitigation strategies adopted in other sectors likely have on fisheries and aquaculture?

Research on the potential for fisheries and aquaculture to contribute to mitigation will provide governments, communities and their partners with a range of options for funding adaptation activities, as most mitigation initiatives are linked to markets or global funds. Reducing the carbon footprint of fisheries and aquaculture, as well as making a small contribution to halting climate change, can set an example to other food sectors in commitment to environmentally sustainable production.

WORLD FISH RESEARCH: MITIGATING CLIMATE CHANGE

- In Solomon Islands, WorldFish is assessing, in collaboration with national government partners, the potential of trading voluntary carbon credits from carbon sequestration by mangroves. Researchers are examining how this approach may promote conservation, mitigate climate change and alleviate poverty. Mangrove carbon credit initiatives can, if found feasible, benefit fishing communities that depend upon mangrove resources in other areas too.

- WorldFish is working with partners through the project Sustaining Ethical Aquaculture Trade, funded by the European Union, to develop sustainability assessments for Asian aquaculture products sold in Europe. This uses life-cycle analysis to inform carbon labeling and identify opportunities for aquaculture operations and trade to reduce energy use and emissions.

4. BUILDING THE CAPACITY TO RESPOND AND ADAPT

Reducing vulnerability in fisheries and aquaculture urgently requires the application of adaptation and mitigation options at appropriate scales. Their effectiveness depends on building community and national capacity to respond to changes and on mainstreaming climate change adaptation in policies regarding natural resource management and development. A broad range of activities are required, ranging from building climate monitoring and forecasting capacity, to applying forecasts to aid disaster prevention, and to develop capacity for policy implementation and technological innovation to address adaptation in aquaculture systems.

By directly managing fish production, aquaculture has the potential to improve adaptive capacity and enhance resilience to climate change in vulnerable communities, compensating for variability and decline in capture fisheries exacerbated by climate change. However, aquaculture depends heavily on fishmeal feeds derived from small, wild-caught pelagic fish and on wild-caught larvae for seed. The stocks of both are sensitive to climate change. Adaptation strategies must include a search for fishmeal substitutes and ways to culture species in hatcheries that previously depended on wild seed. Developing the capacity of national innovation systems in aquaculture will both aid the sectors' adaptation to climate change and keep it competitive in the context of changing markets.

Building adaptive capacity to respond to climate change also involves strengthening the ability of the fishers and fish farmers to respond to current climate threats. Indeed, some areas where aquaculture and fisheries are the most productive and contribute the most to poverty reduction and food security are also the areas most prone to natural disasters caused by extreme weather events and sea level rise. Because these events are forecast to increase in frequency and severity in many parts of the world, and sea level rise is projected to accelerate, it is vital to work with disaster relief agencies and affected communities to develop processes for disaster preparedness and post-disaster rehabilitation of fisheries and aquaculture.

Finally, institutions need support to improve their capacity to facilitate the mainstreaming of climate change adaptation into broader fishery and rural development policy. Understanding and addressing the disproportionate effect of climate change on vulnerable groups will be especially important. Towards these goals, fisheries and aquaculture management and research institutions need to engage in global, regional and national policy fora that shape thinking and investment in climate change adaptation.

In considering these issues, key research questions that need to be addressed include the following:

- 4.1 How can lessons from individual, household, enterprise and community adaptive responses around the world be effectively shared and applied to build resilience to climate change from the bottom up?
- 4.2 What policy processes nationally, regionally and globally do fishery and aquaculture agencies need to engage with to finance and implement adaptation?
- 4.3 How can climate change adaptation and disaster risk management be effectively incorporated into fishery and aquaculture development and management planning?

Research outputs will provide strategies for building adaptive capacity that can be used by governments, communities, or firms to inform their responses to climate change and other drivers. By identifying key policy processes, stakeholders in the fishery and aquaculture sector will have a clearer picture of how to go about getting both technical and financial support for adaptation. By learning from other experiences with mainstreaming, sectoral policies will be more effectively 'climate-proofed' and governments will be better able to work with their aquatic resource-dependent citizens to secure the development benefits of fisheries and aquaculture into the future.

WORLD FISH RESEARCH: BUILDING THE CAPACITY TO RESPOND AND ADAPT

- In sub-Saharan Africa, WorldFish is working with partners to refine integrated aquaculture-agriculture technologies to improve water productivity and the cycling of nutrients on farms, thereby fostering livelihoods resilient to shocks such as climate change. In Malawi, research has shown that integrating ponds into smallholder farming systems increases food production and income during times of drought (Dey *et al.* 2007).

- In collaboration with the Food and Agriculture Organization (FAO) of the United Nations and the Network of Aquaculture Centers of Asia, WorldFish is developing a set of guidelines on appropriate post-emergency responses for fisheries and aquaculture. These recommendations build on recent work with fishing communities in tsunami-affected areas of Asia and the Pacific and cyclone-affected fish-farming households in Bangladesh and Myanmar.
- WorldFish has been active at such recent climate change adaptation fora as the Expert Consultation on Fisheries, Aquaculture and Climate Change in April 2008 in Rome; Regional Forum on the Mekong River Commission Climate Change and Adaptation Initiative in February 2009 in Bangkok; FAO, World Bank PROFISH and WorldFish Informal Coordination Meeting on Climate Change: Impacts, Adaptation and Mitigation in Fisheries and Aquaculture in March 2009 in Rome; and United Nations Framework Convention on Climate Change talks in June 2009 in Bonn.

CONCLUSION

Climate change is inevitably a challenge for fisheries and aquaculture. Through rigorous research on impacts, mitigation and adaptation — combined with practical actions locally, nationally, regionally and globally — WorldFish aims to provide new knowledge to inform solutions. High-quality research that involves resource users, builds strong partnerships and harnesses political will is crucial for making fisheries and aquaculture systems more resilient to the challenge of global climate change and securing a bright future for the people that depend upon them.

For more information, visit WorldFish-Climate@cgiar.org and www.worldfishcenter.org.

REFERENCES

- Allison, E.H., A.L. Perry, M-C. Badjeck, W.N. Adger, N.L. Andrew, K. Brown, D. Conway, A. Halls, G.M Pilling, J.D. Reynolds and N.K. Dulvy. 2009. Vulnerability of national economies to potential impacts of climate change on fisheries. *Fish and Fisheries* 10:173-196.
- Andrew, N.L., C. Béné, S.J. Hall, E.H. Allison, S. Heck and B.D. Ratner. 2007. Diagnosis and management of small-scale fisheries in developing countries. *Fish and Fisheries* 8:227-240
- Daw, T., N. Adger, K. Brown and M-C. Badjeck. 2009. Climate change and capture fisheries. In: K. Cochrane, C. De Young, D. Soto, T. Bahri (eds.). Climate change implications for fisheries and aquaculture: Overview of current scientific knowledge. FAO Fisheries and Aquaculture Technical Paper 530, pp 95-135. FAO: Rome.
- Dey, M.M., P. Kambewa, M. Prein, D. Jamu, F.J. Paraguas, D.E. Pemsil and R.M. Briones. 2007. Impact of the development and dissemination of integrated aquaculture-agriculture technologies in Malawi. In: H. Waibel and D. Zilberman (eds.). The impact of natural resource management research: Studies from the CGIAR. Wallingford, UK: CAB International.
- FAO. 2009. The state of world fisheries and aquaculture: 2008. Rome: FAO Fisheries and Aquaculture Department. 176 p.
- Hoegh-Guldberg, O., H. Hoegh-Guldberg, J.E.N. Veron, A. Green, E.D. Gomez, J. Lough, M. King, H.L. Ambariyanto, J. Cinner, G. Dews, G. Russ, H.Z. Schuttenberg, E.L. Peñaflo, C.M. Eakin, T.R.L. Christensen, M. Abbey, F. Areki, R.A. Kosaka, A. Tewfik and J. Oliver. 2009. The Coral Triangle and climate change: Ecosystems, people and societies at risk. Brisbane: WWF Australia. 276 p.
- IPCC. 2007. Summary for policymakers. In: M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson (eds.). Climate change 2007: Impacts, adaptation and vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, UK: Cambridge University Press. pp 7-22.
- Tyedmers, P.H., R. Watson and D. Pauly. 2005. Fueling global fishing fleets. *Ambio* 34:635-638.
- WorldFish Center. 2008. Small-scale capture fisheries: A global overview with emphasis on developing countries. Preliminary report of the Big Numbers Project. Penang, Malaysia: Food and Agriculture Organization of the United Nations, PROFISH World Bank and WorldFish Center. 63 p.

The WorldFish Center

PO Box 500 GPO, 10670 Penang, Malaysia
Tel: +(60-4) 626 1606 Fax: +(60-4) 626 5530
Email: worldfishcenter@cgiar.org

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