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Implications of climate change on fisheries and aquaculture: challenges for adaptation and mitigation in the Asia-Pacific region

Kathmandu, Nepal, 24–26 May 2011

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FOREWORD

It is now widely recognized that the effects of climate change will impact the fisheries sector, and result in increased uncertainty in the supply of fish from capture fisheries and aquaculture. The warming of the sea surface, river and lakes, changing precipitation, water salinity and ocean acidity and sea level rise will have an effect on marine, coastal and inland environments, producing changes in habitats, stocks and species distribution. Long-term and cyclical fluctuations in marine environments and the frequency and intensity of extreme weather events, such as excessive rainfall, cyclones and droughts, will certainly have an impact on the supply of fish and fisheries products. Food quality may also be threatened with the increased risk of species invasions and the spreading of vector-borne diseases. Nevertheless, there may also be positive impacts like access to new species and new markets as a result of climatic change.

Trying to understand the challenges as well as the opportunities that may arise in future scenarios, member countries of the Asia-Pacific Fishery Commission (APFIC) and regional organizations have convened this technical workshop with the purpose of reviewing their mitigation and adaptation strategies for the fisheries and aquaculture sectors. As expected for a region as diverse as Asia and the Pacific, the focus and priorities of the countries vary according to the variety of issues that might affect them. The workshop nonetheless identified shared concerns such as the lack of understanding of the effects that climate change could have in the fisheries and aquaculture sectors and the insufficient capacity available to deal with such effects in the region. Member countries further underlined the need for integration of the fishery and aquaculture sectors into the national climate change planning process.

This workshop report provides recommendations for member countries and partner organizations to take timely actions to address climate change issues related to the fisheries and aquaculture sectors. These cover the strengthening of climate change related policies for the fisheries and aquaculture sectors, the allocation of financial resources, the strengthening of governance and the use of integrated management approaches and monitoring tools. The workshop highlighted the involvement of all the relevant stakeholders in the fisheries and aquaculture sectors, especially the most vulnerable. These recommendations aim to strengthen the fisheries and aquaculture sectors in the Asia and the Pacific region by promoting better preparedness for climate related change.

Hiroyuki Konuma
Assistant Director-General and
Regional Representative for Asia and the Pacific

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ABBREVIATIONS

APFIC	Asia-Pacific Fishery Commission
ADB	Asian Development Bank
ASEAN	Association of Southeast Asian Nations
BFAR	Bureau of Fisheries and Aquatic Resources, Philippines
BMP	Better Management Practices
BOBLME	Bay of Bengal Large Marine Ecosystem Project
CC	Climate Change
CCB	Climate, Community and Biodiversity Project Design Standards
CEQ	President's Council on Environmental Quality, USA
DRM	Disaster Reduction and Mitigation
EAF/EAA	Ecosystem Approach to Fisheries / Ecosystem approach to Aquaculture
ENSO	El Nino-Southern Oscillation
FAD	Fish Aggregating Devices
FAO	Food and Agriculture Organization of the United Nations
FAO RAP	FAO Regional Office for Asia and Pacific
GDP	Gross Domestic Products
GHG	Green House Gas
GVA	Gross Value Added
ICCATF	Interagency Climate Change Adaptation Task Force, USA
INGO	International Non-Governmental Organization
LDCF	Least Developed Country Fund
MCS	Monitoring, Control and Surveillance
MPA	Marine Protected Area
MRC	Mekong River Commission
NACA	Network of Aquaculture Centres in Asia-Pacific
NAPA	National Adaptation Programme of Action
NOAA	National Oceanic and Atmospheric Administration
OECD	Organisation for Economic Co-operation and Development
PACFA	Global Partnership on Climate, Fisheries and Aquaculture
PES	Payment for Environmental Services
REDD	Reducing Emissions from Deforestation and Forest Degradation
RFLP	Regional Fisheries Livelihoods Programme (GCP/RAS/237/SPA)
SCCF	Special Climate Change Fund
SEAFDEC	Southeast Asian Fisheries Development Center

WORKSHOP SUMMARY RECOMMENDATIONS

The outputs of the three day workshop were drawn up to form the summary findings and recommendations of the working groups. The summary recommendations were reviewed and adopted during the final plenary session at the end of the workshop.

Participating countries and regional organizations have reviewed their national policies and actions relating to mitigation and adaptation to climate change. As expected for a region as diverse as that of the Asia-Pacific Fishery Commission (APFIC) membership,[1] the focus and priorities of the countries was very varied. There is considerable variation in the extent to which countries have commenced climate related planning in the fishery and aquaculture sector, and especially the degree to which this has been integrated into broader climate change related planning at the agriculture sector level and beyond.

It was, however, consistently reported that understanding of sectoral effects of climate change remains very limited, partly due to a lack of capacity building in this emerging area of concern, but also due to the lack of systematic information collection tracking climate related impacts. There is also a general lack of capacity in the assessment and understanding of vulnerabilities of the sector and the people that depend upon it. Integration of the fishery and aquaculture sector considerations into national planning remains quite weak in many countries and is of particular concern requiring urgent attention.

The summary of the workshop recommendations relating to the identified areas of weakness and opportunities for action are:

Advocate for increased policy emphasis and financial resourcing to climate change adaptation and mitigation in the sector

- Increase resourcing to climate change adaptation and mitigation in fisheries and aquaculture, especially in countries with high dependence on these resources;
- Look for ways to harness adaptation benefits from mitigation strategies (within and outside the sector);
- Emphasize comparative advantage of aquaculture in producing animal food in terms of GHG emissions;
- Focus on how to deliver financial resourcing down to local levels;
- Access Payment for Environmental Services (PES) for protection of coastal, inland ecosystems and fisheries resources;
- Look for ways to capture opportunities presented by carbon credit and carbon sequestration incentive schemes;
- Develop compensating/revolving funds from the national/domestic economy – making funds accessible for climate change activities/adaptation;
- Governments should develop or access innovative financial mechanisms, involving communities, to promote adaptation;
- Promote sector insurance mechanisms and develop climate-based risk transfer instruments [this requires government support]; and
- Seek regional resources for climate change adaptation, and build capacity of national agencies in understanding resourcing opportunities and how to access these resources.

Strengthen governance and integrate climate change adaptation into decision-making

- Integrate climate change into existing fisheries and habitat management/programme frameworks;

[1] Australia, Bangladesh, Cambodia, China, France, India, Indonesia, Japan, Malaysia, Myanmar, Nepal, New Zealand, Pakistan, Philippines, Republic of Korea, Sri Lanka, Timor-Leste, Thailand, United Kingdom, United States of America and Viet Nam.

- Where the national climate change policies and/or strategy do not include the fishery or aquaculture sector, seek to review or supplement this (e.g. update National Adaptation Programme of Action, NAPA), supporting review of climate change in the sector);
- Initiate the assessment of vulnerability of systems and people, using risk-based approaches to prioritize response and action;
- Establish institutional mechanisms to deal with climate change issues with mandatory communication, consider creation of a national centre for climate change; and
- Establish focal points for climate change in fisheries agencies/Ministry of Fisheries & establish climate change focal points in each ministry to encourage two-way communication.

Improving monitoring, tracking and assessment

- Strengthen and target support to climate monitoring to inform decision-making and increase climate change monitoring capacity;
- Develop a baseline monitoring system that will give information for policy and planning (incorporating participatory monitoring approaches);
- Recognise the lack of climate change studies and limited experience within the country, and respond with capacity building initiatives;
- Downscale global models to national and local levels;
- Develop ocean monitoring networks to better understand and predict climate change impacts on fish;
- Strengthen inland fisheries monitoring;
- Develop simpler screening tools – adapted to each country and context; and
- Develop simple approaches that will help prioritize where to focus efforts.

Strengthen management of fisheries and aquaculture to improve adaptation and resilience to climate change

- Recognize and address current problems in weak fisheries management that make the sector vulnerable;
- Identify best practices and gaps in fishery management, and look for solutions to bad management practices;
- Strengthen management by engaging local fishing/fishery dependent communities (ecosystem approach); and
- Improve governance of aquaculture taking into account climate change vulnerability and options for adaptation.

Involvement of communities and local institutions in climate change adaptation is critical for success

- Building capacity of communities to adapt to change;
- Strengthen community preparedness and address their vulnerability;
- Focus on climate change as an opportunity to bring fisheries and aquaculture to national attention, as it relates to food and job security; and
- These would be implemented through a strongly participatory approach.

Recognizing the different gender related impacts of climate change

- Take the opportunity for reducing gender-based inequalities in the sector by making sure women are included in adaptation strategies.

Develop accessible information for decision-makers (in other sectors)

- Climate change communication and advocacy for the fishery and aquaculture subsectors is essential;

- Strengthen cooperation and climate change communication between sectors in governments, ministries and relevant private sector, education etc.; and
- Focus on translating science to management, and the associated science communication.

Capacity building

- There is strong need for human capacity development to meet the challenges of climate change;
- Strengthen capacity on aquaculture related adaptabilities and mitigation;
- Support and training on decision-making in case of high uncertainty;
- Improve awareness of the impacts of climate change fisheries and aquaculture;
- Institutional development to incorporate climate change, including transfer of knowledge through secondments and exchange;
- Strengthening preparedness to climate related disasters and threats (e.g. safety at sea, flood/coastal protection, modified aquaculture systems/management); and
- Integration of university research into climate change dialogues.

Recommendatios for targeted research and development, knowledge development

- Address information/data/technology gaps in climate change adaptation and mitigation;
- Changing locations of fish stocks, resource assessments are needed;
- Develop opportunities presented by increased fish stocks;
- Promote green technology in capture fisheries;
- More research on habitat restoration, especially mangroves, wetlands and coral reef rehabilitation;
- Opportunities for to restocking/enhancement (but note potential risks);
- Diversification of aquaculture species;
- Technology development to use new species and facilitating markets for these new species;
- Stimulating development and dissemination of low carbon footprint/green/eco-friendly aquaculture technologies;
- Develop locally-based and low-emission fish culture inputs (e.g. fish feed); and
- Develop and introduce Better Management Practices (BMP) in aquaculture to accommodate climate change adaptations.

Specific recommendations to regional organizations to support member countries

- The region needs mechanisms for lesson learning and sharing on best practices in adaptation and mitigation (Regional Climate Change stakeholder forum);
- Regional organizations can assist in coordinating responses to transboundary issues using ecosystem approaches (EAF/EAA) and regional cooperation relating to climate change;
- Develop and articulate regional scientific needs;
- Promote region-wide monitoring of key climate change related indicators;
- Make use of standard frameworks for valuing ecosystem services to support decision-making in climate change;
- Assist in collating current status assessments for ecosystems, habitats, species, freshwater supply;
- Seek opportunities to engage regional cooperation to develop solutions to address climate change and develop series of connected Marine Protected Areas (MPAs)/regional MPA;
- Promote data/information sharing;
- Link to integrated cyclone prediction system, coupled with synthesis of changes in cyclone patterns [note fisheries organizations unlikely to lead on this];

- Improve regional understanding of resource use/allocation particularly as it relates to fisheries and aquaculture interests; and
- Represent the sector in non-fishery forums and other national and regional bodies (e.g. economic bodies, multi-sectoral dialogues etc.).

Specific recommendations to FAO, APFIC and Regional Organizations to support improved integration of the sector in climate change planning

Assist counties in integrating fisheries and aquaculture into national and regional climate change and related Disaster Reduction and Mitigation (DRM) plans and strategies. Where a NAPA may not include specific or comprehensive coverage, there may be opportunities to develop an updated or revised NAPA. Analysis of the NAPA to rebalance this is possible and support to APFIC member countries in this regard may be of interest for members to follow up with FAO.

- Assisting in the development of an adaptation (and mitigation) strategy for the sector/ integrating the sector into national plans and regional strategies (where there is a specific national request for support).
- Assist member countries to develop policy and legal guidance and awareness raising for integrating climate change into fisheries and aquaculture.
- Support coordination of climate change activities within the sector throughout the region.
- Promote partnerships to develop areas for collaborative actions to implement the national/ sector plan.

Further investigate impacts of and vulnerabilities to climate on the food and livelihoods contributions of fisheries and aquaculture (on top of other drivers) at the local, national and regional levels to continue advocacy of the sector in climate change discussions.

Promote the findings of the workshop into intergovernmental fora. Suggestions for this are the Asia Regional Ministerial Meeting on "Aquaculture for food security, nutrition and economic development" to be convened in Colombo, Sri Lanka, July 2011. The workshop recommended that the APFIC chair country (Viet Nam) be requested to incorporate the key findings into their Ministerial Statement to this meeting.

The recommendations of the workshop could also be presented at the 17th Conference of Parties, United Nations Framework Convention on Climate Change (UNFCCC), Durban, South Africa. There is the potential for participating countries to present this at a side event organized by the Philippines.

BACKGROUND TO THE WORKSHOP

The Asia-Pacific Fisheries Commission (APFIC) is an intergovernmental regional fisheries advisory and consultative body which works towards the improvement, understanding, awareness and cooperation in fisheries/aquaculture issues in the Asia-Pacific region. There are 20 member countries, principally from the Asian region.

The 31st Session of APFIC emphasized that adaptation and mitigation of the impacts of climate change related to fisheries and aquaculture is a very important issue in the region and recommended that APFIC should review the effects of climate change on fisheries and aquaculture in the region and provide advice to member countries on strategic planning for adaptation and mitigation measures for the sector. The Session further suggested that this advice should cover the key aspects of: likely effects on fisheries and aquaculture resources and production; implications for fisheries and farmers vulnerability and potential strategies and opportunities for adaptation and mitigation.

The APFIC/FAO regional consultative workshop "Implications of climate change on fisheries and aquaculture: challenges for adaptation and mitigation in the Asia-Pacific Region" was therefore convened on 24–26 May 2011 in Kathmandu, Nepal. It was convened in collaboration with the Directorate of Fisheries Development, Department of Agriculture, Ministry of Agriculture and Cooperatives of the Government of Nepal.

The regional consultative workshop brought together 50 participants from member countries and competent regional organization partners to further raise the awareness of all relevant stakeholders to the threats of climate change to the regional fisheries and aquaculture sector through sharing of best available information and knowledge, to discuss and analyze specific potential impacts of different types of climate change patterns on marine capture fisheries, inland capture fisheries, coastal aquaculture and inland aquaculture.

The workshop reviewed the materials prepared by the APFIC Secretariat and the presentations of the actions taken by the national governments and international and regional organizations in addressing the climate change issue in the fisheries and aquaculture context. It further analyzed the strength and weakness of the region in fisheries and aquaculture related climate change adaptation and mitigation, and identified the capacity gaps and other constraints of the APFIC member countries in effectively coping with challenge of climate change and maintain the sustainability fisheries and aquaculture industry in the region.

PARTICIPANTS

The 43 participants attending the workshop were delegated by members countries for their involvement in aquaculture and fisheries management/research and related policy development, implementation projects/programmes related to climate change adaptation and mitigation:

- Specifically invited country participants from the APFIC member countries presenting national status of fisheries/aquaculture adaptation and mitigation to climate change: Bangladesh, Cambodia, China, Timor-Leste, India, Indonesia, Japan, Maldives, Malaysia, Myanmar, Nepal, Pakistan, Philippines, Sri Lanka, Thailand, United States of America, Viet Nam
- Specifically invited participants who were nominated by national climate change agencies: Timor-Leste, Philippines, Cambodia, Sri Lanka, Viet Nam
- Resource persons and representatives of Regional Organizations competent in fisheries and/or aquaculture or marine environment: SEAFDEC, NACA, MRC
- Representatives from regional programme relevant to climate change adaptation and mitigation in fisheries/aquaculture: BOBLME, RFLP

- International fisheries research institutions: WorldFish Centre
- FAO staff and resource persons drawn from: FAO Regional Office for Asia and the Pacific, FAO Fisheries department, resource persons from the FAO Regional Fisheries Livelihoods Programme (RFLP)

OPENING AND INTRODUCTION TO THE WORKSHOP

Vijay Kumar Malik, Director General, Department of Agriculture, Nepal welcomed the participants and thanked APFIC for its support in convening the workshop. He noted that APFIC was an important intergovernmental organization with the objective of improving fishery and aquaculture livelihoods and that APFIC provides a platform for capacity development of the member countries. He commented that with such a huge number of people dependent upon fishery and aquaculture in the Asian region, the impacts of climate change will be felt more acutely in this region and within its ecosystems and natural resources.

Bui Thi Lan, FAO Representative to Nepal informed the workshop that the Asia-Pacific region provides 60 percent of the world's aquatic products from capture fisheries and aquaculture and provides livelihoods directly and indirectly for millions. The workshop will share and exchange information of the likely impacts of CC on fisheries and aquaculture and agree adaptation and mitigation measures and that issues and problems to be addressed will be identified. The outcome will be the recommendations drafted for national and regional actions and which will be fed into regional and international processes addressing climate change.

Simon Funge-Smith, FAO RAP Senior Fishery Advisor and APFIC Secretary noted that the timing of the workshop is opportune when many countries are trying to adjust to the realities of climate change. He informed the workshop that APFIC was requested to do this at its last session in Jeju, Republic of Korea. For this workshop, all countries have brought their national perspectives on climate change and will present at the meeting;

Nath Prasad Chaudhary, Secretary of Agriculture, Government of Nepal commented that fisheries and aquaculture is a small but important sector which the government has prioritized for food security, nutrition and livelihoods. He informed the workshop that Nepal has a very small production of green house gases, yet the impacts of CC are very significant in Nepal, as areas at higher altitudes are more prone to the impacts of CC. Increases in ambient temperatures will impact negatively on GDP and the Himalayas provide a water catchment for millions of people. The impacts of CC will negatively impact on drinking water supplies as well as flow into major rivers that support millions of people. The Government of Nepal is working to develop a national plan of action (NAPA) for CC and that this APFIC meeting was therefore particularly timely and relevant for Nepal and its CC efforts.

INTRODUCTION TO THE WORKSHOP AND ITS OBJECTIVES

Miao Weimin, FAO Aquaculture Officer, introduced the workshop and its objectives. He commented that it is expected that the workshop will formulate regional strategy and provide recommendations to the member governments in taking timely actions to address the climate change issue in relation to fisheries and aquaculture. The consultative workshop will be also a good opportunity to identify the most needed support to the regional and national efforts in climate change adaptation and mitigation and discuss the potential opportunities. He noted that specific objectives of the workshop were to:

- Share most updated information on climate changes scenarios and the specific fisheries/ aquaculture related change patterns and their implications/potential impacts on fisheries and aquaculture sector in Asia-Pacific region, build up consensus on threats of climate changes to fisheries and aquaculture and need of timely actions to address the problem;

- Review current planning and action in support of adaptation and mitigation of climate impacts in the areas of fisheries and aquaculture;
- Identify issues and problems in effectively address climate change impacts on fisheries and aquaculture;
- Develop recommendations for national and regional actions to address climate adaptation and mitigation for the fisheries and aquaculture sectors in the region; and
- Introduction to climate change.

AN INTRODUCTION TO THE CLIMATE CHANGE AND LIKELY IMPACTS ON THE APFIC REGION

Simon Funge-Smith, APFIC Secretariat

The world has an ever-changing climate. Over the last few hundred million years there have been both hotter periods and ice ages – changes which appear to accompany shifts in atmospheric carbon dioxide (CO_2) levels. There is considerable evidence that the world's climate is currently changing. Surface air and sea temperatures appear to have increased compared to historical data while the rate of warming has accelerated over the last few decades. Human activity is thought to be contributing to this change mainly through increasing emissions of "greenhouse" gasses (e.g. methane, CO_2, N_2O). Meanwhile, natural events such as volcanic eruptions, changes in energy from the sun or natural cycles such as El Niño may also contribute to the warming process at any time. Accurately projecting changes in global temperatures and climate is extremely difficult. A wide range of factors and variables must be taken into account while climate also responds to feedback mechanisms.

A warming trend

The warming trend in the world's climate has been observed over the last 50 years. Possible scenarios over the next 100 years include rises in temperatures ranging from +0.3ºC to as high as +6.4ºC. Increases in sea level from polar ice cap melting are predicted between 0.18 m to 0.59 m while increased CO_2 levels in the atmosphere may lead to increased acidification of the surface ocean.

Considerable changes are also predicted in global rainfalls. This is likely to be particularly significant in the tropics and higher latitudes. Increased rainfall is projected for the Asian monsoon while there may also be an increase in rainfall variability with possibly less reliable seasonal rains.

An increase in sea level pressure is predicted over the subtropics and mid-latitudes that may influence sea flooding. Furthermore, there may be an increased tendency for drying of the mid-continental areas during summer leading to greater risk of droughts in those regions.

Warming in the Asian region

In the Asian region changes in coastal ecosystems are already taking place, with the migration of some species into previously cooler zones. The initial response to climate change by a range of ecosystems will be to migrate either inland or pole-wards e.g. along the southeast coast of Australia or upwards towards the northern end of the Bay of Bengal. Meanwhile, the species range appears to be changing in large rivers.

Rates of warming of surface air and water temperatures are higher than the global mean in central Asia, the Tibetan Plateau and Northern Asia. In East Asia and South Asia they appear to be somewhat higher than the global mean while in Southeast Asia they are similar to the global mean. Inland water systems will experience greater rates of heating than ocean systems.

Weather patterns in the Asian region

The impact on weather patterns in the Asian region due to climate change is likely to vary. Decreasing trends in mean annual rainfall are possible in certain areas such as North East and North China, coastal belts and arid plains of Pakistan, parts of North East India, Indonesia, Philippines and some areas in Japan. Increasing trends in mean annual rainfall are likely in other areas including Western China, the Changjiang Valley and the Southeastern coast of China, Bangladesh as well as along the western coasts of the Philippines.

There is also a trend toward an increased frequency of occurrence of more intense rainfall events in many parts of Asia although the overall amount of rainfall is likely to decrease with fewer rainy days and reduced total annual amount of precipitation.

Increasing frequency of extreme weather events

The frequency and intensity of extreme weather events may increase as will droughts during the summer months and El Niño events. Extreme rainfall and winds associated with tropical cyclones in East Asia, Southeast Asia and South Asia are also likely to be more common especially in the Bay of Bengal, Arabian Sea, Mekong Delta, the Lao People's Democratic Republic, Viet Nam and the Philippines.

The increase in intense rainfall events (monsoon related) is likely to cause landslides and severe flooding. A greater frequency of storm surges and associated coastal flooding will also occur when low-pressure weather systems, cyclones, or storm winds combine with high tides to drive sea water onshore. Continuing growth in coastal populations means that more communities, property, and infrastructure will be exposed. Heat waves/hot spells in summer are likely to be of longer duration, more intense and more frequent, particularly in East Asia.

Freshwater systems

Irrigation needs are likely to have to increase to sustain productivity in South and East Asia with rainfed crops in certain parts of the region possibly facing challenges. Demand for freshwater is also likely to grow due to rapid urbanization and industrialization (South Asia and Northern China) aggravating water shortages that are largely caused by poorly planned resource management.

Major river basins in Asia are likely to be vulnerable to changes. These include key river basins in Asia, such as the Mekong, the Ganges-Meghna-Brahmaputra, and the Irrawaddy, are all centres of intense inland fishing and aquaculture activity and may be subject to earlier season peak flows as well as an overall reduction in flows. Average river runoff will possibly decline by between 10-30 percent in the mid-latitudes and dry tropics while increases of between 10-40 percent are possible in the wet tropics. At the same time water flow will not be smooth, with increased flooding possible.

Oceans, coastal zones and sea-level rise

Changes to marine ecosystems driven by climate change are likely to be among the most serious. These may include declines in seagrass meadows and seaweed beds due to storms and warmer water; the migration of tropical pelagic fish and other marine species into previously cooler waters; the loss of diversity in coral fish and other coral-dependent organisms; and risks to marine food chains from ocean acidification, potentially affecting fisheries.

Meanwhile coastlines may be subjected to increased erosion, inundation, flooding, loss of coastal wetlands or expansion of mangroves into newly flooded coastal lands as well as saline intrusion into rivers, bays and aquifers. The most immediate and significant effects are likely to be experienced in delta areas, estuaries and associated wetlands, coral reefs, tidal flat communities and salt marshes.

Health related risks

Coastal areas, in South, East and Southeast Asia as well as heavily-populated mega-delta regions all face possible increased risk from sea and river-based flooding. Diarrhoeal disease associated with floods and droughts are expected to rise in the East, South and Southeast Asia. Temperature increase will also possibly support the proliferation of a range of bacterial diseases such as cholera.

Deaths due to heat wave events are also likely to increase especially amongst vulnerable groups such as the poor, elderly and manual labourers. Heat stress combined with air pollution may exacerbate respiratory and cardiovascular disease rates. Moreover, increasing temperatures may increase the incidence and geographical range of vector borne diseases such as malaria, encephalitis and schistosomiasis.

Effect on agriculture and food production

Agricultural productivity may decline due to temperature increase, water availability, drought, flooding and soil degradation as well as increases in pests and diseases. This could affect grain productivity and food security in the region and lead to increases in cereal prices. Subsistence producers are likely to be at greatest risk of productivity declines. However certain parts of Asia may experience increases in production. New opportunities may arise for aquaculture with migrations or booms in species possibly leading to the development of new fisheries.

Identifying vulnerability in the region

It is important to understand and identify areas of vulnerability in the region so as to be able to clearly target adaptation and mitigation strategies and to prioritize effort and resources. Although the effects of climate change are likely to be very different in different places, regional patterns of vulnerability are likely to emerge. Hardest hit will most likely be the poor. Often living in the most vulnerable geographical and social circumstances they will bear the brunt of impact and with little access to funds or public services find it hardest to recover from extreme events.

It is also important to understand gender-related patterns of vulnerability in the region. Poor women are often more vulnerable to natural disasters. They are less mobile, tend to be responsible for the children and may not have basic survival skills (e.g. swimming). The processing sector (e.g. fish processing) in which large numbers of women work tends to also be hard hit by natural disasters.

Developing countries in Asia are more vulnerable to climate change

Developing countries have higher levels of sensitivity to climate change. They have greater reliance on climate sensitive sectors such as agriculture and fisheries and are also experiencing high levels of population growth which will place additional strain on natural resources (e.g. fisheries, water and land).

Climate induced migration has been growing in recent years (ADB, 2010). This is expected to worsen in coming years, especially in developing countries which already experience high levels of migration linked to other drivers (particularly economic migration). As a result, conflicts and social stresses may increase.

Developing countries are highly dependent on water for economic growth and development and climate change may exacerbate the problems already being experienced due to a lack of adequate water infrastructure and management.

Vulnerability of livelihoods and economies in Asia

There is a strong linkage between socio-economic dependence and vulnerability in Asia. Countries that have a high dependency on the fisheries sector as well as a low capacity to adapt to the impacts of climate change will be most at risk of serious socio-economic implications. Cambodia, Bangladesh, Pakistan and Yemen have been identified as highly vulnerable although nutritional dependence on fisheries resources is high in much of Southeast Asia as well as also other countries, such as Bangladesh, Japan and Sri Lanka.

Countries with the largest fisheries landings in the region are China, Japan, Indonesia, India and Bangladesh while dependency on the fisheries sector for export income is highest in the coastal nations of Southeast Asia. Small developing states also depend heavily on capture fisheries access fees for income.

The impact of climate change on fisheries and aquaculture production systems

There are likely to be a number of direct consequences of climate change on fisheries and aquaculture production systems. These include direct biophysical and ecological consequences of projected changes, impact on species compositions and distribution as well as impacts on catch potential and aquaculture production.

Indirect consequences on the other hand may affect the interaction between other sectors (power generation, food production) or lead to increased competition for resources (land, freshwater). Most of these already occur however they may be exacerbated by climate change.

Driver: Changes in sea surface temperature

There may be considerable impacts on fisheries and aquaculture production systems from changes in the sea surface temperature. These include more frequent harmful algal blooms; less dissolved oxygen; increased incidence of disease and parasites; altered local ecosystems with changes in competitors, predators and invasive species; and changes in plankton composition. Changes in sea surface temperature may also damage coral reefs that serve as breeding habitats and help protect the shore from wave action or flooding.

There may be impacts on the abundance and species composition of capture fisheries stocks. Meanwhile for aquaculture there may be changes in infrastructure and operating costs from worsened infestations of fouling organisms, pests, nuisance species and/or predators. In certain areas growing seasons may become longer and natural mortality in winter lower. Metabolic and growth rates may also be enhanced. There may be potential for increased production and profit in certain localities, especially for aquaculture although any benefits may be offset by changed species composition and by eutrophication risks.

Changes may occur in timing and success of migrations, spawning and peak abundance, as well as in sex ratios. In addition there may be potential loss of species or a shift in composition in capture fisheries and impacts on seed availability for aquaculture. Although at the same time there may be potential opportunities for hatchery produced larvae for aquaculture and for cultured-based fisheries.

Driver: Rising sea level

With sea levels predicted to rise due to climate change aquaculture operations in coastal areas may be heavily impacted. Changes to estuary systems may see shifts in species abundance, distribution and composition of fish stocks and aquaculture seed. Saline intrusion would result in damage to freshwater capture fisheries a reduction in freshwater availability for aquaculture and a shift to brackish water species. However it may also result in increased opportunities for mariculture. Changing coastal ecosystems such as mudflats and mangrove forests may result in reduced recruitment and stocks for capture fisheries and seed for aquaculture. Exposure to waves and storm surges may also worsen.

Driver: Changes in rainfall and water availability

River hydrology, flooding, flood plain inundation and duration may all alter due to climate change. This could see changes in fish migration, recruitment patterns, and recruitment success. There may also be altered abundance and composition of wild stock as well as impacts on seed availability for aquaculture. Water availability for aquaculture may be impacted. Scarcity and increased competition with other users may force the use of lower quality resulting in more disease.

Aquaculture operations may face higher costs. These would result from extra expense necessary to maintain pond water levels, from increased stock loss; reduced production capacity and conflict with other water users. At the same time potential opportunities may arise from a change of culture species and culture systems. For fishers, changes in lake and river levels and the overall extent and movement patterns of surface water may lead to altered distribution, composition and abundance of fish stocks. As a result fishers may be forced to migrate more and expend more effort.

Driver: Higher inland water temperatures

Increased stratification and reduced mixing of water in lakes may reduce primary productivity and ultimately food supplies for fish species. Raised metabolic rates increase feeding rates and growth if water quality, dissolved oxygen levels, and food supply are adequate, otherwise there may be possible reductions in feeding rates and growth. However the potential for enhanced primary productivity does exist.

Fish stocks too may possibly be enhanced for capture fisheries, although reduced growth is likely where the food and oxygen supply does not increase sufficiently in line with temperature. Changes may occur in timing and success of migrations, spawning and peak abundance. This could potentially lead to the loss of species or a shift in composition for capture fisheries. Capture fisheries stocks and species composition may change while culture species may be more prone to disease (and hence push up operating costs). Another possible impact may be higher capital costs for aeration equipment or deeper ponds. Reduced water quality, especially in terms of dissolved oxygen may lead to changes in the range and abundance of pathogens, predators and competitors. Invasive species may also be introduced. Impacts could also be felt on seed availability for aquaculture.

Possible potential benefits exist for aquaculture, especially intensive and semi-intensive pond systems. There may also be shifts in the location and size of the potential range for any given species.

Driver: Increase in frequency and/or intensity of storms, drought

An increase in large waves and storm surges may lead to loss of aquaculture stock and damage to or loss of aquaculture facilities and fishing gear. There may be higher direct risk to fishers as well as an increase in capital costs needed to design cage moorings, pond walls, jetties, etc. that can withstand storms. Insurance costs are also likely to rise.

Occurrences of inland flooding from intense precipitation may rise. This could possibly lead to the introduction of disease or predators into aquaculture facilities during flooding episodes. Meanwhile, changes in lake water levels and river flows could result in reduced wild fish stocks; intensified competition for fishing areas and more migration by fisher folk.

Salinity changes may lead to impacts on wild fish recruitment and stocks, lower water quality and less availability for aquaculture.

Driver: Changes in El Niño-Southern Oscillation (ENSO)

The El Niño-Southern Oscillation (ENSO) is a regular occurrence that already affects climate and oceans globally. Changes to the location and timing of ocean currents and upwelling alter nutrient supply in surface waters; affect primary productivity and changes in the distribution and productivity of open sea fisheries. Climate change may exacerbate this process. Changed ocean temperature may also lead to more coral bleaching that will in turn lead to reduced productivity of reef fisheries. Rainfall patterns (delayed monsoon onset) may also be altered leading to drought, water shortages and flash flooding in rivers.

Driver: Ocean acidification

Oceans are an important reservoir for CO_2, absorbing a significant quantity produced by anthropogenic activities and effectively buffering climate change. Ocean acidification is the change in ocean chemistry driven by the uptake of carbon, nitrogen and sulphur compounds by the ocean from the atmosphere. As oceans absorb more CO_2 their capacity to buffer climate change is reduced and levels of acidity increase. This is likely to have impacts on marine ecosystems and the benefits they provide with changes possibly occurring in species growth, reproduction and behaviour.

Sectoral, technical adaptations

The management of capture fisheries stocks needs to be adapted in response to climate change and catch declines. Economic and market diversification should be considered with the potential of bringing new species to markets. Consideration also needs to be made concerning the modification of operations to adapt to operational cost changes. Insurance for the fisheries and aquaculture sector may provide support to cope with unexpected weather events. Technical approaches for adaptation in the aquaculture sector could include selective breeding, modified systems to cope with low dissolved oxygen and adaptation through livelihood diversification. Diversification of aquaculture production should also be considered to take into account the migration of warm water species to cooler zones and lower trophic level species.

Adaptation through livelihood diversification

Livelihood diversification is one way in which adaptation to the possible effects of climate change can be carried out. This would result in income generation being less dependent on the natural resource base and spreading risk. Ideally, adaptation would be directed through the reduction of vulnerability and the implementation of 'no-regret' strategies. Vulnerability to extreme events and unexpected changes can be reduced through: safety at sea activities; basic cyclone and storm surge preparation and response; adaptations to market price shifts, changing species and markets; and the introduction of savings systems to cope with periods of no or reduced income generation.

Adaptation via improved governance

Good governance is essential for effective adaptation. This should be participatory, transparent and based on best practice. Efforts should be made to ensure that the fisheries sector is clearly incorporated into mainstream climate change strategies and vice versa. Efforts should be made to improve understanding of opportunities and threats and to identify winners and losers. Countries and locations at high risk should be identified and supported while the use of appropriate technologies to support emission reduction should be pursued. Capacity building should take place for communities, industry and institutions to increase their ability to cope with unpredictable changes and events. Supportive economic and trade policies are needed, together with flexibility and adaptability in governance and management.

The Ecosystem Approach to Fisheries (EAF), Ecosystem Approach to Aquaculture (EAA) or the "Large Marine Ecosystem" Approach offers a potential framework for integrating climate change related decision making and planning into broader fisheries/aquaculture management.

Discussion

Are there studies using national mapping vulnerability using available data for community level? This is one of the issues of down-scaling and making it appropriate to local situations. The workshop may assist in getting some research focus on Asia rather than the western world.

A lot of work has been done on land based systems, but focus on aquatic systems is also needed. This requires coordination of donor effort to save inefficiencies.

The importance of non climate stressors verses climate change stressors was questioned. The workshop noted that it is extremely difficult to assess. Climate change effects are projected over a 50-100 year period, while fisheries impacts can take place within 6 months to a year as a result of inappropriate human activities. This is an important point, since immediate benefits can be gained through better management and will deliver positive impacts before climate drivers really start to show measurable changes on systems.

The costs of climate change adaptation for the fishery and aquaculture may not have been evaluated yet. The costs of adaptation are a new field, and the World Bank attempted such a study. This was not published as discussion is still ongoing on the methodology. OECD had an economics of climate change workshop for the sector, but certainly more effort is needed.

The legal considerations and governance should also be covered within the climate change analysis.

THE IMPACT OF CLIMATE CHANGE ON FISHERIES AND AQUACULTURE PRODUCTION SYSTEMS

Simon Funge-Smith, APFIC Secretariat

The APFIC region has a large dependency on aquatic ecosystems for both the fisheries and the aquaculture sectors in providing trade and employment opportunities and food security. The stressors of climate change have resulted in increasing ocean acidification, higher distributions of oceanic dead zones, increasing sea water levels, trophic distributions, and irregular cyclone patterns. These changes must be addressed through adaptation and mitigation strategies.

Climate change will cause unprecedented disruptions to aquatic and coastal systems and the risks must be further understood through identification of the more vulnerable systems and development of adaptive strategies to reduce the loss of human and natural systems. Climate change may have increased negative impacts on capture fisheries which are already at their limits through over exploitation, coastal degradation and pollution. Productivity and viability in aquaculture operations are also expected to be negatively impacted as well as other related sectors such as agriculture, land and water management, and costal developments.

In the short term, the non-climate related drivers will most likely have larger impacts on aquaculture and fisheries. The current methods, practices and how we manage the ecosystem undermine the health of fisheries systems, reducing the resilience to climate change related impacts. The lack of ability to perform specific predications on the fisheries sector remains limited and management systems and institutions must be flexible as no clear prescriptive advice can be expected.

Opportunities for fisheries and aquaculture contribution to climate change mitigation

A straightforward approach is to directly reduce the levels of greenhouse gas emissions in fisheries and aquaculture practices. The capture fisheries sector alone contributes to around 1.2 percent of the global total of fossil fuels used. Application of several possibilities for more efficient fuel use or practicing fishing methods that demand less fuel can result in lower levels of green house gas emissions. However, these actions may impact the surrounding ecosystem (e.g. purse seining on fish aggregating devices, FADs).

Adoption of aquaculture systems that have low(er) demands for energy can help mitigate greenhouse gas emission in this sector. Some examples are, increase energy efficiency usage in aquaculture aeration/ pumping, use of liners, seaweed culture (potential as a biofuel), and usage of herbivorous aquaculture species with lower carbon footprint and improvements in transportation of the product to markets.

Innovation and new developments in processing and transportation can also help mitigate climate change impacts. Improving building design and handling practices to reduce energy requirements and

increasing energy efficiency through better insulation in icing plants, freezing plants, cold and chill stores are some examples on how innovation can mitigate climate change in fisheries and aquaculture. Possible positive opportunities in climate change mitigation can also involve numerous other sectors. An example is the branding and certification aspect of fisheries and aquaculture and how the promotion of energy efficient incentives can push the private sector and consumers to promote more energy efficient products.

Climate change mitigation actions may also provide outreaching opportunities for the fisheries sector. The protection of natural ecosystems through emission reduction approaches may enhance fisheries and in addition, can possibly help establish a payment for environmental services (PES) schemes, targeting natural ecosystems and their key services associated with fisheries. These climate change mitigation actions may help in fishery habitat rehabilitation connected with the surrounding wetlands or in mangrove ecosystems rehabilitation schemes and help contribute to initiatives on Reducing Emissions from Deforestation and Forest Degradation (REDD) in mangrove ecosystems and provided possible revenues from eco-tourism.

Mitigation and adaptation in other sectors may impact fisheries and aquaculture

The actions and results of climate change mitigation and adaptation from other sectors may have far reaching impacts and implications on fisheries and aquaculture. The interactions between capture fisheries/aquaculture and the other sectors (agriculture, coastal management, disaster management, and watershed management) must be integrated in policy planning processes. This may be necessary to reduce competition for water between fisheries/aquaculture and agriculture to reduce conflict between different user groups and operators.

An example of mixed-user demand is the alteration of water flow and abstraction requirements from the agriculture sector. This can affect fisheries and aquaculture in several ways, such as the water saving strategies utilized in rice production. This strategy places a limit on the amount of water readily available in the rice paddies and subsequently wild fish production. In addition, flood control and irrigation developments are known to directly and indirectly impact fisheries.

The use of alternate sources of energy which are more carbon neutral may have impacts in aquaculture and fisheries. Fisheries can utilize alternate energy sources such as wind and wave power in coastal areas. This may limit fishing efforts or decrease aquaculture areas in the coastal areas, possibly affecting the surrounding critical natural habitats. Furthermore, aquaculture practices depend largely on feed inputs and the production of biofuels may have several affects on price patterns.

The increasing demand for alternative sources of energy may result in increasing hydropower dam developments on a large scale further affecting aquaculture. The spawning migration routes and larval distributions of certain aquatic organisms can be disrupted through the establishment of physical barriers and erratic water release. Furthermore, hydropower developments may affect human populations in ways such as destruction of fishing gear, fishing grounds, and injury and loss of life.

Discussion

The workshop noted that there was not a strong focus on vulnerable small island states on the representation and coverage of the programme of the workshop. Whilst APFIC membership does not currently contain any small island, so this was not comprehensively covered. The observer from Maldives will hopefully cover this in his country presentation. In terms of absolute number of people, the small islands are not as numerous as the Asian countries.

Adaptive actions are normally only taken by governments when the costs are less than the benefits. Coastal protection systems are not being promoted in the Maldives because of the costs involved. The workshop noted that there are insufficient data available on costs and this is an area which needs additional effort.

The use of national level MPA areas and mangrove rehabilitation areas as a national effort to sequester carbon wais raised as a possible avenue for obtain some form of national recognition to reduce the carbon foot print of aquaculture and fisheries. MPA can be used for both biodiversity conservation. A network of MPA's will insure the safety of some stocks to threats. The Manado workshop on climate change identified that both national and regional initiatives are needed to promote a network of MPA's. Government of Indonesia is promoting a national programme of mangrove planting and regeneration as a no regrets policy that will reduce carbon emissions. The national level calculations on these type of programmes have still to be done and acceptability of this national level aggregation may not be convincing to consumers, compared with more local identification or recognition mechanisms.

There are some indications of adaptation actions which will benefit fisheries and aquaculture. However, it is important to understand that there will be winners and losers, and it is a question of how will governments address this at the sub-sectoral level, will there be changing policy focus? It is expected that for both fishery and aquaculture, economics of operations will drive systems to change. There will be winners and losers and people will change livelihoods as the economy change. Primary management and increasing resilience through good governance will still be important.

IMPLICATIONS OF CLIMATE CHANGE ON AQUACULTURE – VULNERABILITIES, ADAPTATION AND MITIGATION: AN ASIA-PACIFIC REGIONAL PERSPECTIVE

Sena De Silva, Network of Aquaculture Centres in Asia-Pacific, Bangkok, Thailand

The Asia-Pacific region accounts for in excess of 90 percent of global aquaculture production, a trend that has been apparent since the time when aquaculture became a significant contributor to the global food fish supply. Importantly, the region's production is predominated by small-scale farming activities-farmer owned/leased, operated and managed systems. These farming systems, which are very varied in habitat type and commodities farmed, are dispersed inland, brackish water and coastal areas, considered to be conducive for aquaculture.

Some localities in the Asia-Pacific region are thought to be more prone to climate change impacts, such as the deltaic areas, e.g. Ganges-Brahamaputra, Mekong etc., areas which in turn happen to be major population hubs as well as aquaculture activities providing many millions of livelihoods. Aquaculture activities, in different locations and ecosystem types, however, are subjected to different facets of climate change impacts. For example, in the Mekong Delta in South Viet Nam the home to striped catfish farming systems, which currently accounts for a production of nearly 1.2 million t and provide employment to over 180 000 people, mostly in the processing sector, in the lower reaches of the Mekong River branches will be impacted by sea level rise which will cause saline water intrusion and salinity increases, also exacerbated by reduced river flow. These salinity increases will impact on catfish farm productivity and hence economic viability, and extreme increases making such farming completely impossible. On the other hand, some other districts in the Delta where shrimp farming is predominant are likely to encounter continued flooding, making these systems less productive, if not unviable. These examples tend to demonstrate that the vulnerabilities and hence the potential adaptabilities to mitigate climate change impacts will be relatively different to each other, and each will have to be treated on its own merits.

On the other hand, the potential loss of large extents of paddy lands in deltaic areas, as a result of sea water intrusion could provide a positive challenge to aquaculture. In this context aquaculture may provide a suitable and a viable livelihood option to rice farmers. Such shifts, however, will need appropriate policy changes, capacity building to make the livelihood change effective, prudent and pragmatic choice of aquatic species to be farmed and related infrastructural developments such as hatcheries for seed stock production. Sea level rise and loss of rice farming areas from climate change impacts is very likely to occur and planning and implementing adaptive measures such as above need to be initiated before it is too late.

The Asia-Pacific region also has had experienced increased occurrence of extreme weather events in the immediate past, the most notable being increased storm activities and wave surges, all impacting severely on coastal aquaculture farming. In this context there is a need for governments in the region to expedite availability of insurance schemes, in addition to strengthening infrastructure to combat extreme events to a greater degree, to enable farming communities to revive their livelihoods from such calamities.

There is also a general trend to overplay changes brought about from other anthropogenic developments that could impact on aquaculture and related activities, as being primarily a result of climate change impacts. It is therefore important that a more holistic approach is adopted, wherever possible, when only pragmatic adaptabilities to climate change impacts could be discerned, and appropriate policy developments pursued.

Overall, there is also a need for initiating more studies on vulnerabilities of aquatic farming systems in the region. This would enable a more realistic path to sustained adaptabilities of such systems and thereby safeguard livelihoods and contribution to food security through aquaculture.

In general, aquaculture also offer opportunities to become a less carbon emitting and even some forms to be carbon sequestrating, food production sector. In this context a paradigm shift may be forthcoming where consumer preference for fish could gradually move to those commodities that are less GHG emitting, such as those finfish species that feed lower in the food chain, notably the commonly culture cyprinid species, which also happen to be the leading aquaculture commodities both in the region and globally.

FAO ROAD MAP – CLIMATE CHANGE AND ITS IMPLICATIONS FOR FISHERIES AND FOOD SECURITY

Cassandra DeYoung, FAO Fisheries Department

The presentation provided an overview of the contributions of fisheries and aquaculture to food security, livelihoods, and trade, noting that these services are already at risk from ineffective management and impacts from other sectors, climate change being an additional driver of change and increasing the sense of emergency to improve the resilience of the sector. The participants were briefed on projected climate change pathways (e.g. sea level rise, water temperature changes, acidification, changes in intensity of cyclones, floods, droughts) and how these effects would impact the fisheries and aquaculture directly – such as through increased risk at sea, damage to infrastructure and communities along rivers and coasts – indirectly – through changes in species production cycles and ecosystem functioning (such as shifts in tuna distributions and impacts of acidification on coastal reef fisheries and bivalve systems), as well as indirectly – through the society at large (such as increased adaptation and mitigation costs faced by the government, issues relating to distribution of water to the food production sectors, and trade markets). The following options relating to reducing vulnerability within the sector were reviewed:

- Improving *ecological, economic and social resilience* through implementation of ecosystem approaches to fisheries and aquaculture as well as the Code of Conduct for Responsible Fisheries (i.e. including decision-making under uncertainty, adaptive management, integrated management, community-based adaptation, etc.); livelihood diversification, providing for stable yet flexible access rights; improving public and private insurance schemes to ensure fishers and fish farmers are able to reduce/spread risks;
- Relying on *technological innovation* such as developing saline resistant species, using modern communication mechanisms (e.g. cellular phones) to share weather information, using more stable vessels;
- *Planning for adaptation* rather than reacting to change, including ensuring policy coherence across sectors (water, agriculture, forestry, CZM) to maximize synergies and minimize maladaptation and tradeoffs; and

– *Integrating* disaster preparedness and response, climate change planning with sector development as they are often lead by different line ministries without coordination.

The presentation reviewed the sector's potentials to assist in global mitigation (i.e. reducing GHG gasses) efforts (supporting aquatic systems' natural carbon sequestration and storage capacities, investigating biofuels potentials, and improving energy efficiency). In conclusion, the presentation covered the FAO Fisheries and Aquaculture Department's climate change activities, such as coordinating action through the Global Partnership on Climate, Fisheries and Aquaculture (PaCFA)[1], disseminating information[2], advocating for the sector in the climate change discussions, bridging science and policy, as well as the following example priority future actions, which are based on the Department's climate change strategy.

- Identifying vulnerable systems and improving adaptability to climate change in aquaculture and fisheries-dependent communities (e.g. downscaling, national and regional adaptation/ NAPA implementation, community-based adaptation, ecosystem-based adaptation);
- Integrating climate change adaptation and disaster risk reduction planning to increase resilience in fishing and aquaculture communities;
- Implementing EAF/EAA as a means of climate proofing the fish production sector (e.g. integrated systems management, natural barriers and defences);
- Coordinating and collaborating (e.g. PaCFA, UNFCCC COP17, joint project development, information sharing);
- Understanding the emissions and promoting mitigation from fisheries and aquaculture (e.g. establishing methodologies for estimating emissions, identifying win-win solutions, promoting the shift to less energy intensive systems);
- Linking oceanographic information to local vulnerability indicators and vulnerable systems identification; and
- Monitoring climate change in fisheries and aquaculture using GIS and remote sensing.

CLIMATE CHANGE FUNDING IN SUPPORT OF IMPLEMENTATION OF CLIMATE CHANGE ADAPTATION PLANNING IN FISHERIES AND AQUACULTURE

David Brown, FAO fisheries Department

Significant resources will be required to fund general climate change mitigation and adaptation for the fisheries and aquaculture sector in the APFIC region. In addition to government funds, bilateral donors, development banks, UN agencies and UNFCCC funds (GEF) are available to support implementation. The UNFCCC funds administered by GEF include the SCCF (Special Climate Change Fund), LDCF (Least Developed Country Fund) and the new Adaptation Fund (AF). Currently the GEF SCCF and LDCF funds have USD 500 million (USD 320 for the LDCF and USD 180 for the SCCF). APFIC countries eligible for LDCF include Afghanistan, Bhutan, Bangladesh, Nepal, Myanmar, Lao PDR, Timor Leste and Maldives. The LDCF fund supports the implementation of National Adaptation Plans of Action (NAPAs) with a focus on National ownership and prioritization, a principle of equity and special co-financing requirements. Analysis of the NAPA's by FAO[3] reveals that whilst the sector is important in relation to CC adaptation, it is not well represented. Where the sector is present the areas included are aquaculture, post-harvest, resource management, disaster preparedness and early warning.

[1] www.climatefish.org

[2] See, for example, FAO Fisheries and Aquaculture Technical Paper 530, Climate Change and Fisheries and Aquaculture: overview of current scientific knowledge, 2009, http://www.fao.org/docrep/012/i0994e/i0994e00.htm

[3] 2011. FAO. The fisheries and aquaculture sector in national adaptation programmes of action: importance, vulnerabilities and priorities. FAO Fisheries and Aquaculture Circular No. 1064

In order to raise the profile of fisheries and aquaculture in the NAPAs and improve access to the LDCF key areas of follow up include:

- advocacy and awareness raising of the importance of the sector in relation to climate change within national planning processes;
- revision and/or strengthening of NAPAs (to include fisheries and aquaculture) where appropriate;
- ensuring broader consultation with fisheries and aquaculture sector at national level;
- ensuring consideration of transboundary issues for fisheries and aquaculture in national planning;
- strengthening partnerships to address CC adaptation at national level; and
- capacity development (and lesson learning).

FAO has a new results based management framework which now includes CC adaptation. It a GEF agency and can support NAPA development, implementation and access to the LDCF funds. FAO can be involved in NAPA development and planning through the UNDAF process, fisheries and aquaculture sector policies (and alignment of CC adaptation programmes). SIDS and LDC's have specific priority actions with FAO).

COUNTRY PRESENTATIONS – OBSERVATIONS AND RECOMMENDATIONS FOR POLICIES AND ACTIONS TO MITIGATE AND ADAPT TO CLIMATE CHANGE IN FISHERIES AND AQUACULTURE

Participating countries provided overviews of their national policies and actions relating to mitigation and adaptation to climate change. As expected for a region as diverse as that of the APFIC membership, the focus and priorities of the countries was very varied. There was considerable variation in the extent to which countries had commenced climate related planning in the fishery and aquaculture sector, and especially the degree to which this has been integrated into broader climate change related planning at the agriculture sector level and beyond. Some general messages which emerged from the presentations were as follows:

Resourcing to climate change adaptation and mitigation may not be comprehensive

Cost benefits of investments in climate change adaptation are not clear and in remote areas where rural economy does not have high value. In this case, climate change related work may not be prioritized and receive attention in planning and investment. Despite this, there are also examples where the sector is valuable and the sector still remains excluded or deprioritized in climate related planning (related below).

Climate monitoring is not particularly comprehensive in the region

Strong needs for methodologies to formulate indicators and criteria for regular monitoring and evaluation of the impacts of climate change on the fisheries/aquaculture sector. There appears to be more focus on physical monitoring (water, rainfall, temperatures, sea level etc.), rather than biological effects. Improvements to weather monitoring systems (and associated early warning communication), climate and hydrology to strengthen the accuracy of weather and climate forecasting. There is a need to strengthen aquatic animal health monitoring, as well as other routine monitoring such as tracking invasive species or changes in key fishery resources. The lack of fishery assessments hinders tracking of changes for both routine fishery management decision-making as well as determining potential climate change effects. Trends in aquaculture may be more easily tracked (e.g. hatchery spawning changes, grow out performance, fish health).

Few climate change studies and little experience within the country

Many countries identified the need for more comprehensive information on climate related impacts and monitoring. There is a need for downscaling climate information to assist decision-making and planning at national levels and below.

The lack of climate change research and/or training institutions in countries was noted, and this contributes to a lack of data availability and reliability and, in particular, absence of a formal mechanism for information sharing. There remains limited cooperation and coordination among institutional agencies related to research or studies on climate change and climate variability, and how they communicate with the fishery and aquaculture sector.

Non-comprehensive national climate change policies and/or strategy

There is a need for stronger climate change coordination mechanisms and the effective integration of fisheries and aquaculture into this. The potential for updating the NAPA to incorporate fisheries/ aquaculture was noted. There is a need to integrate and mainstream climate change adaptation into infrastructure planning, conflict management, groundwater management and water management institutions. Where climate change strategies do not include subsectoral details which might specifically relate to fisheries and aquaculture, supporting strategy documents for these subsectors is needed.

Assessment of vulnerability of systems and people

This may be ongoing in other sectors (or related to adverse weather, flooding, drought etc.) This information can be linked to aquaculture and fishery vulnerability assessment. Some countries are already piloting pilot testing/downscaling existing vulnerability assessment tools for the fishery and aquaculture sector. Assessments of potential sectoral climate change related risks would increase the ability to identify vulnerable groups. Some harmonization of the information would also assist communication and sharing.

The need to strengthen governance and integrate climate change adaptation into decision-making

Integrate adaptation and mitigation of climate change into planning and management of natural resources, coastal ecosystems, and small islands. Development and/or adjustment of the regulations and policies on marine and fisheries sector on climate change on coastal zones and small islands

The involvement of communities in climate change adaptation is critical for success

Adaptation approaches often based around strengthen management or changing practices will require innovation and acceptance by the target groups. The trade offs and implications for adaptation activities within the sector and from outside of the sector also require strong buy-in for feedback from communities. In many country reports, ongoing rural development activities may be adjusted to incorporate a climate change adaptation element.

Climate change communication and advocacy for the fishery and aquaculture subsectors

There is an urgent need for information dissemination on climate change effects and their implication for the fishery sector in a form that is understandable to policy-makers. A higher degree of communication between regional organizations might improve regional climate change information sharing. The recommendations of the workshop could be presented in other fora including the Asia Regional Ministerial Meeting and the COP meeting in Durban.

There is strong need for human capacity development to meet the challenges of climate change

Many countries identified a relatively low technical capacity of staff and lack of qualified national experts relating to climate change. There is also limited public awareness and education on climate change. Short course training or modular support for steps in climate related planning would be a useful resource.

REGIONAL ORGANIZATIONS' RECOMMENDATIONS FOR ADPATING TO CLIMATE CHANGE

Integrate climate change into existing fisheries and habitat management programme frameworks

Further develop existing programmes to manage fisheries and habitats, fishing capacity, strengthen local organizations, safety at sea and other priority areas important to build awareness that better organization at village level and provinces, improved habitat management and restored habitats, reduction of (destructive) fishing effort, improved registration of vessels, licensing to fish, MCS networks, safety at sea and improved working conditions, etc. are in fact helping to build adaptive capacity and help to mitigate possible impacts of climate change.

Look for ways to harness adaptation benefits from adaptation strategies

It is very difficult to distinguish between changes caused by climate change from changes that are due to over-fishing, encroachment and exploitation of marine and coastal habitats and other destructive practices. The "problem of climate change" should not be seen as a problem, but harness the drive to strengthen actions to improve resource management and livelihoods.

Review current planning and action in support of adaptation and mitigation of climate impacts in the areas of fisheries and aquaculture

Focus on interconnectivity: Determine critical areas for migration, spawning, etc. during wet and dry season. Develop or strengthen planning and zoning: exclude areas likely to be exposed to natural hazards, erosion, etc. for aquaculture and other fisheries related activities.

Look for ways to capture opportunities presented by carbon credit and sequestration incentive schemes

Valuations of carbon sequestration and the opportunities of cost for climate change adaptation are urgently needed. Explore ways to address challenges of macroalgae production. Work towards carbon accreditation including addressing any methodological issues, and also work towards accreditation with social and environmental standards (e.g. Climate, Community and Biodiversity Project Design Standards, CCB). Develop an alternative lower cost accreditation framework that does not yield carbon credits, but provides a socially and environmentally sound 'sustainable development product' focussing on payments for mangrove protection and aimed at corporate buyers.

WORKING GROUPS – CLIMATE CHANGE DRIVERS, THREATS AND IMPLICATIONS

Working groups identified drivers and their possible effects and these were added to a table originally published in Badjeck, 2007

Driver – Changes in sea surface temperature		
Biophysical effects	**Implications for fisheries**	**Implications for aquaculture**
Less dissolved oxygen		– Increased aeration cost, reduction in stocking densities
Increased incidence of diseases and parasites.	– Changing susceptibility of some stocks to disease.	– Aquatic diseases may be come more easily transmitted though aquaculture or fish introductions and movements (especially during CC adaptation activities)
Altered local ecosystems with changes in competitors, predators and invasive species changes in plankton composition.	– Impacts on the abundance and species composition of capture fisheries stocks. – Food webs impacted	– Changes in infrastructure and operating costs from worsened infestations of fouling organisms, pests, nuisance species and/or predators – Increased infrastructure and operating costs from worsened infestations of fouling organisms
Change in the location and area of suitable range for particular species.	– Increase in productivity of some fisheries/species: longer growing seasons lower natural mortality in winter; enhanced metabolic and growth rates. – Movement of fishing operations to follow fish – Potential species loss and altered species composition	– Potential for increased production and profit in certain localities, especially for aquaculture. – Extension of range of warmwater species – Increased costs or loss of performance for species at limit of their tolerance – Impacts on wild seed availability (e.g. shellfish) for aquaculture. • Change in spawning habitats/spawning time/seed availability – Indirect impact due to availability of fish meal for aquaculture (pelagic species shifts)
Enhanced primary productivity.	– Potential benefits of fisheries but perhaps offset by changed species composition; increased harmful algal blooms	– Potential benefits for aquaculture perhaps offset by eutrophication/dissolved oxygen risks
Changes in timing and success of migrations, spawning and peak abundance, as well as in sex ratios.	– Potential loss of species or shift in composition in capture fisheries; – Potential for mitigation through cultured-based or enhanced fisheries	– Impacts on seed availability for aquaculture. – Potential opportunities from hatchery produced larvae for aquaculture
Damage to coral reefs that serve as breeding habitats and may help protect the shore from wave action.	– Reduced recruitment of fishery species – Worsened wave damage to infrastructure or flooding from storm surges.	– Worsened wave damage on cage and line culture – Impacts on coastal pond infrastructure; flooding from storm surges.

Driver – Rising sea level		
Biophysical effects	**Implications for fisheries**	**Implications for aquaculture**
Loss of land.	– Loss of freshwater fisheries.	– Reduced area available for aquaculture.
Changes to estuary systems.	– Loss of nursery grounds for coastal fisheries.	– Shifts in species abundance, distribution and composition of fish stocks and aquaculture seed.
Saline intrusion.	– Impact on freshwater capture fisheries species composition.	– Reduced freshwater availability for aquaculture. – Opportunity to shift to brackish water species. – Increased opportunities for mariculture.
Changing coastal ecosystems – mudflats and mangrove forests – In some areas mangroves/ wetlands may increase through flooding of inland areas	– Reduced recruitment and stocks for capture fisheries. – Worsened exposure to waves and storm surges fishing households and infrastructures.	– Reduced recruitment and stocks for broodstock and seed for aquaculture – Worsened exposure to waves and storm surges and risk that inland/delta aquaculture will become inundated.

Driver – Ocean acidification		
Biophysical effects	**Implications for fisheries**	**Implications for aquaculture**
Reduced capacity of the ocean to buffer climate change. Rate of acidity change faster than any on record.	– Changes in species growth, reproduction and behaviour. – Affecting formation and dissolution of calcium carbonate shells and skeletons. – Impacts on marine ecosystems and the benefits they provide.	

Driver – Changes in El Niño-Southern Oscillation (ENSO)		
Biophysical effects	**Implications for fisheries**	**Implications for aquaculture**
Changed location and timing of ocean currents and upwelling alters nutrient supply in surface waters and, consequently, primary productivity.	– Changes in the distribution and productivity of open sea fisheries.	– May impact productivity of some mariculture locations.
Changed ocean temperature and bleached coral.	– Reduced productivity of reef fisheries.	
Altered rainfall patterns bring flood and drought.	– See impacts for precipitation trends, drought and flooding above.	– See impacts for precipitation trends, drought and flooding above.

Driver – Changes in precipitation and water availability		
Biophysical effects	**Implications for fisheries**	**Implications for aquaculture**
Changes in fish migration, recruitment patterns, and recruitment success.	– Altered abundance and composition of wild stock – Food webs impacted	– Impacts on seed availability for aquaculture.
Temperature/dry period changes: – Dry periods/water scarcity – Altered and reduced freshwater supplies with greater risk of drought	– Increased competition/conflict with other – water users (especially for sustaining river flows) – Water quality changes dues to population pressures, less flow or increased urban/agricultural discharges – Mitigation through: • Improvement or establishment of dry season refuges for floodplains. • Establishing habitats • Engineer water management for the accommodation of fisheries or integration of refuges in water management systems.	– Lower water availability for aquaculture • Lower water quality causing more disease • Increased competition/conflict with other water users • Impacts on traditional systems; e.g. Rice-fish farming • Higher costs of maintaining pond water levels • Reduced production capacity stock losses – Change of culture species and culture systems (including some potential opportunities) – Aquaculture development may be an adaptation option or alternative form of livelihood e.g. rice farmers
Changes in lake and river levels and the overall extent and movement patterns of surface water.	– Changes in food webs and species composition and decreased biodiversity in all inland aquatic environments • Altered distribution, composition and abundance of fish stocks • Fishers forced to migrate more and expend more effort. • Habitat and nursing grounds change – Requires increase dialogue with other sectors – do not block migration, sustain flows in rivers, maintain connectivity. – Possibility of mitigation through fishery enhancement	– Performance of cage operations in rivers/water bodies negatively affected
Sudden, high precipitation leads to rapid runoff: – Local flooding in deltas, coastal areas – Rapidly changing water levels/ flow rates in rivers – Flooding of low lying plains/ floodplains. – Glacial lake outbursts	– Flooding, especially flash flooding • Flash flooding impacts to housing/communities • Migration following flooding. • Major impacts in high dependant freshwater fisheries e.g. Tonle sap, Mekong, Ayerwaddy delta, Hilsa fisheries in Bangladesh • Turbidity and fluctuating water quality with consequent effect on fish stocks • Fishing gears damaged or lost – Possible benefits for increased recruitment if flooding sustained long enough	– Flash flooding impacts to housing/communities – Dam discharges to ease pressure after heavy rain. – Flooding in areas where there is no preparedness. • Aquaculture ponds flood • Cage aquaculture disturbed/damaged • Escape of stock – Fluctuations in salinity temperatures, turbidity • Increased stress and disease • Impacts on seaweed culture (e.g. "Ice" disease)

Driver – Higher temperatures in inland waters		
Biophysical effects	**Implications for fisheries**	**Implications for aquaculture**
Potential for enhanced primary productivity.	– Higher fishery production – Eutrophication	– Eutrophication, weed/fouling growth
Increased stratification and reduced mixing of water in lakes, reducing primary productivity and ultimately food supplies for fish species.	– Reductions in fish biomass – Change in food webs and species composition	– Dissolved oxygen problems and impacts of "turnover" affecting cage culture
Reduced water quality, especially in terms of dissolved oxygen; Oxygen carrying capacity of water declines;	– Possible enhanced fish stocks for capture fisheries, alternatively, reduced growth where the food and oxygen supply does not increase sufficiently in line with temperature	– Reduced oxygen carrying capacity affects stocking densities/ production – Possible reductions in feeding rates and growth – Higher capital costs for aeration equipment or deeper ponds – Increased aeration operational costs
Metabolic rates increased	– Potential loss of species and alteration of species composition for capture fisheries. – Many species in tropical countries are already living at the upper end of their temperature tolerances and therefore may not be able to adapt to even higher temperatures.	– Possible benefits for aquaculture, especially intensive and semi-intensive pond systems. • Raised metabolic rates , increased feeding rates and growth • Only if water quality, dissolved oxygen levels, and food supply are adequate – Potential negative impacts on hatchery and nursery rearing operations or additional costs to mitigate
Changes in the range and abundance of pathogens, predators and competitors; Invasive species introduced.	– Altered capture fisheries stocks and species composition	– New diseases/patterns of epidemiology and possibly worsened losses to disease (and so higher operating costs) – May require changes of culture species
Changes in timing and success of migrations, spawning and peak abundance. Impacts on natural populations that in turn have impact on aquaculture	– Potential loss of species or shift in composition for inland capture fisheries • Species shifting with temperature • Migration timings patterns affected • Gonadal development/maturation/sex ratios change • Spawning times changing	– Impacts on wild seed availability for aquaculture. • Change in spawning habitats/spawning time/seed availability • Spawning period protracted • Maturation of hatchery brood fish affected

Driver – Increase in frequency and/or intensity of storms		
Biophysical effects	**Implications for fisheries**	**Implications for aquaculture**
Large waves and storm surges Inland flooding from intense precipitation Salinity changes	– Impacts on wild fish recruitment and stocks – Higher direct risk to fishers; loss of fishing gears – Capital costs increased for moorings jetties, etc. that can withstand storms – Increased insurance costs	– Infrastructure damage or loss of aquaculture facilities • Mortality of loss of aquaculture stock • Bio-security from escapees • Introduction of disease or predators into aquaculture facilities during flooding episodes. • Extreme fluctuations in culture environment – Capital costs increased in design cage moorings, pond walls – Increased insurance costs
Lower water quality and availability for aquaculture; Salinity changes.		– Loss of cultured stock; Increased production costs; Loss of opportunity as production is limited.
Changes in lake water levels and river flows.	– Reduced wild fish stocks; Intensified competition for fishing areas and more migration by fisher folk.	– Cage operations in rivers/water bodies affected

WORKING GROUPS – GAPS/CONSTRAINTS/ISSUES IN CLIMATE CHANGE ADAPTATION/MITIGATION – AQUACULTURE

GAPS/CONSTRAINTS	CAUSE
Information/data/technology gaps in climate change adaptation and mitigation related to aquaculture	– Insufficient information/data on impacts of climate change to ecosystems that impacts aquaculture activities – Lacks of methodologies for vulnerability assessment – Lack of research on aquaculture climate change adaptation and mitigation – There is no concrete/clear direction for guiding aquaculture adaptation to climate change – Need to bring about a degree of homogeneity in the questionnaires etc. and methodologies used in surveys – Evolve/constitute suitable training modules/courses
Lack of sufficient capacity on aquaculture related adaptabilities and mitigation	– Limited capacity to predict change in the climate – Lack of modern research vessel for marine research – Lack of expertise – Adaptive capacity of the people is low
Lack of financial capacity to cope with climate change	– Lack of resources supporting the study on impact of climate change to aquaculture – Difficult to anticipate and evaluate the degree of the action taking by each country – Lack of financial resources to assist local communities to adapt to climate change
Lack of awareness impacts of climate change impacts on aquaculture	– Lack of aware of impacts of climate change impacts on aquaculture among the different stakeholders, particularly policy-makers and the most vulnerable people; – Difficult in taking coordinated regional actions in addressing aquaculture related climate change issues due difference in perception to impacts of climate change to aquaculture among the different countries – Lack of awareness of potential contribution of aquaculture to climate change mitigation
Lack of institutional development	– Lack of coordination between line agencies – Lack of laws, policy and strategic action plan covering aquaculture – No linkage between inter ministerial, NGO, INGO – Gap between the policy makers and the practitioners – Lack of collaboration among the communities/ministries – Lack of implementation bodies – Conflict of interests between aquaculture and other water users

WORKING GROUPS – OPPORTUNITIES AND OPTIONS FOR ADAPTATION/MITIGATION – AQUACULTURE

OPPORTUNITY	OPTIONS/HOW TO CAPTURE THIS
Diversification of aquaculture species	– New species adapting to changed environment due to climate changes; – Indigenous species – Genetically improved strain/breed with specific tolerance (temperature, salinity etc.) – Low-GHG emission labelled products
Comparative advantage of aquaculture in producing animal food	– Animal food production with lower GHG emission – Carbon sequestration (seaweed, mollusc, herbivores fish); – Efficient water utilization of water resources;
Stimulating development and dissemination of low carbon print/green/eco-friendly aquaculture technologies	– Integrated aquaculture; – Rice-fish farming; – Multi-trophic aquaculture – Water saving/circulating farming system; – Promoting enhanced fisheries and culture based fisheries
Improvement in governance of aquaculture	– Promote the development and implementation of BMP covering appropriate climate change adaptation and mitigation measures in aquaculture; – Promote ecosystem approach to aquaculture in the region;
Positive impacts of warming on aquaculture production	– Faster growth of cultured aquatic animals – Increased productivity; – Earlier maturation of long life-cycle species – New water resources/bodies for aquaculture
Promote capacity building/ coordination	– Enhanced regional networking/collaboration in combating climate change impacts on aquaculture – Establish a regional centre or programmes within regional organizations
Aquaculture in large water bodies available	– Conflict with other uses – Technology and species – Location of the water bodies; some are seasonal – Financial/high maintenance – Land ownership

GAPS/CONSTRAINTS/ISSUES IN CLIMATE CHANGE ADAPTATION/MITIGATION – MARINE FISHERIES

OPPORTUNITIES	GAPS OR MEANS TO CAPITALIZE ON THE OPPORTUNITY
Governance/policy/social	
Focus on climate change is opportunity to bring fisheries and aquaculture to national attention as it relates to food and job security	– Can be too overwhelming (financially), so some governments won't acknowledge a problem exists; difficult to address issue
Opportunity to engage regional to develop solutions to address climate change ➔ series of connected MPAs/regional MPA; Regional CC stakeholder forum	– Change is hard, not a lot of regional collaboration at the national level; hard to facilitate collaboration – Not a lot of experience working regionally – Nations can be competitors – gap between national and regional interests
Opportunity for reducing gender-based inequalities in the sector ➔ making sure women are included in adaptation strategies	– Women can be invisible, difficult to recognize
Broader knowledge ➔ integrated environmental, economic, social	– Lack of capacity to integrate
Cooperation between sectors in governments, ministries	– Communication/channels
Improve management	
Rearrange fisheries management; Strengthen law enforcement to better manage fisheries resources	– Capacity, how do they incorporate knowledge/ science – Available resources – financial, fuel, technology – Stakeholders interest, local interest – How well are countries managing fisheries now/ opportunity to re-engage
Identify best practices in fishery management Identify gaps ➔ improve Link where related to bad management practices	– Lack of baseline knowledge – Lack of monitoring system and indicators
Strengthen management by engaging local fishing/ fish dependent communities (ecosystem approach)	– Building capacity Communities to adapt – Sustainability – Financial resources
Introduce community based management	– Difficult to get governments to give up power to local communities – Communication channels ➔ Demands for resolution quickly, lack of resources to solve quickly – How to deal with public perception

Innovation, research and technology	
Increasing monitoring capacity	– Strengthen physical, biological, chemical data and impact on fisheries (give local institutes opportunity to study) – Methodology for monitoring/defining indicators – Is there enough technical expertise for monitoring ➔ experts could be spread out among departments ➔ need proper linkage and communication
Adaptation: Ocean monitoring network to better understand and predict climate change impacts on fish	– Lack of resources/political issues (international, etc.) – Standardizing methods – Stakeholder consultation (solution)
Green technology in capture fisheries; sustainable capture fisheries by implementing new paradigms in management	– Fish forecasting, migratory (esp. pelagic); – Reduce fuel consumption – Limited by lack of resources and facilities
Changing locations of fish stocks	– Lack of knowledge, unpredictability – Resources/technology
More research on mangroves, resistant species	– Awareness/Funding – Proper species/biodiversity in rehabilitation – Opportunity for fishers to utilize seaweed especially women
Coral reef rehabilitation	– Unpredictability – Technical difficulty/research
Opportunity to restock (but a bit risky environmentally)	– Environmental challenges/lack of research on species
Diversify aquaculture	– Technology, methodology, domestication problems, feed requirements
Technology development to use new species ➔ facilitating markets for new species	– Resources, access to markets – Research – Technology
Develop locally based and low-emission fish culture material (fish feed)	– Efficiency ➔ how to identify
Economic opportunities	
Financial support ➔ take advantage of climate financing	– Lack of awareness/communication ➔ political and stakeholders
Payment for Environmental Services (PES) can be used for protection of coastal ecosystems and fisheries resources	– Lack of research to assess environmental services – Lack of incentives – Distribution of benefits

GAPS/CONSTRAINTS/ISSUES IN CLIMATE CHANGE ADAPTATION/MITIGATION – INLAND FISHERIES

Issues and gaps	Comments
Limited inclusion of inland fisheries in policy and planning (esp. NAPA)	– Fisheries is not included in many APFIC country national action plans, NAPA's for CC and river and watershed management plans – The lack of integrated, holistic cross sectoral planning will lead to increased conflicts for resource use etc. – Poor coordination between government line agencies and international organizations – No focal point person on CC in government departments/ministries
Capacity development	– No adaptive management and decision-making under uncertainty – Limited capacity of government institutions on CC
Limited information for decision-making and projections of sectoral impact	– Lack of science based information – Information gaps and scientific knowledge on the ecology of different types of water bodies (i.e. rivers, reservoirs, floodplains, rice fields, wetlands, etc.) – Poor knowledge on impact of CC on flora, fauna, livelihoods and food security – Poor knowledge on the value of inland fisheries to the rural poor, hence fisheries is often prioritized below other sectors e.g. irrigation, hydropower – Lack of valuation methods for small-scale subsistence fisheries, which would help to sensitize policy and decision-makers – Weak statistical data collection systems – Down-scaling of vulnerability mapping is missing and it is expensive to do
Inland fishery management system are weak	– Ineffective conservation of biodiversity – Current fishing and management practices leading to unsustainable inland fisheries management – Fisher communities should be made aware of the times when they can and cannot catch fish, especially if CC changes the time when fish normally spawn
Impacts from other (more influential) sectors	– Inland fisheries is often negatively impacted by the activities of other sectors and resource users – CC mitigation measures of other sectors may negatively impact on inland fisheries
Limited preparedness	– There are few adaptation and mitigation measures to CC which are appropriate to small-scale inland fishers – Poor awareness and knowledge on CC and its impacts on inland fisheries – Insufficient flood control mechanisms – Poor, inefficient early warning systems – Poor disaster preparedness, e.g. no designated safe zones – Rural poor have limited financial capacity and knowledge to adapt to the impacts of CC

OPPORTUNITIES FOR CLIMATE CHANGE ADAPTATION/MITIGATION – INLAND FISHERIES

Opportunities	Comments
Economic and financing	– Considerable levels of donor funds are available for CC initiatives
Strengthened governance, institutional response to CC	– Integrated holistic/cross sectoral planning and management can be given stronger priority e.g. integrated water resource management – Fisheries will be more empowered to negotiate resource use (e.g. water) and habitat restoration with other sectors – Ecosystems approaches can be promoted with more likelihood of success – APFIC member countries without CC programmes can launch CC programmes – CC can be used to speed transition to more responsible inland fisheries management and fishing
Understand vulnerability	– An understanding of relative vulnerabilities at the local and regional level will allow prioritization of adaptation actions
Research technology, knowledge	– Integrated agriculture systems can be promoted – Research can be conducted on the impact of CC on socio-economics, on livelihoods and on inland freshwater ecosystems including specific species impacts, and eco-friendly fishing gears
Improve communication	– Policy-makers/planners/decision-makers will be more aware of the direct and indirect importance of inland fisheries to rural livelihoods
Improve management	– Inland fisheries can be managed to maintain dry season refuges for broodstock which can later spawn
Strengthen community resilience	– Local community organizations can be strengthened to conserve and manage habitats and to diversify livelihoods options – Other livelihoods opportunities are more likely to be adopted – People can be given CC preparedness adaptation training for inland fisheries – Existing communication and new methods can be used to provide early warning systems – Awareness can be built on the importance of monsoon patterns to wetlands, flood plains and inland fisheries and the effects on fisheries as a basis for adaptive CC measures
Regional support and coordination	– APFIC member states can each be tasked to identify gaps and issues – The Strategic Plan of the MRC and the Basin Development Plan which addresses CC can be used
Develop opportunities presented by increased fish stocks	– Increased flooding events will increase natural fish stocks – More reservoirs and water levels in reservoirs will provide greater irrigation and water storage, which will allow better inland fisheries planning and management – Oligotrophic and mesotrophic water bodies may become more productive

An example of how a regional cooperation mechanism could promote and coordinate responses to address climate change at a regional level

Recommendations from the BOBLME working group on how the Bay of Bengal Large Marine Ecosystem Project could facilitate coordination of responses to climate change with a sub-region.

Serve as a regional synthesis and evaluation body for plans and programmes produced by Bay of Bengal countries

- Support to the review and update of NAPAs
  - Review NAPAs for level of fisheries inclusion
  - Provide supporting information for countries with lower levels of fishery inclusion in NAPAs
  - Disseminate 'best practices' or 'good ideas' from NAPAs across the region
- Broader adaptation strategies
  - Are experts in the field, recommending approaches that are different than those known/taken in the region?

Ensure that BOBLME supported projects incorporate climate change

- MPAs regionally cited to support current needs and future refugia
- Stock assessments that BOBLME is coordinating can consider climate scenarios, at least qualitatively

Develop and articulate regional scientific needs

- Regional ocean observing
- Developing citizen (or tourist) science for monitoring
- Data sharing capabilities – build on tsunami warning system
- Integrated cyclone prediction system, coupled with synthesis of changes in cyclone patterns
- Standard framework for valuing ecosystem services from all coastal resources
- Current status assessments for ecosystems, habitats, species, freshwater supply
- Regional understanding of resource use/allocation

Serve as a clearing house for best practices and good ideas

- Weather prediction
- Increasing resilience
- Raising awareness in the public, and across sectors
- Alternative income generating activities
- Regional pilot projects

Develop tools and programmes that will have lasting (i.e. after BOBLME completed) effects

- Develop an framework for the region to create and manage projects jointly – especially migratory and transboundary species issues
- Training trainers
  - Ecosystem assessments
  - Safety at sea
  - Outreach and education for climate change
  - Stock assessments – incorporating climate impacts in data\poor situations

CLIMATE CHANGE: IMPLICATIONS AND ADAPTATION MEASURES IN THE PHILIPPINES FISHERIES AND AQUACULTURE SECTOR

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The fisheries sector is vital to the Philippine economy, providing substantial employment and income, contributing export earnings, and meeting local food security and nutrition requirements. In 2009, the contribution to the country's total fish production from fisheries and aquaculture was about 5.08 million MT (BFAR 2009). Of which aquaculture had the biggest share with 49 percent, while commercial and municipal fisheries contributed to approximately 25 percent and 26 percent, respectively.

In 2009, the fishing industry's contribution to the country's Gross Domestic Product (GDP) were 2.3 percent and 4.3 percent at current and constant prices, respectively. This translates to some PHP143.4 billion for current prices and PHP58.6 billion for constant prices of the country's GDP. The industry also accounted for 15 percent (P170.4 billion) and 24 percent (P61.8 billion) of the Gross Value Added (GVA) in Agriculture, Fishery and Forestry Group of PHP1 102 billion and PHP259 billion at current and constant prices, respectively, the largest share next to agricultural crops.

Based on retrospective analyses of resource surveys in the Philippines, the biomass levels of coastal fish stocks in various fishing areas in the Philippines are today only 10-30 percent of the levels in the late 1940's (Barut et al. 2003; Armada 2004). In addition, about 25-30 percent of the total catch is lost due to improper handling, inadequate storage facilities and inefficient marketing (Hermes 2007).

The Philippines is considered highly vulnerable to climate change impacts. These bring along further pressures on agricultural and fisheries production, which is already hard pressed by other resource scarcities and economic challenges. Changing rainfall patterns, rising temperatures, increasing frequency and intensity of typhoons and dry spells, and sea level rise are expected as a result of climate change.

The current vulnerability of local coastal communities is related to ecological factors in addition to socio-economic and political ones. The degradation of mangroves, coastal forests, coral reefs and upland forests reduce the capacity of ecosystems to provide goods and services to the society. Many of these services are crucial for adaptation to climate change.

Based on DOST-PAGASA scenarios for 2020 and 2050, there is a projected widespread warming in most parts of the country. Longer hot days and shorter cold days are expected. The number of days with maximum temperature of >35^{o}C is expected to increase in all parts of the country in 2020 and 2050. Projected seasonal mean temperatures in the Philippines are expected to rise by about 0.5^{o}C to 0.9^{o}C for 2020 and 1.2^{o}C to 2.0^{o}C by 2050. Also, extreme rainfall is projected to increase in Luzon and Visayas while a decreasing trend is projected in Mindanao.

Global warming affects aquatic ecosystems and their fishery productivity (WorldFish 2007). Fisheries and aquaculture are also threatened by the secondary effects of warming: changes in ocean currents, precipitation that affects lake levels and river flows, and increasing storminess and extreme floods and droughts. This makes living near water and catching or farming fish more hazardous than it is already.

In a recent study in Zamboanga Peninsula in southern Philippines where upwelling supports a thriving sardine fishery showed that sardine landing data correlate remarkably well with the monthly chlorophyll values during 2009-2010 (Villanoy et al. 2011). Inter-annual variations in upwelling, phytoplankton productivity, and sardine catch suggested that inter-annual ENSO variations can affect the small Zamboanga Peninsula pelagic fishery. In addition, despite the prevailing notion that La Niña causes strengthening of the monsoon-driven upwelling, long-term fisheries production data for Zamboanga demonstrate a decrease in fish catch due to weaker upwelling during the 1999/2000 and 2007/2008 La Niñas.

In an earlier study in Bolinao, Pangasinan, a relatively short-term, indirect impact of bleaching may be shown using catch data derived from fish corrals, from 1996 to 1999 i.e., data showed that a year after the bleaching event in Bolinao (June 1998), there was no peak in rabbitfish catches compared to the previous years (Cesar et al. 2001). Fish corrals are deployed by the fishers on the reef and the fishery contribute about 10 percent to the total fishery in Bolinao during the study. The majority of the fish caught by fish corral gear are rabbitfish (siganids) and the annual peak abundance was observed between March and June. This annual peak coincides with what the local communities call the *barangen* (rabbitfish) runs. Schools of juvenile rabbitfish enter the reef consistently, year after year, thereby supporting a thriving siganid fishery.

The comparison of species richness between 2010 and 2050 also shows that there will be an overall decrease in terms of fish biodiversity across the Southeast Asia region including the Philippines. The predicted decrease in species richness in the SEA region by 2050 roughly ranges between 12 percent – 47 percent in proportion to the predicted species richness in 2010 (WorldFish/FIN 2010).

In terms of perceived climate aberrations, the top three effects as perceived by the respondents include: (i) prolonged rainfall/floods; (ii) prolonged heat/drought; and (iii) occurrence of typhoons/storms. Other minor climate aberrations identified were forest fires, abnormal rise or lowering of water/sea level, and landslides. With regard to negative effects of climate change, declining fish catch and crop yields as well as loss of crop, livestock and fish production were the most notable factors. The above discussions provide perceived bio-physical vulnerabilities to climate change of six provinces namely the twin provinces of Camarines, Mindoro, and Misamis. These provinces are considered among the vulnerable and also the prevalence of extreme poverty in the coastal and agriculture communities.

The paper also presented and discussed various adaptation and mitigation measures and strategic directions that the country has been undertaking or initiated. For example, the Philippine Climate Change Commission was established by Republic Act 9729 or the Philippine Climate Change Act of 2009 and the formulation of the ***National Climate Change Action Plan (NCCAP) 2011-2028***, is committed towards ***ensuring and strengthening the adaptation of our natural ecosystems and human communities to climate change***. Also in 2009, the Department of Agriculture has developed the framework for Climate Change Policy with a goal to ***build the adaptive capacity of farming and fishing communities and increase the resilience of natural ecosystems to climate change, and optimize adaptation with mitigation opportunities towards sustainable development***.

The paper concludes with WorldFish Center initiatives in supporting research to climate change issues related to fisheries and aquaculture. ***WorldFish***, as a research organization dedicated to helping achieve development impact generate and synthesize knowledge which is then shared and help applied. Consistent with its membership of the CGIAR, the Center's focus will be on both the creation of International Public Goods and on actively helping to make development happen on the ground in selected geographies.

The outcomes of CGIAR change process represent a fundamental shift in the WorldFish Center operating environment. As a research centre in the CGIAR system, it must now align our efforts with the CGIAR's new, results oriented Strategy and Results Framework (SRF) and the strategic objectives contained within it. WorldFish will do this by working with sister centres and other research and development partners on the two fishery specific strategic objectives: (i) ***Reduce poverty and vulnerability***: improve the livelihoods of those who are specially poor and vulnerable in places where fisheries and aquaculture can make a difference; and (ii) ***Sustainably increase food and nutrition security though fisheries and aquaculture***: achieve large scale, environmentally sustainable, increases in supply and access to fish at affordable prices for poor consumers in developing countries. WorldFish believe these foci for fisheries and aquaculture are key for helping to realize the CGIAR's ambition to deliver development impact at scale. Specifically, our efforts will focus on two: CRP 1.3 Harnessing the development potential of aquatic agricultural systems for the poor and vulnerable; and CRP 3.7 'More meat, milk and fish by and for the poor'.

It must be noted that one of the key research area of the Centre is on ***climate change vulnerability and adaptation***. Research activities include: (i) diagnosis of vulnerabilities; (ii) understanding current coping mechanism and adaptive responses; (iii) contributing to mitigation; and (iv) building the capacity to respond and adapt to climate change at different scales.

CURRENT AND PROJECTED CLIMATE IMPACTS ON US MARINE ECOSYSTEMS AND FISHERIES AND THE APPROACHES TO UNDERSTANDING AND RESPONDING TO THEM

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The United States of America has a wide variety of efforts underway both domestically and internationally to help increase understanding, prepare for and respond to the current and future impacts of climate change on marine ecosystems, fisheries and aquaculture. These efforts span international to national to local levels and involve partners from government and non-government sectors. This paper provides a summary of some of these efforts to help safeguard marine ecosystems, fisheries, aquaculture and the communities that depend on them in a changing climate. There are a growing number of national policies and actions in place to promote adaptation to climate change. There are three major areas of activity:

- Efforts to understand and predict how the climate is changing;
- Efforts to understand and predict how climate changes impact coastal and marine ecosystems (including living marine resources, habitats and the communities that depend on them) now and in the future;
- Efforts to develop and implement adaptation actions to reduce the vulnerability and increase the resilience of marine ecosystems and fisheries in a changing climate.

AGENCY ADAPTATION STRATEGIES

One of the most significant of these policies is the 2009 Presidential Executive Order 13514 directing all federal government Departments to (1) assess the vulnerability of their mission and assets in a changing climate and (2) develop climate adaptation strategies by July 2012.[4]

NATIONAL ADAPTATION STRATEGY

In general, these national efforts are being led and coordinated by the President's Council on Environmental Quality (CEQ) through a high-level, cross governmental Interagency Climate Change Adaptation Task Force (ICCATF) established in 2009 to lead and coordinate development of a U.S. national adaptation strategy.[5] In Oct 2010, the ICCATF issued its first report outlining needs and actions including the following recommendations for how Federal Agency policies and programmes can better prepare the United States to respond to the impacts of climate change:

- Make adaptation a standard part of the Agency planning to ensure that resources are invested wisely and services and operations remain effective in a changing climate.
- Ensure scientific information about the impacts of climate change is easily accessible so public and private sector decision-makers can build adaptive capacity into their plans and activities.
- Align Federal efforts to respond to climate impacts that cut across jurisdictions and missions, such as those that threaten water resources, public health, oceans and coasts, and communities.
- Develop a United States strategy to support international adaptation that leverages resources across the Federal Government to help developing countries reduce their vulnerability to climate change through programmes that are consistent with the core principles and objectives of the President's new Global Development Policy.
- Build strong partnerships to support local, state, and tribal decision-makers in improving management of places and infrastructure most likely to be affected by climate change.

[4] http://www.whitehouse.gov/administration/eop/ceq/sustainability

[5] http://www.whitehouse.gov/administration/eop/ceq/initiatives/adaptation

The ICCATF also identified a set of guiding principles that public and private decision-makers should consider in designing and implementing adaptation strategies. They include (but are not limited to) the following:

- **Adopt integrated approaches**: Adaptation should be incorporated into core policies, planning, practices, and programmes whenever possible.
- **Prioritize the most vulnerable**: Adaptation strategies should help people, places, and infrastructure that are most vulnerable to climate impacts and be designed and implemented with meaningful involvement from all parts of society.
- **Use best-available science**: Adaptation should be grounded in the best-available scientific understanding of climate change risks, impacts, and vulnerabilities.
- **Apply risk-management methods and tools**: Adaptation planning should incorporate risk-management methods and tools to help identify, assess, and prioritize options to reduce vulnerability to potential environmental, social, and economic implications of climate change.
- **Apply ecosystem-based approaches**: Adaptation should, where appropriate, take into account strategies to increase ecosystem resilience and protect critical ecosystem services on which humans depend, to reduce vulnerability of human and natural systems to climate change.

NATIONAL CLIMATE ASSESSMENT

The U.S. is conducting a comprehensive National Assessment of climate impacts and response options every four years as required by law. The Assessment will also identify science needs in understanding current and future climate impacts and regional or sector-related vulnerability to those impacts, supporting adaptation and mitigation decisions, and informing effective translation of science into services and applications. http://www.globalchange.gov/what-we-do/assessment

FISHERIES SPECIFIC POLICIES AND STRATEGIES

General perceptions and awareness

There is general and growing awareness among federal government agencies involved in marine fisheries and aquaculture such as the National Oceanic and Atmospheric Administration (NOAA) that (1) the planet's climate is changing and (2) that these changes are already impacting the nation's valuable marine ecosystems including fisheries and aquaculture and (3) that these changes and impacts are expected to significantly increase in the future. In general, there is less awareness of what the specific impacts have been to date, what is projected for the future and what can be done to reduce these impacts.

Policies and strategies

In general, agencies at federal and state levels are currently working to assess the impacts of climate change on living marine resources and determine how best to incorporate this information into management of fisheries and other marine resources. One of the major NOAA policies and strategies that is helping incorporate and address climate change and other stressors into fisheries management is the use of ecosystem-based approaches to management (for more information see: http://www.nmfs.noaa.gov/). One of the major efforts to advance adaptation of fish and other natural resources is development of the first National Fish, Wildlife and Plant Climate Adaptation Strategy.[6]

Coordination among agencies

There are several efforts to ensure coordination among agencies as they develop their agency-specific adaptation plans, and among national adaptation initiatives such as the National Climate Assessment and the National Fish Wildlife and Plant Climate Adaptation Strategy. The Interagency Climate Change

[6] http://www.wildlifeadaptationstrategy.gov/

Adaptation Task Force (Task Force) plays a major role in this coordination. (http://www.whitehouse.gov/administration/eop/ceq/initiatives/adaptation)

Climate and fisheries related initiatives and projects

There are a wide variety of initiatives and projects underway on the impacts of climate change on fisheries and aquaculture. The following are just a few examples of efforts NOAA Fisheries Service and partners are engaged in.

Changing distributions of fish stocks in the Northeast USA: Analysis of ocean temperatures and marine fish distributions over the last 40 years in the Northeast U.S. continental shelf ecosystem finds that 24 of 36 major fish stocks moving northward and into deeper waters as ocean temperatures increases across the region. The work suggests that fish stocks are already responding to changes in climate, and that fisheries managers need to incorporate the effects of climate change into fish stock assessments and fishery management plans.

Forecasting fish population changes in the Northeast USA: NOAA fisheries scientists are beginning to quantify and forecast impacts of climate change on specific fish stocks and fisheries by coupling climate change models with population models – in this case for the Atlantic croaker, an important fishery on the U.S. east coast. The results indicate that the centre of the population is expected to shift 50-100 km northward along the U.S. northeast coast, and croaker population biomass is forecast to significantly increase by 60-100 percent, allowing managers to consider increasing harvests of the species in future management scenarios.

Pollock catch levels reduced in the Bering Sea: Recently NOAA fisheries researchers were able to link changing ocean conditions in the Eastern Bering Sea with declining recruitment of pollock fish stocks, which could result in significant declines in the pollock population. The pollock fishery alone is worth > $1 billion annually, and the area provides almost 50 percent by weight of the U.S. landings of seafood. Based on this information, resource managers reduced pollock catch levels as proactive measure to reduce long-term impacts of climate-related changes on the fishery. This is one of the first examples of incorporating climate change information into U.S. marine fisheries management.

Pacific salmon: climate change impacts on inland and ocean life-stages: The inland early life history stages of Pacific salmon are expected to be significantly affected by increasing temperatures and climate-change driven changes in freshwater flows, while changing ocean temperatures, currents and productivity will affect ocean-based adult stages. NOAA Fisheries Service researchers have active monitoring, research and modeling efforts underway to understand and forecast the impacts of these climate-driven changes across the complex salmon life history from rivers to oceans and back. These efforts are also developing and testing management responses, including where and when to restore salmon stream habitat to help increase the resilience and adaptation of Pacific salmon in a changing climate.

New, overlapping distributions and habitat use for Arctic whales: NOAA Fisheries Service has research underway to better understand and forecast the impacts of climate change, especially loss of sea ice, on Arctic whales and other marine mammals. In addition to changes in ocean conditions with warming temperatures and the loss of sea ice, the two resident whale species (beluga and bowhead) will increasingly have to share their habitats with seasonally-migrant whale species as these species extend their distributions toward the pole. Already, bowhead and gray whales are feeding together in late summer.

Warming air, declining sea ice, krill and penguins in Antarctica: The Scotia Sea and adjacent West Antarctic Peninsula regions are among the fastest warming ecosystems on the planet, with 5-6°C increases in mean winter air temperatures and associated decreases in winter sea-ice cover. These perturbations have had profound effects on this ecosystem, including significant declines in both

ice-loving Adélie and ice-avoiding chinstrap penguin populations. Evidence suggests past increases and current declines in penguin populations are primarily the result of changes in the abundance of their main prey, Antarctic krill, in response to climate change.

Effects of ocean acidification on fish, shellfish and ecosystems: NOAA Fisheries Service has research efforts underway around the country to understand and forecast the impacts of ocean acidification on fisheries and marine ecosystems. Researchers in Alaska are conducting laboratory experiments to understand impacts of increasing acidification on the most vulnerable early life history stages (eggs, larvae) of king crabs, pollock and other key fishery species; researchers in the Pacific Northwest are studying the impacts of acidification and other stressors on larvae from variety of important species. NOAA led intergovernmental team to develop the U.S. research strategy on ocean acidification (www.pmel.noaa.gov/co2)

Linking Climate Change and Marine Resource models to assess impacts: A challenge in understanding the impact of climate change on living marine resources is linking the climate models to changes in ocean conditions and ultimately to changes in the fisheries and other resources. To help meet this challenge, researchers and modellers from climate and marine resource fields are joining forces to develop the next generation of modelling tools that will allow better projection of climate impacts on fisheries and other living marine resources.

CAN COASTAL COMMUNITIES TURN MANGROVES TO MONEY?

Angela Lentisco, APFIC Secretariat and Regional Fisheries Livelihoods Programme

Mangroves play a well documented environmental role that includes providing protection from coastal hazards and maintaining coastal fisheries resources. In addition, mangrove ecosystems commonly contain much larger amounts of carbon than most terrestrial forests and also have higher rates of primary productivity than many other tropical forests types. In view of this, the FAO Regional Fisheries Livelihoods Programme (RFLP) commissioned a review to investigate the possibility of generating income from mangroves through carbon credit sales and payments for environmental services as an alternative livelihood option for fishers and their families (The full report will be available at www.rflp.org)

The lack of well fitting methodologies and the need to provide communities with income within a short time frame (~3 years) suggests that the sale of carbon credits is not a practical course for RFLP to follow in providing alternative means of livelihood support to fisher communities. A more realistic alternative may be to develop an alternative lower cost accreditation framework that does not yield carbon credits, but provides a socially and environmentally sound 'sustainable development product' focussing on payments for mangrove protection and aimed at corporate buyers.

Markets still in early stage of development

Rising concern over climate change has seen the establishment of markets both through voluntary and internationally agreed measures. However issues associated with monitoring and quantifying carbon flows with precision have meant that costs of including forestry activities in markets have exceeded associated benefits. Meanwhile, markets for environmental services have yet to develop to any great extent.

Methodology wanted

The inclusion of soil carbon, in addition to carbon in biomass, is particularly important in the case of mangroves as soil carbon stocks may account for well over half of the total carbon present in the ecosystem. However, rates of soil carbon collection as a result of root turnover and litter fall are not well known and may be highly variable. Time-consuming methodological work is likely to be necessary before rates of accretion/conservation of soil carbon can be quantified, validated and credited.

Changing architecture

In addition to the technical issues, investment in mangrove related carbon emissions reduction suffers risks associated with transitions in the global climate change architecture. A post-2012 replacement for the Kyoto Protocol has yet to be agreed while voluntary markets for forestry related carbon sales will end once national level reduced emissions from deforestation and forest degradation (REDD) mechanisms are established.

Institutional and administrative issues

Institutional and administrative issues must also be taken into account in assessing the feasibility of setting up carbon sales. For example, costs will be associated with distributing and monitoring benefits to local communities in relation to mangrove activities such that income per hectare will be spread among many people and only a certain proportion will make it to the local level.

Economies of scale

Even with carbon emissions reductions of 34 tonnes per year (the upper level recorded by existing forestry initiatives) any project would likely have to cover over 1 000 ha to break even within 5 years given a sale price of $5 per carbon credit.

Most profitable possibilities

Given the nature of mangrove ecosystems and potential for sequestering carbon/reducing emissions, the most profitable sites are likely to be reduced emissions from deforestation and forest degradation (REDD) activities in threatened degraded mangrove areas with peat soils; and afforestation and reforestation (A/R) activities in abandoned fish ponds.

Despite the above, under current conditions it is still possible for communities to benefit from mangrove related activities. The RFLP will work towards one of the following options:

- Carbon accreditation including addressing methodological issues, and accreditation with social and environmental standards; or
- Develop an alternative lower cost accreditation framework that does not yield carbon credits, but provides a socially and environmentally sound 'sustainable development product' focussing on payments for mangrove protection and aimed at corporate buyers.

The presenter also provided information on the possibilities of using algae as biofuel, categorizing the differences between macro and micro algae and related products.

STREAMLINING CLIMATE CHANGE IN ALL ASPECTS OF PROGRAMME PLANNING AND IMPLEMENTATION

Magnus Torell, SEAFDEC

Introduction

The last decade has seen an increasing attention being given to climate change in Southeast Asia and elsewhere. Consultations have been held in the region on the possible effect to environment, natural resources, fisheries and people. Organizations have been struggling to find ways and means to address climate change and the response has often been to develop new projects with a special focus on climate change. SEAFDEC on the other hand have had the opportunity, through the Swedish supported project on "SEAFDEC activities related to climate change and adaptation in Southeast Asia with special focus on the Andaman Sea", to build upon experiences from earlier projects and address climate change in a cross-cutting manner with regards to integration of fisheries and habitat management, managing fishing capacity and other activities implemented by the project.

The approach promoted by the SEAFDEC-Sida Project on responses to climate change is to build awareness in specific areas, in provinces, nationally and at regional level to show that better organization at village level and provinces, improved habitat management and restored habitats, reduction of (destructive) fishing effort, improved registration of vessels, licensing to fish, developing MCS networks, safety at sea, etc. are in fact helping to build adaptive capacity and help to mitigate possible impacts of climate change.

Subsequently, capacity building, including specific focus to build up resilience and protection against national hazards and effects of climate change should be incorporated in the context of coordinated habitat and fisheries management, development of larger fisheries resources conservation areas (refugia), management of fishing capacity including safety standards as well as the preparedness and ability of crew-members. The work so far, with partners in the region, has clearly indicated that improved resources and environmental management is linked to the process to build up resilience and adaptive capacity. With improved resources and environmental management including resilience and adaptive capacity some of the basic elements to address poverty alleviation are in place.

An important part of the approach is to build up the ability of SEAFDEC (the Project) and partners to report efforts to improve habitat/fisheries management, improved local organization and reduction of fishing efforts and other results in a "climate change perspective". This ability is also crucial in for the process to indicate impacts generated by the Project in promoting responses to climate change.

SEAFDEC organised an important Consultation with ASEAN-SEAFDEC Member Countries, regional/ international organizations and international experts in November 2010 on "Adaptation to a Changing Environment". The consultation was successful in summarising and to provide recommendations on a number of key aspects of importance to the immediate development in the region, including aspects on climate change. To facilitate the process the Consultation had a full day session on "Climate Change and responses by the sector and by people involved in and dependent on fisheries and fisheries products".

In line with the approach taken by SEAFDEC, the consultation stressed, among other things, that it is important to highlight that existing programmes and actions being implemented and of importance to improve fisheries management and the well-being of people involved in fisheries and fisheries related activities (coastal/inland fisheries, commercial fishing, processing and post-harvest) which are relevant in terms of responses from the sector to climate change and local variations in monsoon and hydrology patterns. What is needed is to develop methods and indicators on how actions taken contribute to building up of adaptive capacity, to mitigate effects caused by climate change and to reduce contributions by the sector to climate change. The Consultation also stressed the need to have "fisheries" incorporated in national plans of action on responses to climate change and on the importance to incorporate aspects of climate change in fisheries policy framework (the results of the Consultation are included below).

The approach taken by the Project on climate change has increasingly been recognized by member countries and during the events such as the October 2009 Andaman Sea Meeting, the Annual Review Meeting with Sida (January 2010), the meeting on vessel record and inventory, July 2009, the Expert Consultation on combating IUU fishing, September 2010, the Consultation on Changing Environments, November 2010 and in discussions with FAO, MFF, BOBLME and MRC.

Perspective on Southeast Asia

Southeast Asia is dependent on the seasonal variety of the monsoon and related variations in the climate. Hydrological and oceanographic patterns are important for the life-cycle of aquatic resources. Through actions by humans important habitats, including biodiversity, are threatened through environmental degradation and destructive fishing. Over-fishing is a problem leading to reduced availability of fisheries products. Erosion is a serious problem and constructions (dams, roads, etc.) in and around watersheds

is impacting on the on the interconnectivity in the river systems affecting migration and spawning of fish. Livelihoods of inland and coastal communities are threatened. Immediate action is needed to combat negative trends both inland and offshore.

With the perspective of Southeast Asia as a background it is important to emphasise that effects of climate change acts, in general terms, as a "stressor" or add to existing problems including that of coastal erosion, abundance of resources, frequency of storms, typhoons, etc.

The SEAFDEC approach is also in line with ambitions expressed in the ASEAN Charter that emphasise that there is an urge "to promote sustainable development so as to ensure the protection of the region's environment, the sustainability of its natural resources, the preservation of the cultural heritage and the high quality of life of its peoples" (ASEAN Charter Article 1, Section 9) and to promote the sustainable use of coastal and marine resources (ASEAN Socio-Cultural Community Blueprint Article D.7). ASEAN Economic Community Blueprint Chapters D.6, D.7, D.8, D.9 and D.10 provide other useful ASEAN references to ASEAN and Climate Change adaptation, mitigation and related actions.

Climate change and the Andaman Sea

The monsoon pattern around the Andaman Sea combined with geographical features such as coral reefs, mangrove areas, sea-grass beds – and for the inland areas of Myanmar vast flood-plains and wetlands – and other critical habitats are unique to the region and provide the basis of the ecological specificity as well as some protection against natural hazards and in support of reduction of perceived effects of climate change.

Poor coastal villagers are also pressured from expansions of urban, industrial and tourism development often resulting in a push to move families and whole villages often leading to increased competition for fish with other villagers in places where they try to settle down. This together with increased clearance of mangroves for urban and industrial development, shrimp farming and other uses leaves the coastal villages more exposed to natural hazards and climate change. In the process traditional knowledge on how to "live with the sea" and how to manage and maintain coastal habitats is rapidly being lost.

Climate change and changes in the monsoon pattern can have far-reaching effects on coastal livelihoods and availability of fisheries resources in marine as well as in fresh water. Smaller coastal villages throughout the region are facing hardships due to the impact from natural hazards such as storms, tornados, floods, etc. The coastlines of the Andaman Sea are exposed as were seen in 2008 with the cyclone Nargis in Myanmar leading to losses in lives, boats and equipment. Lessons learnt from disasters like these should be incorporated into efforts to, given the specific geographical situation, integrate fisheries management into habitat management and coastal management. This could include safety and rescues at sea, keep records on available boats, etc. This should also include efforts to build resilience, incorporate local knowledge and to restore important, and protective, coastal features and habitat. The work to mitigate effects caused by natural hazards should not only be viewed based on common seasonal monsoon patterns in Southeast Asia but also, and increasingly so, in the perspective of climate change that threat to further expose already vulnerable coastal villages and fisher-folk.

During the First Andaman Sea Meeting in October 2009 it was noted that climate change cuts across all aspects related to fisheries and habitat management including social development. It was noted that actions needed to improve fisheries and habitat management, maintain ecosystems health and increased resilience among coastal and inland fishing communities would also be relevant to address impacts of climate change and building up adaptive capacity. It is important to find or develop suitable indicators to report results of actions implemented and to train people and project staff to include perspectives of climate change in the regular reports. Furthermore the meeting stated that local knowledge, traditional practices and local organizations are important elements to build upon when building up capacity to adapt to climate change and in efforts to mitigate effects caused by climate change, such as impact from storms, typhoons, floods, etc.

Furthermore, some of the developments in coastal areas of Southeast Asia are, if not properly controlled, contributing to climate change as well as for the changes in the local climate and environment. A reversal of present trends of coastal environmental degradation could, in fact, be important in order to reduce effects caused by natural hazards. In the process of rehabilitating important coastal habitats (such as mangroves) and geographical coastal features (such as sandy beaches) to be able to maintain critical areas for various fish species during their lifecycle this should, ideally, be done incorporating plans to restore protective features as well as to mitigate potential effects caused by climate change.

In the protection of fisheries resources and the environment there is a call for fisheries and environmental authorities to come together and start integrating fisheries management with habitat management and in the process involve authorities responsible for development and spatial planning in order to build up a common position to seek ways to ensure that developments in coastal (and inland) areas taking due concern to the aquatic resources and the marine environment. It is important to find ways to assess potential impacts of climate change and how that will affect availability of natural resources and aquatic products. Without action, fishing pressure, fishing conflicts and conflicts with other uses are likely to increase, and will lead to resource depletion through environmental degradation and/or through heavy fishing. These issues call for strong collaborative efforts, at different levels, to curb the escalation. Furthermore, reports on the importance of specific geographical features in the coastal areas for protection against natural hazards should be assessed and addressed in the development of management plans and in the perspective of potential impacts of climate change.

An analytical problem is how to distinguish changes caused by climate change from changes that are due to over-fishing, encroachment and exploitation of marine and coastal habitats and other destructive practices. The "problem" should not be seen as a problem but rather to strengthen the imperative to act now and not wait for "global" solutions. However, it is important that capacity is being built up to report on actions and results to different audiences, including those addressing climate change and adaptation.

Recommendations for future actions from the November 2010 Consultation on "Changing Environments"

These recommendations are important to highlight that existing programmes and actions being implemented and of importance to improve fisheries management and the well-being of people involved in fisheries and fisheries related activities (coastal/inland fisheries, commercial fishing, processing and post-harvest) are also relevant in terms of responses from the sector to climate change and local variations in monsoon and hydrology patterns. What is needed is to develop methods and indicators on how actions taken contribute to building up of adaptive capacity, to mitigate effects caused by climate change and to reduce contributions by the sector to climate change. ASEAN Economic Community Blueprint Chapters D.6, D.7, D.8, D.9 and D.10 provide useful ASEAN references to Climate Change and related actions.

Note: Some information required on seasonal variations in climate and hydrology is outside of the mandate of most fisheries agencies. Cooperation with other, relevant institutions, NGOs, etc. will be needed to ensure that implementation is done efficiently and that good quality information can be provided and that effective measures can be taken to build up adaptive capacity and to strengthen mitigation efforts.

1) *Develop and implement policies and programmes to maintain and restore coastal/inland habitats, improve fisheries management and the well-being of people involved in fisheries and fisheries related activities (coastal/inland fisheries, commercial fishing, processing and post-harvest).*

Add indicators to report on how that would be contributing to responses to climate change. Do what's in our mandate, what we are good at and do it better.

Actions and programmes that would be supportive in providing responses to the need for mitigation measures and to build up adaptive capacity include actions such as:

- Restore and rehabilitate degraded habitats and protective features. Conserve and maintain healthy ones.
- Promote regional and sub-regional cooperation on habitat and fisheries management, specifically on trans-boundary stocks and habitats, including efforts to combat illegal and destructive fishing.
- Strengthen local community organizations (coastal and inland), including capacity to conserve and manage habitats, manage and record fishing capacity, capacity to explore diversification of family incomes, etc. to improve well-being and strengthen resilience.
- Manage and reduce fishing capacity and work out energy saving schemes together with selective fishing gear.
- Focus on aspects such as health of crew members, working conditions and training while improving development of safety at sea measures.
- Undertake programme on management of inland fisheries during the dry season (establishment of refugia) in order to alleviate the impact of extended dry season period and uneven rainfall in wet season that would impact fish recruitment and the livelihood of rural people.
- Pay more attention to the variations of monsoon patterns to wetlands, flood regimes and inland fisheries and how to ensure that interconnectivity and migration paths are maintained.

2) *Build up adaptive capacity of people dependent and involved in fisheries related activities to cope with changing environments, including effects caused by climate change*

Strengthen the capacity of local inland/coastal communities to:

- be aware of how possible impacts of climate change would add to present problems and hard-ships and needs to improve management
- actively provide inputs to the process of recording information on the local variation of weather/monsoon patterns and other key parameters such as sea temperature with a view to assess if any changes and trends over time can be noticed
- regularly monitor availability of fisheries resources and changes in biodiversity patterns (e.g. reef check programme) and make note of any possible deviations from regular patterns
- Initiate, together with partners locally, and at province and national level, management, conservation and rehabilitation programmes for fisheries resources and habitats in their respective areas building upon the involvement of community, government agencies, NGOs, local authorities and others as suitable

Mobilize and/or document the local and indigenous knowledge and practices to monitor changes in the availability of fisheries resources as well as changes in biodiversity in both inland and coastal areas. Furthermore, incorporate as suitable traditional/local practices to manage, conserve and rehabilitate fisheries resources and habitats

3) *Ensure that fisheries aspects are incorporated in the national action plans on responses to climate change*

- Review national action plans on responses to climate change to clarify the extent to which fisheries and habitat aspects are incorporated and as needed explore ways to have fisheries aspects further emphasized in the plans
- Invest more time and resources to increase level of predictability on instances and impacts by typhoons, storms, and other hazards on coastal communities as a basis for actions to reduce susceptibility.
- Conduct risk assessment for all infrastructure development and resource enhancement structures in coastal and wetland areas (ASCC D.6.36.v)
- Assess the interconnectivity of the ecosystem from upland down to marine ecosystem to determine the overall impacts of major constructions and other developments that might

block the free flow of water and how effects of climate change might add to problems of interconnectivity during dry and wet season.

– Pay more attention to the variations of monsoon patterns to inland fisheries and make sure that it is adequately reflected in action plans on responses to climate change.

4) Integrate climate change into fisheries policy framework

– Involve all levels, national, province and local, in the process of planning and policy formulation for management, conservation and rehabilitation of habitats and protective geographical features as well as in terms of policy formulation on the use and management of natural and human resources (ASCC D.10.40)
– Groups of people in different geographical areas are to various degrees vulnerable to changes in the environment and to the effects natural hazards and as climate change is anticipated to add to the stress it is important to conduct assessment on the level of vulnerability and possible effect on habitats, fisheries and livelihoods.
– Assess the interconnectivity of the ecosystem from upland down to marine ecosystem to determine the critical areas with regards to the migration of fish species, spawning, etc. during wet and dry season with a view to have responses adequately reflected in fisheries policy frameworks. Indicate how impacts of climate change could further add to perceived problems.
– In the planning and zoning processes ensure that areas that are more likely to be exposed to natural hazards, erosion, etc. are excluded from the development of mariculture parks and other fisheries related activities. The importance of this is further emphasized by the fact that vulnerable areas are likely to be impacted by climate change effects.
– Conduct research on carbon sink in mangroves, flood forests, MPAs and other areas (inland and marine) as/if applicable and explore other ways (not as carbon sinks) or areas that could function in processes to absorb or balance carbon emissions (ASCC D.10.40.v)

5) Integrate climate change into existing fisheries and habitat management programme framework (additional points to section I)

– Work with and further develop existing programmes and projects to mange fisheries and habitats, reduce fishing capacity/combat IUU fishing, strengthen local organizations, safety at sea and other priority areas, but make sure to develop indicators and reporting routines on how the implemented actions also contribute to responses to climate change.
– Manage, conserve and maintain fisheries resources and biodiversity by
    - establishing more refugia, MPAs, "Closed Season" and/or other defined "management areas" as needed for defined purpose together with plans for the management of each specific area (ASCC D.7.37.iii)
    - design and implement assessment and/or research on the status of the availability of fisheries and aquatic resources and biodiversity including species composition to be able to indicate changes and impacts by climate change
– Monitor the managed areas (e.g. MPAs and other "sites") and observe any changes including status of fisheries resources and biodiversity inside and outside of the areas.
– Strengthen the involvement of local communities, local government and NGOs in rehabilitation/conservation of mangrove forests/flooded forests and as needed, in especially inland areas the restocking and the enhancement of fisheries stocks (ASCC D.10.40. xi)

6) Minimizing the impacts from climate change to fisheries/aquaculture and the contributions from fisheries to climate change

– Develop methods to distinguish the effects of climate change on fish stocks from the effects of overfishing to be able to assess impacts of climate change on available fish stocks and to develop and apply relevant responses such as further reduction of fishing effort if needed.

- Promote the use of alternative energy, develop and introduce energy saving equipment/ engines and appropriate fishing gear and fishing boat designs that are less energy demanding in addition to efforts to reduce the number of active fishing vessels with the purpose to reduce emissions (and cut down on running costs) (ASCC D.10.40.v low carbon economy)
- Increase efforts to address and improve safety at sea for all vessels including smaller and larger ones. In the process include early warning system, working conditions, documentation of crew members, provide training of coastal communities and crew members of larger vessels (ASCC D.10.40.vi)
- Assess the vulnerability of fisheries and aquaculture to natural hazards and changes of the environment to be able to apply mitigating measures and to build up adaptive capacity where it is most needed including the strengthening of local organization.

7) Information Collection, capacity building and inter-agency coordination

- Strengthen the capability of fisheries related organizations, NGOs and private sector to better implement necessary actions towards enabling the communities and local organizations in increasing resilience and adaptive capacity to Climate Change.
- Strengthen Information and Education Campaigns on important habitats and ways to conserve, restore and maintain biodiversity together with adaptive capacity.
- Explore existing databases (ASEAN Database) or Portal with information on monsoon patterns, hydrology, oceanography, flood patterns, rain-fall, among others and avail of their existing data.
- Strengthen inter-agencies cooperation among relevant sectors in order to share experiences and information, build up and provide indication on predictability and instances of natural hazards and their impacts as well as to come up with common response and capacity building. Scale down prediction models to local level as applicable.

ANNEX I – AGENDA OF THE REGIONAL WORKSHOP

"Implications of climate change on fisheries and aquaculture: challenges for adaptation and mitigation in the Asia-Pacific Region"

Kathmandu, Nepal, 24-26 May 2011

Day 1	
09.00-09.30	**Opening Ceremony** – Welcome Address – *Mr Vijay Kumar Mallik, Director-General, Dept. of Agriculture, Nepal* – Welcome Remarks – Ms Bui Thi Lan, FAO Representative to Nepal – Introductory Remarks – *Simon Funge-Smith, Secretary, Asia-Pacific Fishery Commission* – Address – *Mr Nath Prasad Chaudhary, Secretary of Agriculture, Govt. of Nepal* – Inauguration of the workshop by lighting the lamps
09.30-10.00	**Workshop objectives and programme:** *Miao Weimin, APFIC Secretariat*
10.00-10.30	*Group photo* *Coffee*
10.30-11.15	**Keynote presentation:** "An introduction to the climate change and likely impacts on the APFIC region" *Simon Funge-Smith, APFIC Secretariat*
11.15-12.00	**Keynote presentation:** "The impact of climate change on fisheries and aquaculture production systems" *Simon Funge-Smith, APFIC Secretariat*
12.00-13.00	*Lunch break*
13.00-13.30	**Keynote presentation:** "Implications of climate change on aquaculture – vulnerabilities, adaptation and mitigation: an Asia-Pacific regional perspective' Sena De Silva, NACA
13.30-14.00	**Presentation:** "Climate change and its implications for fisheries and food security: FAO mid-term road map" *Cassandra DeYoung, FAO Fisheries Department*
14.00-14.30	*Presentation:* "Current and projected climate impacts on U.S. marine ecosystems and fisheries and the approaches to understanding and responding to them". *Michael Abbey, National Marine Fisheries Service, NOAA*
14.30-15.30	**Working group discussion:** threats of climate change to fisheries and aquaculture in the region (prioritization)
15.30-15.45	*Coffee break*
15.45-16.15	**Presentation of working group discussion outputs**
16.15-17.45	**Country presentations:** National policy, strategies and action addressing climate changes issues related to fisheries and aquaculture – 6 countries

Day 2	
08.30-10.00	**Country presentations:** National policy, strategies and action addressing climate changes issues related to fisheries and aquaculture – 6 countries
10.00-10.15	*Coffee break*
10.15-12.00	**Country presentations:** National policy, strategies and action addressing climate changes issues related to fisheries and aquaculture – 6-7 countries
12.00-13.00	*Lunch break*
13.00-15.00	**Presentations by international, regional and intergovernmental bodies/programmes:** on initiatives addressing fisheries/aquaculture related climate change issues *[Tentative list – all presentations to be confirmed]* – **Worldfish Center** "Climate Change: Implications and Adaptation Measures in the Philippines Fisheries and Aquaculture Sector" *Len Garces* – **SEAFDEC** – *Magnus Torrel* – **MRC** – *Xaypladeth Choulamany* – **SAARC** – *Riaz Hamidullah* – **BOBLME** – *BOBLME project representative [TBC]* – **RFLP** – *Angela Lentisco/Don Griffiths*
15.00-15.15	*Coffee break*
15.15-16.45	**Working group discussion II:** Opportunities for fisheries/aquaculture related climate change adaptation and mitigation. Gaps and issues in fisheries/aquaculture adaptation and mitigation to climate change in Asia-Pacific. Break into thematic groups – fisheries and aquaculture (both covering inland and marine environments)
16.45-17.45	**Presentation of working groups:** and plenary discussion

Day 3	
08.30-09.00	**Keynote presentation:** "Climate Change funding in support of implementation of climate change adaptation planning in fisheries and aquaculture " *(Includes reflections on the submitted national/regional papers)* *David Brown, FAO Fisheries Department*
09.00-09.40	**Presentation:** Linking national CC planning to resource mobilization. *The Nepal NAPA experience and linking to the access to LDCF and CC funding. Also includes a review of the LDCF project cycle as an example.* *Batu Uprety*
09.40-10.00	*Coffee break*
10.00-11.30	**Working group discussion III:** *Recommendations for national and regional actions (working groups on LDCF, LSSF GEF funds) facilitated by FAO HQ colleagues. Three breakout groups (depending on numbers)* *a. Regional: Issues, priorities, funding sources, ways forward.* *b. National: Issues, priorities, funding sources, ways forward (for non LDCF countries)* *c. National: Issues, priorities, funding sources, ways forward (for LDCF countries)*
11.30-12.00	Presentation of working group discussion III outputs
12.00-14.00	*Lunch Break (preparation of APFIC action plan/recommendations)*
14.00-16.00	**Plenary review of action plan and endorsement**
16.00-16.30	Workshop closing

ANNEX II – LIST OF PARTICIPANTS

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