Food and Agriculture Organization of the United Nations

FISHADAPT

A GLOBAL CONFERENCE ON CLIMATE CHANGE ADAPTATION FOR FISHERIES AND AQUACULTURE

8-10 AUGUST 2016

CENTARA GRAND LADPRAO, BANGKOK, THAILAND

Conference Handbook

Global Partnership for Climate, Fisheries and Aquaculture

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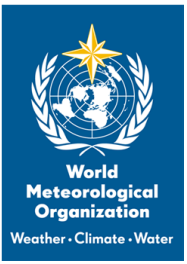

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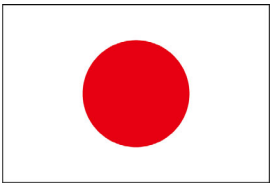

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Background

Climate change vulnerability in fisheries and aquaculture

Worldwide, over 600 million people depend, directly or indirectly, on fisheries and aquaculture for their livelihoods. Fish provides essential nutrition for over 4 billion people and at least 50 percent of animal protein and essential minerals to 400 million people in the poorest countries. Trade in fish and fisheries products is also important for societies and economies: fish products are among the most widely-traded foods, with more than 37 percent by volume of world production traded internationally. Yet, the fisheries and aquaculture sectors are facing many issues, such as over-fishing, habitat degradation and pollution, and climate change and variability have the potential to compound existing pressures on the sector, but can also provide opportunities.

Climate variability and change is already affecting aquatic systems' physical, chemical and biological processes - potentially resulting in changes in fish life cycles, habitats, species compositions, distributions or abundance, which can impact fisheries management, livelihoods, food security and sustainable development. Sea level rise and extreme climate events can also have direct impacts on fishing operations and safety-at-sea as well as on the physical infrastructure of coastal communities and communities along rivers and lakes; destroying or severely damaging assets such as boats, landing sites, post-harvesting facilities and roads. Displacement of populations due to high-dam construction is also an issue. There may also be positive opportunities in fisheries associated with locally improved ecosystem and productivity conditions and in aquaculture with sea level rise and expansion opportunities in salinised coastal margins, or with better temperature conditions for local stocks.

Fisheries- and aquaculture-dependent economies, coastal communities and fishers and fishfarmers are expected to experience direct effects of climate change in a variety of ways, such as increased risks of human diseases (malaria, cholera, etc) relating to increased temperatures and displacement and migration of human populations from low-lying areas to less risky areas or to follow changes in fish distributions. One must note that many fishing (both inland and marine) and coastal communities already subsist in precarious and vulnerable conditions because of poverty and rural underdevelopment, with their well-being often undermined by overexploitation of fishery resources, degraded ecosystems and water scarcity. Fisheries and aquaculture-dependent

communities often lack ability to anticipate and adapt to climate change and variability and hence they tend to be among the most vulnerable. Climate variability and change can exacerbate food insecurity in areas currently vulnerable to hunger and malnutrition.

Climate change adaptation in fisheries and aquaculture

Much can be done at the household, community and sector levels to support the resilience of the sector in a changing climate. For example, fisheries and aquaculture-dependent communities can receive targeted and improved weather and extreme event information, as well as safety of fishing vessels and fishers while at out fishing. The sector can also be supported to improve its monitoring and analysis of local changes and to have access to global information. Other adaptation options include social protection and livelihood diversification as well as support to exit from the sector when needed. Fishing and fish-farming methods and zones can be adapted to the change that is likely to occur and post-harvest processes can be improved to adjust to changing species and to minimize losses due to temperature-related spoilage and disease risks. The adaptive capacity of the aquatic ecosystems can also be improved, such as through implementing the ecosystem approach to fisheries and aquaculture, using natural defences to erosion and storms and minimizing negative impacts of harmful fishing and farming activities to support the general resilience of the ecosystems supporting the sector.

Fisheries and aquaculture systems and communities can also be provided with important enabling environments, such as through secure tenure and access rights to the natural resources upon which they depend. Policy makers and managers can implement adaptive fisheries co-management plans, legislate vulnerability assessments within the sector and ensure that management, development and trade strategies and policies are climate and disaster-proofed. It is also essential to ensure that the needs of the sector are included in broader national and regional climate change discussions and that adaptation and mitigation measures in one sector do not negatively affect food security and livelihoods in other sectors, such as fisheries, through reduced water flows or hard irrigation infrastructure impacting aquatic habitats.

FishAdapt will provide the opportunity to share practical experiences in understanding vulnerabilities and in identifying, prioritizing and implementing adaption and disaster risk management actions. The focus will be on applied vulnerability assessments and on case studies focusing on real-life community

impacts. The conference will be the occasion to showcase adaptation planning and implementation activities that work toward building the resilience of livelihoods, governance frameworks, climate and disaster-proofing development strategies, providing technical and process-based actions, as well as reducing the vulnerability context within regions, countries, sectors and dependent communities and throughout the value chains.

Goal

Through a series of panels and presentations, collaborative problem solving, interactive workshop events, discussion spaces, participants will exchange experiences and create ideas and best practices on which to act to assist the sector in furthering its efforts to reduce vulnerability and improve resilience to climate variability and change. The conference will:

- Provide countries, fisheries and aquaculture institutions and networks, civil society, private sector, development partners, and academic institutions the opportunity to present their work in fisheries and aquaculture climate change adaptation and disaster risk management.

- Foster the exchange of information and experiences from case studies and projects which aim to show how climate change adaptation in fisheries and aquaculture and disaster risk management may be implemented in different regional and ecosystem settings among fishers, farmers, value chains and dependent communities.

- Disseminate the wealth of experiences shared through conference proceedings, which will include selected conferences papers.

- Inputs from the Conference will support the development of policy briefs to inform policy makers on best practices on climate change adaptation and risk management.

- Increase awareness of United Nations Framework Convention on Climate Change (UNFCCC) processes and inform on how efforts may be communicated to the UNFCCC through, for example, the Nairobi Work Plan, the UNFCCC Least Developed Countries Expert Group and the UNFCCC Adaptation Committee activities.

Scientific Committee

- Vera Agostini - The Nature Conservancy.
- Tarub Bahri – FAO.
- David Brown – FAO.
- Tony Charles - Saint Mary's University.
- Victoria Chomo – FAO.
- Beau Damen – FAO.
- Cassandra De Young – FAO.
- Nicole Franz – FAO.
- Maria Gasalla - University of Sao Paulo, Brazil.
- Roger Griffis - NOAA Fisheries Service.
- Johanna Johnson C2o Consulting/James Cook University.
- Daniela Coswig Kalikoski – FAO.
- Gerd Marmulla – FAO.
- Marc Metian - IAEA-Environment Laboratories.
- Gretta Pecl - Institute for Marine and Antarctic Studies.
- Florence Poulain – FAO.
- Susana Siar – FAO.
- Doris Soto – FAO.
- Robert Stefanski-WMO.
- Cherdsak Virapat - Network of Aquaculture Centres in Asia-Pacific.
- Meryl Williams (Co-Chair, Organizing Committee, 6th Global Symposium on Gender in Aquaculture and Fisheries).

Collaborating partners

- Agricultural Meteorology Programme at the World Meteorological Organization.
- Bedford Institute of Oceanography, Fisheries and Oceans Canada.
- Central America Fisheries and Aquaculture Organization.
- Convention on Biological Diversity.
- European Bureau for Conservation and Development.
- Fisheries & Aquaculture Centre, University of Tasmania.
- Global Partnership for Climate, Fisheries and Aquaculture.
- International Atomic Energy Agency Environmental Laboratories.
- International Fund for Agricultural Development.
- Network of Aquaculture Centres in Asia-Pacific.
- NOAA Fisheries.
- Plymouth Marine Laboratory.
- RARE.
- Rhodes University and the GULLS project.
- Saint Mary's University.
- Secretary of Pacific Community.
- The Nature Conservancy.
- University of São Paulo, Brasil.
- University of Seattle, Washington.
- United Nations Development Programme.
- UN Food and Agriculture Organization.

Invited speakers

Paul V. Desanker

Manager, United Nations Framework Convention on Climate Change (UNFCCC)

Paul Desanker is a manager in the Adaptation Programme of the secretariat of the United Nations Framework Convention on Climate Change (UNFCCC), and is responsible for the subprogramme on National Adaptation Plans and Policy (NAPP). He has extensive experience working on issues related to adaptation to climate change, and served as Coordinating Lead Author of the Third Assessment Report of the IPCC. His professional experience within the United Nations also includes work on capacity-building and outreach, and currently supports work on National Adaptation Programmes of Action (NAPAs) and National Adaptation Plans (NAPs), and serves at secretary to the Least Developed Countries Expert Group (LEG). Prior to his current position, he served as a member and Chair of the LDC Expert Group, and was an Associate Professor of Geography at Penn State University in the USA. He holds a Masters in Mathematics and a PhD in Forest Biometrics from Michigan Technological University, USA.

Scaling up adaptation action from the local to the national, regional and global level through the National Adaptation Plans

Paul V Desanker

From the old adage that adaptation is local, we show how adaptation in fact should be planned and implemented at multiple scales and levels, with a deliberate process of sequencing actions over time based on specific trigger points. The actions include policies, adjustments and processes designed to respond to the changing climate. Under the UNFCCC, a process to formulate and implement National Adaptation Plans (NAPs) was created a few years ago, as a way to address adaptation needs in the medium- to long-term, focusing on the national level by building upon local and sectoral actions, while integrating into regional and global efforts. The Paris Agreement further consolidates action on adaptation through a well-specified global goal of adaptation, linked to a less than two degree Celsius global temperature limit, linked to sustainable development goals, and strengthened links to funding and national reporting. This talk will discuss the latest technical guidance on NAPs.

Bill Dewey

Since receiving his degree in shellfish biology from the University of Washington in 1981 Bill Dewey has worked as a shellfish farmer in Washington State. He is Director of Public Affairs for Taylor Shellfish Farms, the largest producer of farmed shellfish in the United States and owns and operates his own clam farm in Samish Bay.

He serves on a number of boards and committees locally and nationally including the Board of Directors of the National Aquaculture Association and the Pacific Shellfish Institute. He served on Washington State's Ocean Acidification Blue Ribbon Panel in 2011 and currently serves on the Washington Marine Resources Advisory Council (MRAC). MRAC advises Washington's current Governor Jay Inslee and the Legislature on the state's response to ocean acidification. Internationally he participates on the Ocean Acidification International Reference User Group.

In 2006 the National Shellfisheries Association honored Bill with the David H. Wallace award in recognition of his service in promoting research, understanding and cooperation among shellfisheries scientists, culturists, managers, producers and regulators.

In 2008 NOAA presented Bill with their Environmental Hero award in recognition of his work to help develop and implement public policy that protects water quality, marine resources and supports sustainable aquaculture.

In 2014 the National Aquaculture Association presented Bill with the Joseph P. McCraren Award for Outstanding Contributions to the Aquaculture Industry.

Impacts of ocean acidification on United States West Coast shellfish aquaculture

Bill Dewy

In the Pacific Northwest of the United States seasonal upwelling of deep, CO_2-enriched ocean water combines with the influence of anthropogenic CO_2 emissions to compound changes in seawater chemistry. Two of the West Coast's major shellfish hatcheries experienced significant declines in oyster larvae production that has been linked to coastal upwelling of these high CO_2, low pH corrosive waters. In addition, in Willapa Bay, the largest oyster producing bay on the U.S. West Coast, where many growers have come to rely on natural recruitment of oyster seed, the set has failed during the same period the hatcheries were experience problems. These natural set failures may also be attributed at least in part to the upwelling of corrosive seawater. The combination of these impacts on hatchery and natural seed recruitment resulted in serious shortages of oyster seed for U.S. West Coast oyster farmers between 2007 and 2010. Incorporating sophisticated real time monitoring systems initially allowed hatcheries to successfully dodge the corrosive water events and recover some production. Subsequently, to help the shellfish industry adapt, scientists collaborated to develop automated water treatment systems that adjust seawater chemistry real-time as it is pumped into the hatcheries. These treatment systems boost the availability of carbonate ions and improve shell building capacity of the young shellfish. The industry in collaboration with University scientists is also exploring rearing oysters bred to survive the corrosive conditions and culturing shellfish in conjunction with seaweed or seagrass to improve water chemistry conditions on their farms. In addition to monitoring and adapting shellfish growers are also speaking out about their experiences hoping to serve as the proverbial canary in the coal mine. They are hopeful this very real impact will help policy makers and others who are concerned about the health of our oceans understand the implications of unchecked carbon emissions for the marine food web.

Meryl J. Williams

Meryl Williams has worked for nearly 40 years in Australian and international fisheries, aquaculture, aquatic resource conservation and agricultural research and development. Currently, she is focusing on research and advocacy on women and gender in aquaculture and fisheries, and information and science for fair and responsible fish production for food security and nutrition.

She is presently the Vice Chair of the Scientific Advisory Committee of the International Seafood Sustainability Foundation and a member of the board of Aquaculture without Frontiers (Australia). She was formerly Director General of the WorldFish Center (1994-2004), during which time she concentrated the focus of WorldFish on eradicating poverty, improving people's nutrition, and reducing pressure on the environment. She was previously the Director of the Australian Institute of Marine Science, Executive Director of the Bureau of Rural Sciences, tuna fisheries statistician at the Secretariat for the Pacific Community and fisheries biologist in the Queensland state government service.

She was elected a Fellow of the Academy of Science, Technology and Engineering (ATSE) in 1993, and awarded an Australian Centenary Medal in 2003, made an Honorary Life Member of the Asian Fisheries Society in 2004, named an 'Outstanding Alumnus' of James Cook University, Australia in 2010, and, in 2015, awarded the Crawford Medal.

The gender dimension in climate change adaptation: Gleanings from 20 years of gender in aquaculture and fisheries symposia

Meryl J Williams

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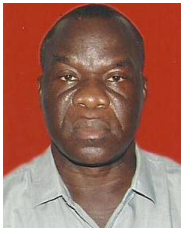
In fisheries and aquaculture, fishers, farmers, policy and decision makers are paying more attention to climate change adaptation measures, often as a direct result of experiencing the impacts of droughts, storms and sea level and temperature changes. In addressing climate change, experts first focused their efforts on predicting the changes, and they have only more recently turned to exploring economic and social consequences. Despite a growing number of vulnerability and risk assessments, the gender dimension has not yet found a niche in climate adaptation studies. To help create this niche, I will analyse results from relevant women/gender studies presented over the last two decades at the 8 global gender symposia of the Asian Fisheries Society (AFS) plus earlier national and regional Asian events with which AFS was associated. The relevant gender studies, mainly from Asia and the Pacific, include those focusing on climate change, as well as others that dealt with gender-specific impacts in the aftermath of natural and human disasters and conflicts, such as typhoons, tsunamis, floods, oil spills and civil war. These studies do not represent a large body of work but insights from them do create a solid platform on which to build future work.

The analysis will be based on empirical approaches rather than standard "gender" narratives that emphasise women's poverty, lack of agency, greater dependence on natural resources, and greater caring disposition. Based on the diverse situations encountered in the gender studies, the present analysis concludes that climate adaptation action should be based on sound diagnoses and understanding of the complex, multiple relations between women and men in fish supply chains and economies, rather than on formulaic assistance measures. It also draws on recent approaches to agricultural resilience in the face of climate change, and the debate on the disaster relief, rehabilitation and development "continuum," concerned with finding coherent solutions for long-enduring crises, acute events and chronic underdevelopment.

Solomon I. Ovie



Solomon Ovie is currently the Director of Research Operations of the National Institute for Freshwater Fisheries Research, New Bussa, Nigeria, and has worked there as a fisheries research scientists from 1980 to date. He obtained his bachelor's degree in biological sciences from the University of Ilorin, Nigeria; a masters degree in Aquatic Ecology from Rutgers University, New Brunswick, USA and a doctoral degree in Fisheries/Hydrobiology from the University of Benin, Nigeria.

His doctoral dissertation on the Ecology and Culture of Jebba lake zooplankton has continued to underpin and popularize the use of live indigenous zooplankton for fish larval rearing. In consideration of this modest breakthrough, the Fisheries Society of Nigeria (FISON), honoured him with the 2002 Professional Merit Award for "Immense Contribution to Aquaculture Development in Nigeria".

Dr. Ovie has been engaged in a wide range of research in the areas of Limnology, Aquaculture, Fisheries/Natural Resources Management and Fisheries and Livelihoods. He has consulted for the FAO on Climate Change implications for the fishing communities of the Lake Chad Basin; for DFID/FAO under its Sustainable Fisheries Livelihood Programme (SFLP); and has vigorously pursued the introduction and adoption of the Sustainable Livelihood Approach (SLA), the Code of Conduct for Responsible Fisheries (CCRF), Gender mainstreaming and Participatory Rapid Appraisal (PRA) into the curricula of Federal Colleges of Fisheries Technologies and other Fisheries Research Institutions.

Impacts of and adaptations to climate change in the fisheries communities of the Lake Chad Basin, Africa

Solomon I. Ovie[1] and Belal Emma[2]

[1]*National Institute for Freshwater Fisheries Research, P. M. B. 6006, Niger State, Nigeria. Email:* soloovie@yahoo.com

[2]*Ministry of Livestock, Fisheries and Animal Industries, (MINEPIA), P. O. Box 721, Douala, Cameroon*

The Lake Chad and its basin is located in the Central Region of Africa and is shared by eight countries (Algeria, Central Africa Republic (CAR), Libya, Sudan, Cameroon, Chad, Niger and Nigeria). However, due to massive lake shrinkage over the years, only the last four countries are in direct contact with the lake. From an early 1960 area of about 25,000km2, the lake has reduced to approximately to 2,000km2 – a reduction of over 90%. Over the years, hydrological and biophysical changes, attributed to climate change factors and anthropogenic stream-flow modifications have been implicated for this for this massive reduction. The fisheries and other natural resources of the region were huge, and had significantly underpinned livelihoods in the region in terms of food/nutrition security, income generation and employment. The massive reduction in hydrology has depleted the natural resources and threatens community survival and resilience. Over the years, communities have had to adopt and adapt different livelihoods coping strategies in response to prevailing annual and inter-annual environmental changes. This report focuses significantly, on evaluating the hydrological cycle of the basin and the impact on the environment, the natural resources and the fisheries communities. The report fishes with a set of coping (adaptation) strategies for overcoming household/regional vulnerabilities that would lead to resilience-building in the face of continued drastic water shortage in the area.

Maria A. Gasalla

Maria A. Gasalla is Professor of the University of São Paulo, in Brazil, currently appointed at the Institute of Advanced Studies (IEA). She has been leading the Fisheries Ecosystems Laboratory at the Oceanographic Institute since 2005, where interdisciplinary research and capacity building in contemporary fisheries science have been a focus. Her research projects include strategic analysis exploring indicators of sustainability, vulnerability and innovation in fisheries systems, as well as grassroots interaction. Mary has a PhD in Oceanography, MSc in Biological Oceanography, and a BSc in Biology, and became a fisheries scientist after a 10-year position at a public research body in Brazil and scientific opportunities at international institutions where she studied quantitative modelling but also social sciences and economics. Since then, she has been involved in scientific and local basis for ocean resource management, fisheries economics, marine biodiversity assessments, climate change impacts, and fishing communities' issues, and as a member of several international steering committees. She is interested in the vulnerability and adaptation to climate change of people dependent on marine resources in addition to their biophysical drivers.

Effects of climate change on the world's oceans: footprints to adaptation in fisheries food production and security

Maria Gasalla

The effects of climate change on the world's oceans were discussed in an international symposium convened in Santos, Brazil, by the International Council for the Exploration of the Sea, the North Pacific Marine Science Organization, and the Intergovernmental Oceanographic Commission of UNESCO in March 2015, having the Oceanographic Institute, University of Sao Paulo as the local organizer. As the third of a series that started in Gijon, Spain, with the aim to capture latest evidences on ocean change as a preparation to the Intergovernmental Panel on Climate Change followed by a second in Yeosu, Korea, the symposium in Brazil showed new scientific developments and challenges, some of which have implications to the fisheries and aquaculture sector. This talk will overview scientific contributions that inform footprints to the fisheries food production and security, highlighting knowledge gaps and societal and political challenges relevant to develop adaptation at the local community scale.

Vera Agostini

Vera Agostini joined The Nature Conservancy in November 2007. After close to a decade tenure as Senior Scientist with TNC's Global Marine Team, she is currently the Director of Science and Conservation of TNC's Caribbean Program, where she provides strategic guidance and scientific oversight to marine conservation projects and programs across the Caribbean.

She is a fisheries scientist by training, who came to the Conservancy with 15 years of international experience in climate and fisheries, providing technical expertise across a range of multi-disciplinary efforts. Dr. Agostini has held marine science positions across three sectors: non-governmental, U.S and international government, and academic/educational. Her experience ranges from comprehensive ecosystem research to broad policy and planning. In addition to her management responsibilities, Vera's work is currently focused on integrating people and human well-being into conservation. Examples include ecosystem based climate adaptation, ecosystem approaches to fisheries, marine zoning and protected area network design.

Adapting to climate change: solutions for healthy costal ecosystems and communities

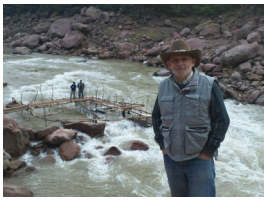
Vera Agostini

Director of Science and Conservation – Caribbean Program, The Nature Conservancy.
Email: vagostini@tnc.org

Robust and resilient ecosystems offer some of the best protection from climate change impacts. Actions to help reduce the vulnerability and increase the resiliency of coastal communities in the face of climate change (ecosystem based adaptation) are increasingly considered as essential elements of effective coastal management. Ecosystem based adaptation strategies are a cost effective and accessible means of adaptation often more accessible to the rural poor than technology or infrastructure solutions.

Recognizing the critical role that ecosystem services play in supporting some of the world's most vulnerable people, The Nature Conservancy is committed to working with partners to improve the science and practice of ecosystem based adaptation to climate change across a diversity of ecosystems and socio-economic conditions. We focus on bringing the best science and latest knowledge to planners, managers, governments and communities so that they can make informed decisions about managing current and future climate change impacts across a variety of ecosystems. In this presentation I will outline approaches used to examine fisheries vulnerability as linked social-ecological systems. I will also discuss how novel partnerships are helping us understand the vulnerability of the fisheries sector and have fishers meaningfully participate to the design of adaptation actions. I will illustrate, with examples from the Caribbean region, how ecosystem based adaptation can be used alongside other adaptation responses to reduce the vulnerability and risk to the fisheries sector from climate change.

Claudio Baigún



Claudio Baigún is a fisheries biologist who earned a fisheries master's degree at Oregon State University (USA) and a PhD at the University of Buenos Aires (Argentina). Currently he holds the position of Program Coordinator of Fish and Fisheries Program at Wetlands International (Latin America and the Caribbean Office) and is leading the Laboratory of Applied Fisheries Ecology at the Institute of Research and Environmental Engineering (San Martin University, Argentina). His main research focus has been related to Neotropical fish ecology and management and evaluation of large rivers fisheries. He also put efforts in educating fishers, managers and other stakeholders about good fishing practices and the need to envisage small scale fisheries management within a participatory governance framework and under an ecosystem-based approach. Claudio Baigún made around 200 presentations in congress, workshops, conferences, being also invited as keynote speaker by the American Fisheries Society, the Freshwater Fish Conservation Group (IUCN), Universities of Iowa and Oregon State University (USA), Lodz (Poland), Concepción (Chile), Central University of Venezuela, Pontificia Javeriana University (Colombia), Institut de Recherche pour le Développement (France), U.S. Army Corps of Engineers (USA), FAO, the World Fish Migration Foundation (Netherland), etc. He has published more than 60 peer review papers and participated in over 20 book chapters related to fish conservation, fisheries as ecosystem services, dam impacts, fishery management.

Key factors governing the potential for adaptation of artisanal fisheries to climate change in the La Plata River basin

Baigún, C.[1] and Castillo, T.[2]

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[2] *Instituto de Investigaciones Socio-históricas Regionales (ISHIR-CONICET), Bv. 27 de febrero 210 Bis (Ocampo y Esmeralda), S2000EZP, Rosario (Santa Fe), Argentina.*

South America (SA) river fisheries provide food security, employment and mobilize local and regional economies based on considering fish production as a valuable ecosystem service. However, and despite their socio-economic importance at local and regional scales, riverine communities have been ignored or poorly considered by governmental agendas in terms of policies development and adaption to climate change (CC). Taking the La Plata River basin, the second largest one in South America and the fifth in the world as a study case, the aim of this presentation is to identify main constraints and conflicts related to the potential for adaptation of artisanal fisheries to CC under incoming scenarios. Predicted climate changes for the basin suggest strong temperature increase that would promote positive effects on target fish populations improving also the fish yield in the long term. However, a negative water balance due to land use and dams installation in the upper basin could exert severe impacts on migratory species and deterioration of critical habitats. Based on the assessment of different small-scale fisheries artisanal fisheries have developed suitable mechanisms to cope with climatic variability but main barriers for climate change adaptation and resilience maintenance will be limited by weak livelihood capitals, poor governance mechanisms, trans-boundary resources, inappropriate management approaches, and loss of rivers ecological integrity. To improve the process of adaptation of artisanal fisheries and reduce their vulnerability in this and other SA basins is critical that governments improve socio-economic conditions for fishing communities, governance processes and orientate fisheries management toward an ecosystem-based approach.

Doris Soto

Chilean National with a Ph.D. in Aquatic Ecology from the University of California, USA, in 1988. Former Senior Aquaculture Officer, Food and Agriculture Organization of the United Nations (Rome HQ). From 2005 to March 2016 she has been in FAO leading the implementation of an Ecosystem Approach to Aquaculture (EAA) and following countries reporting of compliance with the aquaculture elements of the Code of Conduct for Responsible Fisheries (CCRF). She has more than 25 years' experience in sustainable aquaculture, addressing various aspects of production and sustainability including integrated multitrophic aquaculture, environmental impact assessment and improving aquaculture-fisheries interactions. During the past decade Doris also lead the aquaculture and climate change initiatives in the Fisheries and Aquaculture Department of FAO addressing climate change impacts on aquaculture, adaptation options and GHG and mitigation in the sector being actively involved in climate change adaptation field work in different regions and countries. She has also conducted extensive normative work on various aspects of aquaculture sustainable development, has published numerous scientific papers and leaded different types of projects to advance sustainable aquaculture for food security and equitable development.

Adaptation strategies of the aquaculture sector to the impacts of climate change

Doris Soto[1] and Pedro B. Bueno

[1]Senior Aquaculture Officer (Retired) FAO Rome. Email: dorissto7@gmail.com

From 2014, farmed species have become the main source of fish for human consumption. By 2021 aquaculture is set to surpass total capture fisheries (including non-food uses). This share is projected to reach 57 percent in 2025 (OECD/FAO 2016). The need for adaptation and associated challenges is expected to increase with climate change. The Intergovernmental Panel on Climate Chance in its Fifth Assessment Report (IPCC AR5) has stated this with a very high level of confidence. The Report also avers to the complexity of adaptation in describing constraining factors and laying down overlapping approaches for managing the risks of climate change through adaptation. In reviewing

the options for aquaculture we emphasize three main adaptation pathways, namely, structural/physical, social and institutional. The conceptual frameworks for our analysis of the appropriateness and effectiveness of tried and proposed adaptation options are imbedded in the ecosystem approach to aquaculture (EAA) and the sustainable livelihoods approach (SLA). The premise is that adaptive capacity of an aquaculture farm, a farming household, a farming community, an industry or the sector depends on the state and availability of the five livelihood capitals and the entity's ability to utilize them to reduce risks to its economic viability and sustainability. We argue that its ability to do so, and its linkages with other users of the livelihood capitals, enables aquaculture to itself be an adaptation option for other economic sectors. Based on literature research and field experience we identify key structural, social and institutional actions including research areas that would improve adaptive capacity of the sector to climate change impacts and strengthen policy on adaptation.

Johanna Johnson

Johanna Johnson has over 20 years' experience working in applied ecosystem science, particularly on climate change implications for tropical marine ecosystems and communities. Johanna has worked as a researcher and natural resource manager, having lead studies on marine protected area management, climate change vulnerability assessments for fisheries, aquaculture and dependent communities, and community-based adaptation to climate change. She has worked in the Great Barrier Reef, Torres Strait Islands, Pacific Island region, Caribbean and southeast Asia. She has spent over a decade assessing climate vulnerabilities and developing tools to operationalize the concept into practical adaptations. Johanna has worked in the Pacific region since 2008, and has current projects supporting climate change adaptation in Vanuatu, PNG, Solomon Islands, Fiji, and French Polynesia. She has expertise in using diverse sources of information to inform practical climate change adaptation, and working with local communities to develop and implement on-ground local actions.

Climate change vulnerability and adaptation of Pacific fisheries and aquaculture

Johanna E. Johnson[1,2] and Johann D. Bell[3]

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[3]Australian National Centre for Ocean Resources and Security, University of Wollongong, NSW 2522, Australia.

Fisheries and aquaculture are of great importance to the people of the tropical Pacific. Nowhere else do so many countries and territories depend so heavily on fish and shellfish for economic development, government revenue, food security and livelihoods. Maintaining these benefits in the face of rapid population growth is a major challenge for Pacific governments and communities. Climate change is an additional driver that is affecting the region's plans to maximize sustainable economic and social benefits from fisheries and aquaculture. An assessment of the projected effects of global warming and ocean acidification on surface climate, the Pacific Ocean, fish habitats and stocks, and aquaculture production covered the vast domain of the Pacific Island region. The results are mixed – there are 'winners' and 'losers'. Tuna catches are expected to be higher around islands in the eastern tropical Pacific Ocean later in the century, but lower in the west. Harvests from coastal fisheries and aquaculture are projected to decrease across the region. Yields from freshwater fisheries and pond aquaculture are likely to be enhanced, while some mariculture products will decline. The adaptations, policies and investments recommended to reduce the threats of climate change to fisheries and aquaculture, and capitalize on the opportunities, are of interest to a broad range of stakeholders in the region, and are being implemented at national and regional scales.

Patrick McConney

Patrick McConney is a Senior Lecturer in the Centre for Resource Management and Environmental Studies (CERMES) at the University of the West Indies Cave Hill Campus in Barbados. His applied research includes resilience, socio-economics and governance related to small-scale fisheries and marine protected areas in the Caribbean.

Considering climate and disasters in Caribbean fisheries and aquaculture management planning

Patrick McConney

University of the West Indies

Fisheries and aquaculture in the seventeen states and territories of the Caribbean Regional Fisheries Mechanism (CRFM) are extremely vulnerable to the impacts of climate change and variability, and to associated hazards that typically result in disasters. Hydro-meteorological and geological hazards are compounded by technological hazards. To many stakeholders in the region climate change adaptation (CCA) can only be practical if it integrates disaster risk management. In recent years, CRFM fisheries authorities and fisherfolk have considered ecosystem approaches to fisheries and aquaculture management planning at multiple levels of governance. Fisherfolk have been encouraged to develop the capacity to network, self-organise and participate in governance. This presentation outlines some of these state and non-state initiatives, and reflects upon how adaptation to climate change and variability can be further enhanced in the Caribbean.

Geral Miles

Gerald Miles is the Vice President of Global Development for Rare – a non-profit that is applying 25 years of experience in behaviour change to help governments reduce overexploitation of near shore fisheries. He works with local partners, governments and global institutions on the policy and incentives required to support the restoration and sustainable management of small-scale fisheries that provide protein, livelihoods, protect valuable habitat and improve resilience to climate change. From his previous roles as Head of Environmental Management and Planning (SPREP) and Regional Director for External Affairs and Policy (TNC) he brings over 20 years of experience in conservation and resource management. He worked with Pacific Island Governments to build climate change adaptation programs in the Pacific in the '90s and between 2005-2013, he worked on a range of policy and financing initiatives for Ecosystem Based Adaptation. With Heads of Government he promoted sustainable development of marine resources through the Micronesia Challenge, the Coral Triangle Initiative and the establishment of the Global Islands Partnership. As a visiting lecturer at the University of Queensland he has been teaching conservation policy and continues to be actively involved in the negotiation of the United Nations Conventions on Climate Change and Biological Diversity.

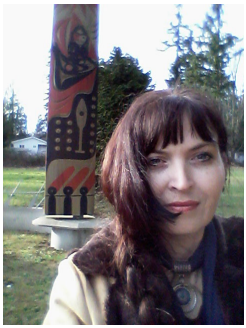
Does climate change need behavior change? A behavioral approach to communication and building community resilience

Gerald Miles

Communicating the impacts and necessary responses to climate change is a fundamental building block to changing behavior and reducing vulnerability. Social resilience increases a community's ability to organize and respond to climate-related threats. Rare has built communication strategies and trained local leaders in more than 50 countries to design and execute sophisticated behavior change campaigns that inspire communities to change the way they interact with nature. These "Pride" campaigns leave behind a legacy of increased technical capacity, a sense of ownership and responsibility for natural resource management, and a community empowered with stronger institutions and social capital to manage a volatile and changing environment. Such increases in social cohesion have significant potential to help local communities adapt to climate change.

Drawing from examples of Rare's current work with small-scale fishing and farming communities in Latin America, Asia and Africa, this presentation will explore emerging efforts to apply the best insights from the behavioral sciences to collective action problems like natural resource management and climate adaptation. Specifically, it will consider how behavioral approaches like Rare's can build social resilience, help communities adapt to climate change, and connect the dots between community engagement and national policy. Rare will highlight how two Pride campaigns - in the coastal town of Pilar, Cebu (during and after 2013's Typhoon Haiyan) and in the San Vicente de Chucuri municipality of Colombia (before and after a landslide that destroyed more than 70% of the cocoa-producing properties upstream) transformed the local communities as willing stewards of their marine and freshwater resources and helped them to adapt to a changing climate's threatening impacts. Such adaptation and resilience building, done in collaboration with local democratic governance has generated demonstrable evidence of changes at the subnational and national levels.

Julia Sanders



Julia Sanders is Deputy Director of the National Fisheries Conservation Center and its Global Ocean Health program, and has worked with the seafood industry for 15 years. She is editor and main author of GOH's Ocean

Acidification Report, a quarterly email publication of unique ocean acidification content which reaches over 7,500 subscribers across the globe. Her work on the Report and in other publications keeps her in close contact with ocean acidification researchers, other NGOs in the field, and affected stakeholders — following and reporting on their struggles and breakthroughs. She has worked directly with stakeholders in many coastal communities, conducting outreach on ocean acidification and the threats and opportunities associated with sea level rise, including the potential for habitat restoration projects. She speaks often on the threat of ocean acidification, and has delivered dozens of presentations on the topic to a wide variety of audiences.

Communicating ocean acidification where it impacts the most, and where communication is hardest

Julia Sanders

National Fisheries Conservation Center. Email Julia@globaloceanhealth.org

The Pacific Northwest of the US is the frontline for ocean acidification (OA). When mass oyster larvae mortality first started occurring in 2008-2009, the problem was very nearly passed over as just another incidence of disease or virus. Fortunately, industry and the NGO community raised funds to bring in scientists to pinpoint the problem: ocean acidification. Carbon dioxide from the atmosphere is combining with the ocean, and upwelling of carbon-rich deep ocean water on the US West Coast exacerbated conditions, reaching a tipping point that killed oyster seed in their crucial first 72 hours of life. Oyster farms that had been in operation for 5 generations or more were in danger of closing their doors forever. Only through significant innovation and the industry pulling together with scientists and other stakeholders was the crisis put on hold, for

now. We believe this story is repeating itself across the world, but in places where they don't recognize symptoms and can't afford the resources to identify it.

Since 2007, we've learned crucial lessons about communicating such a complex topic to stakeholders, politicians, funders, and developing world audiences. You can't describe the chemistry: you have to tell a story people relate to. As author of the Ocean Acidification Report, the most widely read publication on OA (7,500 subscribers), I have extensive experience communicating OA, as well as the stories of those who have shared OA with developing world countries across the globe.

Abstracts

Applied risk / vulnerability assessments in fisheries and aquaculture

The impact of methodological choices on the outcome of national-level climate change vulnerability assessments: an example from the global fisheries sector

Iris Monnereau[1], Robin Mahon[1], Patrick McConney[1], Leonard Nurse[1], Rachel Turner[2] and Henri Vallès[1]

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Climate change vulnerability assessments have been receiving increasing attention from policy-makers and academics. Given the scarce funds for adaptation, the United Nations Framework Convention on Climate Change Secretariat has suggested that eligible countries be prioritized for support based on their vulnerability to climate change. National-level fisheries sector climate change vulnerability assessments as well as other overall vulnerability assessments to date have indicated that least developed countries (LDCs) are most vulnerable in comparison with small island developing states (SIDS) and other coastal countries. We demonstrate that this is partly due to the methodological choices made, as we systematically show how simple methodological choices in the implementation of these types of assessments can substantially change the perceptions of which country groups (SIDS, LDCs and other coastal countries) are most vulnerable. We argue that national-level vulnerability assessments, and particularly those dealing with the fisheries sector, often suffer from four main methodological shortcomings: (i) an inconsistent representation of countries belonging to each group; (ii) use of socio-economic indicators that are not scaled based on population size; (iii) use of a small number of indicators; and (iv) lack of accounting for potential redundancy among indicators. Our results show that methodological choices make a significant impact on the vulnerability ranking of country groups, and, while previous vulnerability analysis showed the fisheries in SIDS to be least vulnerable, our results suggest they are in fact most vulnerable. Though our study focuses on assessing the vulnerability of the fisheries sector to climate change, the implications also apply to other sectors and country groupings.

Potential vulnerability of artisanal fisheries to ocean acidification in the Western Indian Ocean

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Artisanal fisheries of the Western Indian Ocean are the mainstay of coastal peoples' livelihoods, providing a vital source of protein and income. To our knowledge, there has been no research on the impacts of ocean acidification (OA) on the people and the fisheries on which they depend. Fisheries data were sourced from published literature and publically accessible databases from countries of the Western Indian Ocean. Data were categorized into eight categories of fish taxa, ranked in decreasing OA vulnerability: shelled molluscs, coral reef associated finfish, shallow non-coral reef finfish, crustaceans, sharks and rays, pelagic fishes, unshelled molluscs, and sea cucumber. Increasing and decreasing trends in the landings over years of the OA vulnerability categories were apparent in Kenya's fisheries. Coral reef associated finfish, shallow non-coral reef finfish, pelagic fishes, and shelled and unshelled molluscs showed a general upward trend. A noticeable downward trend was observed for sharks and rays, while sea cucumber catches appeared to peak around 2005–2007 and later declined. Pelagic fishes, ranked low in vulnerability to OA, showed substantial contribution compared with other vulnerability categories, from 1996 to 2002 at 45.6 percent to 48.9 percent, respectively. Moreover, decadal increases in catches, particularly pelagic fishes, were also evident from 1950 to 1990. Consequently, the management of pelagic fisheries at both the national and regional levels is crucial in mitigating the impacts of OA on coastal people and as a trade-off with the most vulnerable OA categories.

Mapping climate change vulnerability in the fisheries sector of Bangladesh using a composite index approach and GIS

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Research on district-level vulnerability of fisheries to climate change is essential for allocating resources and developing policy, on which no study is available in Bangladesh. This study develops the indicators and measures the degree of vulnerability of fisheries to climate variability and change in 64 districts of Bangladesh using a composite vulnerability index approach and Geographic Information System (GIS). A total of 21 climatic, environmental and socio-economic indicators are identified to reflect the three components of vulnerability: exposure, sensitivity and adaptive capacity. The results of the study show that the highly vulnerable districts (higher to lower order) in the fisheries sector are Shariatpur, Lakshmipur, Kurigram, Bhola, Rangamati, Lalmonirhat, Panchagarh, Sunamganj, Nilphamari, Patuakhali, Gaibandha, Thakurgaon, Chapai Nawabganj, Noakhali, Rajbari and Chandpur. This vulnerability has emerged due to very high/high exposure, moderate sensitivity and low/moderate adaptive capacity. The low vulnerable districts are Dhaka, Comilla, Mymensingh, Chittagong and Jessore. Interestingly, the vulnerability of fisheries to climate change varies spatially in Bangladesh: North-Bengal, coastal districts and districts adjacent to the river are highly vulnerable, while most divisional districts are low vulnerable because of their low sensitivity and high/very high capacity to adapt. The findings of this study will allow the policy-makers and practitioners to easily identify the most vulnerable districts so as to undertake actions to decrease the vulnerability and/or ensure sustainable adaptation to climate change.

Livelihood vulnerabilities of fishing households in the Volta Basin, Ghana

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The study examined the livelihoods of fishing households upstream, below and between the Akosombo and Kpong hydroelectric dams in Ghana. In these ecosystems, river flow alteration had caused reduction in floodplain agriculture, an explosion of weeds that were increasingly choking off the fishery, an increase in disease vectors, and the formation of a permanent sandbar at the estuary resulting in massive erosion. Climate variability has worsened the vulnerabilities of the households along these ecosystems. Consequently, some 800 000 inhabitants are presumed to be deprived of their income-generating activities. Therefore, the developmental issues that propelled the study sprung from the need to proactively manage current and future risks. Vulnerability indices, including the IPCC indices, were employed alongside a Tobit regression model to estimate parameters from 715 households forming the study sample. Preliminary results of the livelihood vulnerability analysis revealed that fishing households in the Volta Basin were vulnerable with respect to four specific areas: social network (0.55), livelihood strategies (0.41), natural disasters and climate variability (0.38) and water (0.32); had low adaptive capacity to withstand extreme climate events (0.34), were exposed (0.34), and were considerably living in sensitive environments (0.22). Also, the regression results revealed that the age of the household head, educational level, dependency ratio, access to credit, membership of associations, possession of fishing assets and weed removal from fishing grounds were factors that significantly influenced vulnerability. The policy implication is that practical, timely and reliable information on interventions and technologies should be made available to fishing households to minimize adverse impacts of climate change.

Are climate change impacts the cause of reduced fisheries production on the African Great Lakes? The Lake Tanganyika case study.

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Human-induced changes to climatic conditions in the Great Lakes region in Africa have allegedly caused reduced fisheries production in Africa's Great Lakes. Temperature measurements on Lake Tanganyika over a one-century period show increases over time at different rates at different depths. Changes in wind patterns would have caused variations in upwelling intensity and frequency. Further, increased human pressures around the lake have contributed to accelerated nutrient loading and pesticide and fertilizer runoff. The changes in the lake's water quality could be considered a factor influencing the output of the fisheries industry around the lake. The present paper summarizes the recent theories on climate change impacts and its potential effect on the primary and secondary production in the lake. Recent estimates of fishing effort and fish harvests seem to contradict that the reduction in harvest is attributed to the rise of water temperature in the lake's water column; the author provides ample evidence that the drop in fish catches and the disappearance of an industrial fleet are not necessarily caused by climate change, but by a sudden upsurge in activities from an ever-developing artisanal fisheries sector. Recommendations are provided to monitor a range of indicators for determining the possible cause of the decline, including climate-related parameters.

Teasing out the impacts of climate change on fisheries in the Lower Mekong Basin

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The Mekong is one of the world's largest and most important rivers based on productivity, biodiversity and livelihoods support. It, like many other large rivers, supports high population densities of economically and resource poor communities; they are dependent on the freshwater ecosystems for both their water and protein sources, making them highly vulnerable to the impacts of environmental change, of which climate change is of particular concern. Unfortunately, there is little understanding of the impacts of climate change on the livelihoods and food security of people dependent directly or indirectly on the fisheries and subsistence agriculture of these rivers. This study explores the likely impacts of climate change, and specifically the recent El Niño event, on the hydrology and ecosystem productivity and the services in the Lower Mekong Basin. Climate change scenarios suggest the high precipitation in the wet season, but more extreme dry season low flows. The study will tease out hydrological changes associated with climate change events from other development projects (hydropower and agricultural development), and show how they will potentially impact on ecosystem functioning, especially the flooding extent which is the key driver of ecosystem productivity, and food security (fishery and rice production) in the Cambodian floodplain and Viet Nam Delta. Strategies for how rural communities will likely respond to, and cope with, these impacts will be elucidated from livelihood responses of other major stressors. Attention will be paid to how water resource development projects may mitigate or exacerbate the potential impacts.

Potential effects of climate change in reservoir fisheries: A gender analysis

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The fisheries sector faces many challenges, out of which a major challenge faced today is climate change, as it imperils the structure and function of already stressed aquatic ecosystems. Because of climate change, most vulnerable groups face a number of problems; therefore, a study was conducted to assess the potential effects of climate change on the livelihood of fishers of the Bhadra Reservoir in Karnataka, India. A questionnaire was administered to 120 fishers whose livelihoods are dependent on this reservoir. Questions centred on the potential effects due to climate change on five livelihood capitals. Responses were scored on a scale of 0 to 4, with score 0 denoting no potential effect and 4 denoting very high effect. The overall score for potential effect of livelihood capitals was 2.87, suggesting that fishers perceived climate change to have a moderate effect on their livelihood capitals. The overall score for potential effect of livelihood capitals for men was 2.80 and 2.94 for women, suggesting that women perceived that climate change will have more effect on livelihood capitals. Both men and women perceived that financial capital will be affected more than other livelihood capitals, with a score of 3.16. Interestingly, women perceived that natural and human capitals will have more effect due to climate change, with a score of 2.93. This study has shown that women perceive more negative effects due to climate change, so their greater involvement in reservoir management is needed. With reference to climate change, there is a greater need to integrate gender perspectives into mitigation and adaptation initiatives.

Socio-economic impacts of *Sargassum* on the fishery sector of Barbados

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Barbados, as other Eastern Caribbean islands, has been impacted by several events of high *Sargassum* abundance, with 2015 being the most recent and most impactful. One of the major stakeholder groups affected by these "*Sargassum* influx" events are the fisherfolk and other actors within the fishery sector in Barbados. The paper examined and analysed the socio-economic impacts of *Sargassum* influxes on the fishery value chain, and the corresponding coping or adaptive mechanisms developed as a result of these impacts. The ability of fish landing data to capture trends directly related to the *Sargassum* influx events between the years 2010 and 2015 was also examined.

Adaptive responses and recommendations for improved monitoring, and policy measures, for future occurrences were set out based on qualitative data. Data were collected through semi-structured and informal interviews, and through discussions at landing sites on the east, west and south coasts of Barbados. A group interview with the Fisheries Division was conducted, as well as key informant interviews and a series of focus groups in which scenarios were considered by people with different livelihoods along the value chain. Stakeholders' adaptive capacities and resilience to environmental issues caused by the influx of *Sargassum* are reported on.

Climate change implications for Torres Strait island fisheries: Assessing vulnerability to inform adaptation

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Climate change impacts on marine fisheries are being observed in tropical regions, including northern Australia and the Pacific. In the Torres Strait, islanders have a strong association with their sea country, which holds significant cultural, social and economic importance. Future impacts of climate change on marine fisheries stocks and supporting habitats will affect Torres Strait islander communities. We assessed the relative vulnerability of 15 key fishery species in Torres Strait using a semi-quantitative framework modified from the Intergovernmental Panel on Climate Change that integrated both ecological and social indicators of exposure, sensitivity and adaptive capacity. The assessment identified species with high, medium and low vulnerability to projected climate change in 2030. The species assessed as having the highest vulnerability were: *Holothuria whitmaei* (black teatfish), *Pinctada margaritifera* (black-lipped pearl oyster), *Dugong dugon* (dugong), and *Trochus niloticus* (trochus). A further prioritisation step that considered the cultural and economic value of species identified three high priority species for future management focus: *D. dugon*, marine turtles (principally green turtles, *Chelonia mydas*) and *Panulirus ornatus* (tropical rock lobster). These results are informing fishers and managers to prepare for the effects of climate change through adaptions that minimize impacts and maximize resilience. The fact that most fisheries in the Torres Strait are sustainably harvested is expected to support successful adaptation.

Climate change impacts on the livelihood vulnerability assessment –adaptation and mitigation options in marine hotspots in Kerala, India

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Climate change, a global challenge facing mankind, necessitates governments to develop mitigation and adaptation plans. Climate change has multidimensional impacts on the environment, fishery, social, economic and development drivers. Marine hotspots are certain regions of the world that warm faster than the global average temperature. Southwest India has been recognized as one among the twenty-four hotspot regions accepted globally. The present paper assessed the vulnerability of 800 fisher households in two major fishing villages of Kerala from the southwest hotspot regions of India. Exposure (E), sensitivity (S) and adaptive capacity (AC) are the key factors that determine the vulnerability of households to the impacts of climate variability and change, which were collected using household questionnaires. Based on the availability of data, 198 indicators were used in the construction of vulnerability indices, 37 related to sensitivity, 36 to exposure, and the other 125 indicators to adaptive capacity. The overall vulnerability of the regions was assessed and the analysis revealed that the southernmost village of Kerala was more vulnerable when compared with the northern portion. The results also revealed that 54 percent of the fisher population in both villages were highly vulnerable to climate change, which is a major cause of concern. The study advocates the need for a bottom-up approach in developing location-specific plans to ensure the livelihoods of the fishers, and the sustainable development of the fisheries sector in the climate change regime with the proactive participation of the fishers.

Climate change and vulnerability of fishing communities

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Fishing communities living in developing countries are more vulnerable to climate change, mainly due to increased economic activities near the coast, which alter the natural environment and reduce the living space for fishers. Environmental issues, including climate change, are an extra burden to these communities. Evidence shows that there is a tremendous decline in available fish, migration of fish species, and declining availability of particular species of fish. Fisheries communities adapt to the changing environment in different ways; however, low literacy levels, little support from the government, the increase in competition, and lack of opportunity for technical upgrades act as barriers to adaptation. In this particular study, we discuss the vulnerability of fishery communities living in Mumbai, India; they are popularly known as Koli communities. They are the earliest inhabitants of the city; their livelihood, however, is threatened by irregular rainfall and changes in wind patterns and sea currents. Floods and rising sea levels are also continuously threatening the communities and making it difficult to live in their traditional place. This study is based on a primary survey of five fishing villages comprising 180 fishers, from large mechanized boat owners to traditional daily fishers. The study found that it is the large and rich fishers who are able to adapt efficiently in comparison with the daily and small-scale fishers. These fishers are now targeting different fish species, as they are more aware of climate change; hence, they are maximizing their catches by changing their fishing patterns. This includes intensive fishing for two to three months; however, this method is raising the issue of sustainability in fishing. The local government needs to develop strong policies and needs to provide training to local and small-scale fishers; it also needs to encourage fishers to use modern cost-cutting technologies such as fishfinders and GPS.

Climate change perception in a fishers' community from southern Brazil: Traditional ecological knowledge and meteorological time-series data

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Fishers' communities in vulnerable areas perceive climate and environmental changes. Traditional and local knowledge regarding these changes in coastal communities could increase their adaptive capacity and improve scientific understanding of complex social-ecological systems. The effects of climate change reach the socioeconomic and ecological systems and bring losses to human welfare, mainly in more vulnerable areas. As various studies have been detecting changes in rainfall and temperature regimes in South America for the last decades, strategies to cope and adapt are urgent on many levels and scales. In this context, we aim at understanding how people from an artisanal fishers' community (Costa da Lagoa) in southern Brazil perceives climatic changes and their impacts on the environment. The community is located in an estuarine-like landscape, with salty waters and an open connection to the sea. We used structured interviews with both local residents older than 40 years old (N=29) and key informants (the eldest fishers, N=10), and a participatory tool (N=9) to register community perceptions. Then, perceptions were cross-checked with the actual trends in meteorological time-series data. Our analysis shows that the community perceived increases in temperature and changes in precipitation patterns that were in agreement with the time series of meteorological data since 1980. Such accurate perception of climatic trends is indicative of both learning and memory, essential attributes of local adaptive capacity.

Abstracts

Climate change adaptation efforts in fisheries and aquaculture

Adapting to climate change in fisheries management in Micronesia

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Adaptation efforts in small island fisheries of developing states require significant collaboration across organizations and stakeholders to develop sufficient measures, policy, and community outreach and empowerment. This paper highlights this approach in Micronesia, where non-governmental organizations, government agencies, researchers, managers and others are working to improve fisheries management to address climate change across seven regional jurisdictions. Entities with the capacity or mandate for research, monitoring and/or management of fish stocks have been working with fishing communities and decision-makers to: monitor stocks through innovative techniques; develop policy to adjust fishing pressure to sustainable levels; identify and enhance resilience-valuable factors; understand value chains and improve local market systems; and apply spatial planning to define use zones and access arrangements, all to maximize resilience of coastal fisheries. Policies reflecting precautionary principles have been established to encourage rapid recovery of stocks and maintain their health through long-term management strategies. Parallel activities focus on vulnerability assessments, adaptation planning and outreach activities with stakeholders to promote greater effectiveness in adaptive measures, enhancing policies and increasing overall adaptive capacity. Organizational capacity building has also played a vital role in these efforts. Climate adaptation campaigns have been designed to communicate climate change issues and potential impacts to community members, fishers, marketers, policy-makers, planners and other stakeholders. These efforts seek to identify adaption "bright spots" and share useful information. Additional activities work to link and align local, national and regional programmes and mainstream adaptation policies related to fisheries and food security to ensure incorporation into broader development planning.

Promoting behavioral change for territorial user rights for fisheries implementation as a climate change adaptation strategy

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Since 2004, Kepulauan Seribu National Park has been managed through a zonation system. Nevertheless, fishers in the area – Kelapa, Kelapa Dua, Harapan, Pramuka and Panggang Islands – are still found to be incompliant to the regulations of the zone. The participatory rural appraisal by Hidayat (2014) reported evidence of fishers fishing farther away and the decreases in the amount and size of catches. This phenomena is worsened by the impacts of climate change, in which fishers reported unpredictable fishing season changes, challenges in predicting wind changes and storm events, and evidence of the higher sea level.

Since 2014, the national park and Rare are working together to establish a managed access area for fishing. This initiative focuses on organizing and strengthening the fishers' collective capacity to be strategic partners of the national park, responsible for managing an 852-hectare area that allows for local harvesting including supporting its conservation function. The intervention aimed at shifting the fishers' focus from an individual motive in resource use to collective action and engagement, including decision-making for sustainable resource management. The intervention applied social marketing and a group dynamics approach, along with capacity building in conservation and fisheries management.

The objectives of this presentation are to describe the interventions conducted to date – social marketing and appreciative inquiry techniques – in working with the fishers' champion group (consisting of fishers from three islands, and focusing on two high-value fish), which serves as a working group to enable reaching out to the wider community in the area. This fishers' group identified a fisheries management option as a way to adapt to the climate change impact. The intervention approach resulted in high engagement, ownership, and selfled communities that are managing their coastal and marine resources as a way to adapt to the impact of climate change.

Building a fishing community's resilience to climate change through a social marketing drive

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Communicating the impacts and necessary responses to climate change is a fundamental building block to changing behaviour and reducing vulnerability. Building communication strategies and training local leaders to design and execute sophisticated behaviour change campaigns can build social resilience and increase a community's ability to organize and respond to climate-related threats. Fishing communities are among the most vulnerable sectors in the Philippines in times of disasters. In the aftermath of Typhoon Haiyan in 2013, the United Nations estimated 30 000 boats and equipment were lost, thereby severely affecting fishers who were dependent on nearshore fisheries.

In the coastal town of Pilar in Cebu, a communication and social-marketing campaign highlighted the vulnerability of its coastal life to typhoons and the importance of community participation in reducing the impact of similar disasters in the future. The campaign included how a super typhoon's impact on marine ecosystems could adversely affect livelihoods, but also showed how they used adversity and vulnerability to trigger behaviour changes towards adopting sustainable fisheries management practices as an adaptation measure. Community support was mobilized through engaged "compliant" fishers whom they called "star fishers" and leveraged their model practices to spark a shift in community behaviours among "non-compliant" fishers towards collectively protecting their marine/fisheries sanctuary.

Cataylo will present steps undertaken during and after the storm and her various campaign activities, which effectively transformed the local community as stewards of its coastal and marine resources, willingly taking part in their conservation as a way to adapt to the threatening impact of climate change.

Conservation organizations need to consider adaptive capacity: Why local input matters

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Conservation organizations are increasingly applying adaptive capacity assessments in response to escalating climate change impacts. These assessments are essential to identify climate risks to ecosystems, prioritize management interventions, maximize the effectiveness of conservation actions, and ensure conservation resources are allocated appropriately. Despite an extensive literature on the topic, there is little agreement on the most relevant factors needed to support local scale initiatives, and additional guidance is needed to clarify how adaptive capacity should be assessed. This article discusses why adaptive capacity assessment represents a critical tool supporting conservation planning and management. It also evaluates key factors guiding conservation NGOs conducting these assessments in tropical island communities that are dependent upon fisheries and aquaculture, and explores alternative priorities based on input from academic experts and key local stakeholders. Our results demonstrate that important differences exist between local stakeholders and nonlocal academic experts on key factors affecting adaptation and coping mechanisms. The exclusion of local community input affects the validity of adaptive capacity assessment findings, and has significant implications for the prioritization and effectiveness of conservation strategies and funding allocation.

Adaptation strategies to climate change in marine systems

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The world's oceans are highly impacted by climate change and other human pressures, with significant implications for marine ecosystems and livelihoods that they support. Adaptation for both natural and human systems is increasingly important as a coping strategy due to the rate and scale of ongoing and potential future impacts. Here, we conduct a formal review of literature concerning specific case studies of adaptation in marine systems, and discuss key factors for success, including motivation, strategy, timeline, costs, and limitations. We found that marine species are adapting to climate change through shifting distributions and timing of biological events, while evidence for adaptation from evolutionary changes are limited. For human systems, existing studies focus on frameworks and principles of adaptation planning, although examples of implemented adaptation actions and evaluation that successes are scarce. These findings highlight potentially useful strategies given social-ecological contexts, as well as key barriers and specific information gaps requiring further research.

Genetics programs that can help rural aquaculture communities cope with climate change

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Smallholder aquaculture farmers can improve their livelihoods and open up new, global economic opportunities in response to climate change if they network and work together to develop genetic strains adapted to local environments. Terrestrial agriculture offers many examples of this networking process that can be used as models in aquaculture. This presentation will review some of the technical and social structures that are needed to take advantage of this opportunity for rural aquaculture development in Asia-Pacific.

Kole fish culture: an alternate option for climate change adaptation to support livelihood of fishers in drought drought-prone northwest Bangladesh

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Fish culture in the non-traditional waterbody river-kole is a recent initiative that offers great opportunity, especially for fishers' alternate livelihood options in northwest Bangladesh. In the dry season, the river Padma, lacking inflow of sufficient water from the upstream, becomes dryied up and leaving leaves some depressions or pockets (like ponds or small lakes) on the river bed, popularly called ""kole"". These koles remain un-inundated for nearly 6 six months till tountil the next rainy season, which offers an opportunity for fish culture. Recently, nearby local fishers and unemployed youths of Chapai Nnawabganj district have become interested and involved to usein using these river-koles for fish culture. In 2012, the average fish production was 767 ± 447 kg/ha, including 42 ± 31 kg of wild fish; however,but experienced kole fish farmers managed to

increase their production up to 2 235 ± 970 kg/ha, including 82 ± 15 kg of wild fish in 2015. Based on growth performance, native and exotic carp species as used in carp pond carp poly-culture were found suitable. The investigation revealed that the present production level and profit margin can be increased further with better management practices. Kole can also be used as a nursery facility for early carp fingerlings rearing, while as most earthen nursery ponds in the northern area lack the required water. In Bangladesh, fish, the major source of animal protein in the daily diet, is mostly supplied from inland aquaculture, as fish harvested from the open water are declining due to the impact of climate changeimpact. Therefore, both public and private initiatives are suggested to explore these potential water-bodies for fish production, support vulnerable local fishers for alternative livelihood options and mitigate climate change impacts.

Climate change adaptation efforts in coastal shrimp aquaculture: Case study from northwestern Sri Lanka

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Unexpected temperature variations and rainfall patterns bring direct adverse impacts to shrimp farmers in northwestern Sri Lanka. Specifically, such climate change impacts shrimp disease spreading patterns along the interconnected lagoon waterbody and makes it difficult for shrimp farmers to predict and control it – the primary water source for coastal shrimp aquaculture. This paper examines how small-scale shrimp farmers adapt to climate change impacts by collectively managing shrimp disease. We studied three shrimp-farming communities in northwestern Sri Lanka. We analysed adaptation using a social-ecological resilience approach with a four-part framework: (i) living with uncertainty: shrimp farmers deal with the uncertain nature of the shrimp business by controlling (rather than trying to eliminate) disease; (ii) nurturing diversity: farmers tend to diversify their income sources to include other activities. They spread disease risk by dispersing pond wastewater in space and time; (iii) using

different kinds of knowledge: farmers combine their experience with large-scale (failed) companies, their own experience, government technical expertise, and new knowledge from adaptive management (the "zonal crop calendar" system); and (iv) creating opportunities for self-organization: farmers have built on their experiences with producer cooperatives (samithi) to self-organize into a multilevel community-based management structure. Collaboration and collective action are central features of this adaptation mechanism. This small-scale shrimp aquaculture is persisting (sustainable) and resilient because it is adapting.

Aquatic farming systems will require a range of diverse adaptations to combat and mitigate climate change impacts: case studies from Asia

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The backbone of global aquaculture is Asia, which contributes approximately 65–70 percent to the global output. Moreover, the great bulk of Asian aquaculture is small scale and rural and therefore the impacts of climate change tend to mostly affect rural, poor livelihoods. Aquatic farming systems in Asia are very diverse: farming is conducted in marine, brackish and freshwater environments, in a variety of containments that range from simple indoor tanks to cages in open waters, varying climatic regimes from high altitudes, e.g. in Nepal to sea level, and most importantly involves over 300 species of finfish, molluscs, crustaceans and plants.

Ideally, the adaptive measures that are developed should by and large ensure that existing farming communities are not dislocated, except in extreme instances, nor should these impose major changes to the existing practices. In view of the diversity of the practices and distributed across a wide geographic and climatic regimes, "one size fits all" adaptation(s) are highly unlikely to provide a solution. The adaptive measures could be scientific/science- based, socio-economic and/or physical, packaged together or singly, and are illustrated using the following aquatic farming systems.

Some of the focal points of Asian aquaculture tend to be physically located in areas that are most vulnerable to some of the major facets of climate change. Such primary areas are the deltaic areas of the major Asian rivers, the Yangtze and the Pearl (China), Red and the Mekong (Viet Nam), the Irrawaddy (Myanmar), and the Ganges and Brahmaputra (Bangladesh), all of which have major aquaculture activities involving millions of livelihoods.

The climate change impacts on the aquaculture practices in the above deltaic areas are manifold. Foremost among these are sea level rise and concurrent saline water intrusion that will have a direct impact on large-scale farming of the tra catfish (Pangasianodon hypophthalmus) in the lower Mekong Basin and the continued inundation of shrimp culture facilities with high saline water. Tra catfish is a freshwater species, and salinity increases up to 5 ppt will impact on productivity and beyond that the farming practices will not be viable. As such, the plausible solution to sea water intrusion into catfish farming areas will have to be a scientific adaptation, in which a strain that is selectively bred for higher salinity tolerance, without compromising growth and yields, be developed and extended among farming communities. Such a measure will permit the farmers to continue to be engaged in catfish farming without major changes in the practices they are accustomed to.

In Bangladesh, alternate rice and shrimp farming systems are beginning to be impacted by facets of climate change such as coastal flooding, cyclones, sea level rise and drought. These climatic variables adversely affect the socio-economic conditions of farming households because of ensuing low survival rates, growth, and production rates of shrimp. It has been proposed that community-based adaptation strategies and integrated coastal zone management are plausible adaptive measures that are needed to cope with the challenges. On the other hand, giant freshwater prawn-rice farming systems in Bangladesh possibly will have to resort to a different adaptive measure; a relocation from the coastal areas to less vulnerable inland areas, but will require appropriate adaptation strategies and an enabling institutional environment.

All farmed aquatic animals are poikilothermic. Hence, temperature increases will impact on the metabolic rates and thereby on production and associated costs. Obviously, the temperature increases will not be uniform across the farming systems, nor would there be uniformity on the impacts on metabolic rates. It therefore will be relevant to develop bioenergetics models for the major farmed aquatic species and appropriate adaptive measures be developed based on parameters, such as changes in energy requirements, feed consumption, and digestibility of feeds and the like.

Experiences in building climate change resilience in the fisheries and aquaculture sector through international and domestic funding mechanisms in India

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The National Bank for Agriculture and Rural Development (NABARD) is the apex development finance institution in India and is accredited as a National Implementing Entity for two important funding mechanisms under the United Nations Framework Convention on Climate Change, namely the Adaptation Fund and the Green Climate Fund. NABARD has accessed adaptation finance of US$2.48 million from the Adaptation Fund under the direct access modality for two projects in the fisheries sector: (i) conservation and management of coastal resources as a potential adaptation strategy for sea level rise; and (ii) building adaptive capacities of small inland fisher communities for climate resilience and livelihood security.

As a National Implementing Entity for the National Adaptation Fund for Climate Change, NABARD has been instrumental in mobilizing US$10.82 million of domestic finance for: (i) management and rehabilitation of coastal habitats and biodiversity for climate change adaptation and sustainable livelihoods in the Gulf of Mannar in Tamil Nadu; (ii) promotion of an integrated farming system of shrimp and paddy in the coastal wetlands of Kerala; and (iii) climate adaptation in wetlands along the Mahanadi River catchment area in Chhattisgarh.

The existing climate finance architecture in India and the experiences of NABARD in accessing both international and domestic climate finance and their implementation are discussed. The concept of the National Action Plan on Climate Change and the Subregional State Action Plan on Climate Change and the role of NABARD in the operationalization of these plans with an aim to build climate change resilience in the fisheries sector will be discussed in detail.

The opinions expressed are personal views of the authors and need not necessarily reflect that of the organisation they represent.

Development of Sustainable Rice-Shrimp Farming in Coastal Communities in the Mekong River Delta, Vietnam

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Coastal Areas of Mekong River Delta (MRD) is key brackish water shrimp farming region of Vietnam. It features diverse farming systems including intensive, semi-intensive and shrimp rotation: shrimp-mangrove, rice-shrimp. Rice-shrimp farming is common in coastal provinces, and considered by Vietnam Government (GoV) a potential model for expansion. This study contains a situation assessment, identifies challenges, and proposes solutions for improving efficiency and sustainable development of rice-shrimp farming in MRD.

Although started in the early 1970s, rice-shrimp farming has expanded in recent years. Currently the GoV plans to develop the rice-shrimp area in MRD to reach 250,000ha producing 150,000 tons of shrimp by 2030. Production of shrimp from the rice-shrimp system was estimated at 65,000 tons in 2014, accounting for 11% of national shrimp production; one hectare of rice-shrimp produces 300-500 kg shrimp and 4-7 tons of rice.

The major limitations are insufficient high quality post-larvae (PL) and limited capacity in management of PL quality. Water supply and drainage infrastructure are below standard for rice-shrimp farming. Climate change impacts, saline water intrusion, prolonged dry season, heatwaves, drought, as well as human management activities like the construction of hydroelectric dams in upper Mekong River are affecting the sustainable development of the rice-shrimp system in MRD.

Although rice-shrimp models are considered by GoV as effective and sustainable farming systems, farmers are not provided with sufficient technical guidelines, optimal technical specifications and guidelines have not been identified to maximize efficiency.

Greater efforts need to be taken to promote sustainable rice-shrimp towards improving efficiency and sustainability, particularly in the context of climate change, such as: national policy advocacy and planning; technical support to agriculture extension officers and farmers; environmental monitoring systems; research and market development; capacity building and awareness raising about climate change impact and sustainable farming.

Integrated shrimp aquaculture for climate change adaptation

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Shrimp aquaculture started in Ganges-Brahmaputra-Meghna (GBM) delta during 1980s and mainly within coastal polder areas. It expanded rapidly where it was supported by saline suitability. However, there was much environmental and social concern due to mal-practice of shrimp culture and diseases. In course of time, practice pattern and areas of shrimp culture changed and mix culture initiated. This has turned to be good practices with more integrated form. Further, integration with brackish and freshwater shrimp and others added value and some of these covered risk also. Where salinity range is more than 15 ppt integration has been limited. Within integration and such cropping pattern, Finfish-Golda, Mix Shrimp and Geese/Duck farming are important. These integrated approaches expected to be more resilient, cost effective, rational use of resources to climate change condition to improve livelihoods and wellbeing.

It is apprehended that in climate change condition new areas of GBM Delta will be inundated and that area may not be suitable for paddy cultivation but may be considered for shrimp aquaculture. In such situation only good practices with integrated form may be one of the adaptive solutions. Based on investigation made during 2015-16 by a study, several integrated and sustainable shrimp farming practices have been identified in coastal area of Bangladesh. This aquaculture pattern absorbed seasonal and local unemployed youth including women as farming labor. This is reducing migration also.

Aquaculture insurance as an adaptation strategy: Experiences from China and Viet Nam

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The old perils of farming have been exacerbated by climate variability. Hazards from natural factors, i.e. rising temperatures, droughts, floods and cyclones, and erratic climate patterns as well as increasingly less predictable climate variability, have intensified risks. Their impacts include direct damage to crops and structures. The indirect ones are their effects on the culture medium, such as acidification of saltwater, stress in farmed organisms, and the increase and virulence of pathogens. Insurance as a risk-mitigation strategy has assumed even a greater importance in the face of climate change-wrought uncertainties and risks. In developing countries and for small farmers, aquaculture insurance has yet to be a default risk-sharing option. This presentation draws on the experiences and lessons from the pilot insurance programmes of China and Viet Nam to illustrate the role of insurance in facilitating policies, programmes and practices that strengthen resilience of the aquaculture sector and improve its capacity to adapt to climate change. It describes the challenges to insuring aquaculture operations, especially insurers' viability and farmers' access.

Adaptation strategies for climate change impacts of major aquaculture systems in the Philippines

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Aquaculture, the farming of aquatic plants and animals, is the most vulnerable sub-sector of Philippine fisheries to climate change impacts, namely, severe typhoons, floods, droughts, high ambient temperature and sea level rise. Practical adaptation strategies for aquaculture in response to climate change impacts in the Philippines are needed. Such strategies for major aquaculture systems, namely, pond culture systems, cage/pen culture systems and open-water culture systems are presented.

For protection of brackish water and fresh water pond against floods, increasing dike height and installation of net enclosures to minimize loss of cultured stocks are recommended. The application of good aquaculture practices (GAPs) for cage/pen culture of fishes in fresh water lakes, tidal rivers and coastal waters along with the use of typhoon-proof submersible cages should be done.

The negative impacts of high ambient temperature (38-40OC) can be reduced with the deepening of fishponds for rain water collection, use of shallow tube wells to augment water supply and artificial shading for lessening light penetration. The culture of seaweeds (Kappaphycus/Eucheuma) in deep coastal waters rather in shallow waters can be done to minimize the occurrence of the "ice-ice" disease.

Local environmental monitoring systems to strengthen fisheries and aquaculture resilience to climate change

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Although fisheries and aquaculture are sensitive to climatic variability, as well as to long-term trends and changes, in general, aquatic monitoring systems providing information that fishers and fish farmers trust and can use to make decisions are rare. Even though some information (e.g. on meteorological and oceanographic conditions) could be available, this may not be enough for them to make decisions for short term and longer term action. Simple information collected on a permanent basis (e.g. water temperature, transparency, water level, fish behaviour, salinity, new species in the catch) can be highly relevant for decision-making, especially when changes can produce dramatic consequences. For example, temperatures above or below average can trigger diseases in farmed animals, and sudden water movements or internal circulation can bring anoxic water to the surface or trigger toxic algal blooms, or could drive away fish that are normally captured by coastal fishers. In general, local environmental monitoring systems should follow a risk-based approach, recognizing that increased risk requires increased monitoring efforts. But most important, the involvement and the value of locally collected information are being seen as relevant for farmers and fishers to better understand the biophysical processes and become part of the solution, e.g. rapid adaptation measures and early warning, long-term behavioural and investment changes. The current presentation discusses the potential process, design and operation of local environmental monitoring systems through some recently initiated experiences led by FAO and other partners in different countries (Bangladesh, Chile, Nicaragua and Lower Mekong countries).

Capacity development of stakeholders to integrate fisheries and aquaculture in emergency response and preparedness

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Under the theme "climate change and adaptation", ICAR-Central Institute of Fisheries Education has undertaken a project on Capacity Development of Stakeholders to Integrate Fisheries and Aquaculture in Emergency Response and Preparedness. In this project, three workshops have been organized. The first workshop was conducted on 18 December 2015 at CIFE, Mumbai; the second workshop from 25 to 27 February 2016 in the Sundarban region at the Kakdwip Research Centre of the Central Institute of Brackishwater Aquaculture in West Bengal; and the third from 10 to 12 March 2016 at Jorhat, Assam, at the Fisheries Research Centre, Assam Agricultural University, Jorhat. Workshops were held as per FAO's Fisheries and Aquaculture Emergency Response Guidance and Guidelines for the Fisheries and Aquaculture Sector on Damage and Needs Assessments in Emergencies by Cattermoul, Brown and Poulain (2015). Diverse stakeholders attended these workshops, representing central and state government, NGOs, fishery cooperatives, academicians, researchers and youth. Representatives from ICAR, KVKs, the Municipal Corporation of Greater Mumbai, Indian Coast Guard, National Disaster Response Force, Marine/Sagari Police, District Disaster Management Office, Marine Products Export Development Authority, NGOs such as the International Collective in Support of Fishworkers and the World Resources Institute, fishery societies, and academicians participated in these workshops. The aim of these workshops was to enhance the quality and accountability of preparedness and response to emergencies affecting the fisheries and aquaculture sector. Knowledge on topics, including crosscutting issues affecting vulnerability, the importance of rebuilding better, damage and needs assessments, value chains, livelihood and ecosystem approaches to be used in emergency responses, through participatory teaching methods was provided to participants as per FAO guidelines.

Embracing the value chain framework for post-disaster livelihood interventions: The milkfish industry in a Haiyan-affected area in Leyte, Philippines

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Haiyan took away the fish pens and fish cages of fishers in Brgy. Sta. Cruz in the municipality of Tanauan in Leyte province. There was once a booming production of milkfish, but the fishers and their households now had to survive through the economic shocks and dislocations brought by the sudden onset disaster. The impact on the women fishers extended beyond the problems of milkfish production and sales, since women had to ensure that fish was on the family table, whatever it took.

With the assistance of JICA and government agencies, such as the Department of Trade and Industry and the Bureau of Fisheries and Aquatic Resources, the economic opportunity for rehabilitating milkfish production was pursued. Stakeholders realized that in a post-disaster scenario, "business-as-usual" may not make the situation any better. That is, businesses carrying on individually as if all other counterparts are competitors will not result in the desired post-Haiyan rehabilitation. Hence, the value chain framework served as a guide in the design of post-disaster interventions.

This paper shows the processes and the gains derived from the strengthened and upgraded milkfish value chain. It describes the industry situation and includes the opportunities and constraints faced by the four major value chain players: (i) input suppliers of fingerlings , fries, feeds and equipment; (ii) milkfish producers who grow, harvest and sell fresh milkfish; (iii) processors of softbone milkfish; and (iv) traders, shops and retail outlets. The ways forward from the lessons learned are included in this paper.

Co-managing disaster risk: spending, legislation and the non-governmental organisations in agricultural and fishing communities in the central Philippines

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The central Philippines, known for having a diverse marine ecosystem and an abundant fishing economy, has been continually exposed to annual typhoons and coastal overpopulation. As a consequence, the well-being of socially-disadvantaged coastal communities and their neighbouring towns are affected. More so, the local budgets for floods and related-disasters are usually difficult, misdirected and limited. The central aim of this paper is to examine the actual disaster spending of households, legislation/guidelines, and the role of non-governmental institutions. We emphasize on spending and legislation related to disasters because the documentation of these experiences in local governments is required and imperative to disaster planning. Using 524 geographically selected households from six agricultural and coastal towns in Iloilo, we found that strong disaster legislation leads to minimum flood damage; while the level of spending is not deterministic of low flood impacts. We conjecture that the implementation of legislation (including monitoring) and support from non-governmental organizations or other civic organizations are essential in reducing local vulnerability. This is especially true in the coastal communities of Oton and Leganes where strong collaboration with these organizations are prevalent. Non-governmental organizations in the central Philippines, as frontliners in disaster responses, have strong involvement in community-based disaster management, which includes organizing and capacity building, advocacy, and "influencing jurisprudence for disaster prevention."

Adaptation of fishers in the Philippines to climate change

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More than half a million marginal fishers in the Philippines have been availing of loans from Quedancor, the credit arm of the Department of Agriculture. The financing scheme has been quite successful with a repayment rate at 95 percent. However, the impact of climate change has affected the productivity of fisheries, thus hindering fishers from paying and renewing their loans. Failure to access credit could disable them to continue venturing in fishing activities and could eventually jeopardize the welfare of their entire household. The inability of creditors to pay their loans and meet their obligations could also impair the financial operation and viability of the lending institutions. This study analyses the risk management practices of these fishers. It recommends mitigation mechanisms to minimize the impact of natural calamities. Moreover, it suggests a bridge financing scheme that can be an effective and efficient instrument to enable fishers to carry on their livelihood activities and slowly recover from their losses.

Climate change and variability adaptation effort in fishing and aquaculture in SICA's participating countries. Strategic measures.

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The countries of the Central American Integration System (SICA) have significant biodiversity in their available oceans, fisheries and aquaculture resources that are vulnerable to the effects of climate change and variability. The losses in extreme events are counted in millions of dollars. Therefore, the Organization of Fishing and Aquaculture in Central America (OSPESCA/SICA) is working with other agencies and with the Global Partnership on Climate, Fisheries and Aquaculture (PaCFA) system to boost regional processes of adaptation and resilience in the fisheries and aquaculture sectors.

The concrete expression of that collaboration, to which the productive sector is integrated, is the Fisheries and Aquaculture Integration Policy 2015–2025. The policy comprises a strategic component related to climate change, and within its actions includes the strengthening and interaction of the regional and international organizations that address climate; the permanent work on the adaptation and resilience processes; the creation of a response baseline against climate; the institutionalization of a specialized group in the region; and the strengthening of the mass media.

Within that framework, a regional plan for climate-smart fisheries and aquaculture is formulated; collaboration with other agencies related to climate analysis and forecast application in the fisheries and the aquaculture sectors is carried out; and a weekly newsletter called "CLIMAPESCA" is published.

Lake Chapala's fisheries: Coping and adapting to water-level fluctuations

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Lake Chapala is a shallow tropical lake and the largest in Mexico; its riparian communities have always practiced fishing, trying to satisfy the regional demand for fish. As a shallow tropical lake, it experiences water-level fluctuations, which have been intensified by anthropogenic activities and natural phenomena such as El Niño, affecting the annual rainfall. These events affect the lake's health and, as a consequence, fishing activity.

This work aims to examine the main factors affecting water-level fluctuations in shallow tropical lakes and to analyse how the fishers from the riparian communities adapt and cope with these changes, considering the case of Lake Chapala. The research design was mainly qualitative, consisting of interviews with fishers in riparian communities carried out in two periods (2011 and 2012). However, statistical databases were also considered as well as consulting historiographic databases about Lake Chapala's history of decline.

Results show that catch levels are strongly related to the environmental conditions of the lake, showing instability and decline that affect fishers' livelihoods. One of the most common coping strategies are fishers following the water edge to continue fishing, adapting their gill nets and mesh sizes to be able to fish smaller fish (juveniles), and thus affecting the fishery. Some fishers also combine fishing with other economic activities such as farming or construction work. Women play a crucial role because they sell and/or process fish from other waterbodies, and, when the catch from Lake Chapala is not good, their income becomes crucial for household survival.

Local skills and indigenous knowledge in building socio-ecological resilience to climate change with particular reference to aquatic resource utilisation in north-eastern India

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Resilience to climate change can be deciphered through strategy available from fine-scale spatial and grassroots techniques. Aquatic resources utilization in north-eastern India is mainly based on the local skills, techniques and innovations held by the aboriginal people that transmitted them over successive generations. Such practices have been sufficient to sustain livelihoods to the on-site communities, and have the capacity to respond and adapt to socio-economic and climatic stressors. Rich funds of knowledge are embedded in local customs and behaviours, which act as shock absorbers during disasters. Successful building of climatic resilience depends on the adaptive strategies oriented in the space, time and beliefs of on-site communities. In the face of fluctuating markets, environmental change and cascading energy, indigenous knowledge plays an essential role in resilience via diversifying livelihood strategies. Temporal protection of aquatic habitats, resource rotation and social mechanisms, such as taboo rituals or ceremonies, and social and religious sanctions among others, are maintained by village chiefs and local priests including women. The biocultural refugia of indigenous communities in north-eastern India are bound with customary laws and cultural practices. Such norms and livelihood strategies are highly adapted to climate-induced variability. Mainstreaming of gender and conservation of indigenous knowledge to address climate change policy can successfully adapt to inevitable calamity in aquatic resource conservation.

Empowering climate change adaptation-driven innovation in Brazilian fishing communities through science-based support

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It is unclear whether fishing communities adjust in response to actual or expected climatic effects in a particular different way than they adapt to other types of variability and hazards. However, addressing climate change risks, building adaptive capacity and reducing vulnerability are currently important considerations in development plans for the fisheries and aquaculture sector that are not often covered effectively by governmental agencies. Here, we report an ongoing evaluation of the adaptation continuum (from impacts focused to vulnerability focused) as part of the actions derived from the GULLS project (a Belmont Forum international project) in Brazil, which plans to provide adaptation options in five countries of the southern hemisphere considered hotspots of ocean warming. In GULLS-Brazil, climate change impacts have been addressed through different sources and innovative approaches, including bottom-up surveys within fishing communities, the application of the "ethno-oceanographic framework", vulnerability analysis, the downscale of global/regional ocean models and stock assessment modelling. Coastal fishing communities have shown their own perspectives, which allow to build on both extremes of the adaptation continuum. On the other hand, the outcomes of a series of scientific working groups currently running specific analysis with local and international teams will be presented to the selected fishing communities, where participatory approaches will allow the development of local adaptation plans and strategies to climate change challenges. Regional plans will be proposed while respecting the numerous geographical, economic and cultural peculiarities of this heterogeneous coastline area of Brazil, aiming to moderate harm or exploiting beneficial opportunities to the sector.

Climate change initiatives for fishing communities in Indian Sundarbans by non-governmental organisations

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Climate change is affecting the lives and livelihoods of coastal fishery communities of Sundarbans, the unique Biosphere Reserve and World Heritage site of India, and the largest mangrove vegetation of the world. Out of a total area of 14 300 km2, Indian Sundarbans occupies 4 267 km2, encompassing the 19 adjacent blocks of two coastal districts of 24 Parganas (north and south). Being internationally recognized, Sundarbans is a place of work for different non-governmental organizations (NGOs) with international repute. Different funding agencies have been extending their support in livelihood interventions, including climate change. A study was conducted with an objective to analyse interventions and programmes undertaken by NGOs in the field of climate change. This study revealed that NGOs gave priority to environmental awareness campaigns, environmental awareness mapping, biodiversity/climate awareness programmes, and observation of environmental days or week. These programmes were mainly sponsored by the World Bank under the Integrated Coastal Zone Management Project; others sponsors were the Ministry of Environment and Forests, Government of India, West Bengal Biodiversity Board, Government of West Bengal, and the Institute of Environment Studies and Wetland Management, West Bengal. Reports suggest that climate change is resulting in rising sea levels, disappearing islands and increasing salinity in the water and soil, resulting in adverse effects on the health of mangrove forests, soil, changes in fishing patterns and erratic monsoons, which are detrimental to the fishing communities. There is a need for NGOs to make fishing communities aware about climate-resilient fisheries and provide adaptive solutions to climate change for the communities.

Special sessions

Special Session: Climate change in small-scale fisheries: Vulnerability, adaptive capacity and responses

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Small-scale fishing communities, especially those in low-lying areas, are highly susceptible to climate change. Many of these communities have managed to cope and adapt, while others remain at risk. The session aims at enhancing understand about the vulnerability of small-scale fishing communities, how they respond to different types of change and stressors, as well, factors, conditions, instruments and tools that help enable small-scale fishing communities to cope and adapt. The first presentation provides an overview of adaptive capacity of small-scale fisheries, focusing on the role of resilience and local knowledge. Effects of climate change on fishing livelihoods and food security are illustrated in the following two presentations, with examples from Bangladesh and Africa, respectively. The fourth paper presents case studies in Ghana about how adaptive capacity can be mobilized. The next paper contextualizes gender issues in small-scale fisheries and climate change using examples from Europe and elsewhere. The final paper examines the contribution of international instruments in strengthening community-based adaptation, using a case study from India.

Adaptive capacity in small-scale fisheries: Role of resilience and fisher knowledge

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Climate change is altering aquatic ecosystems, and small-scale fisheries (SSF), along with others, need to adapt to these changes. Some literature has emphasized the vulnerability of SSF to change. Yet other literature has characterized SSF as flexible and adaptable (by necessity – otherwise they would not have survived up to present). Which is the case? And specifically, what are some of the more important factors related to adaptive capacity in SSF? The discussion is in the context of climate change, acknowledging that there are many other drivers of change as well. The paper emphasizes two factors related to adaptive capacity: fisher knowledge and resilience. Fisher knowledge is what enables a small-scale fishery to persist and adapt. First, fisher knowledge is itself resilient, in the sense that it evolves through feedback learning as conditions change. Second, fisher knowledge contributes to the overall resilience of the fishery social-ecological system (the fisher, the fish and their environment considered together as the unit of study). Fisher knowledge enables the fishery to respond to shocks and stresses, while maintaining the functioning and identity of the fishery system. Drawing from international experiences with SSF, the paper will emphasize resilience in its three dimensions: coping, adapting and transforming. Some fisheries cope with change, making short-term adjustments in response to change. Other fisheries transform, for example, turning from a capture fishery to recreation and tourism. Adapting, the in-between dimension, requires capacity to adapt, and that capacity is closely related to fisher knowledge, both local and traditional.

Bringing gender dimension into the debate about ocean and climate change

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International debate and available literature about climate change often mention gender and point to the fact that women could be more vulnerable to climate change than men. As such, it is urgent to make the gender dimension and equality issues part of the climate change debate, as a way to guarantee equal access to economic and natural resources, and improve life conditions for women in coastal areas.

Ocean warming, acidification and de-oxygenation are the three major stresses of climate change on marine ecosystems. They all, separately or combined, result in changes to biodiversity, food webs and productivity with potential impacts on marine provision and recreational ecosystems services. The combination of these three stresses with other land based pressures will increase risks to food security and impact considerably the industries depending on healthy and productive marine ecosystems. Fisheries, shellfish farming and finfish aquaculture could be impacted and obviously fishers, households, women and men and, of course, their communities. Many communities depending on coral reef ecosystems, and particularly small island states, are already strongly affected. Gender relation and equality can be impacted by these changes, even more in countries were these activities are undertaken mostly by women.

Sea level rise and increase in frequency and intensity of extreme climate events (e.g., storms, cyclones) are other consequences of climate change. Extreme climate events can also affect the conditions for fishing, shellfish farming and aquaculture by reducing the resilience of marine ecosystems thus increasing the vulnerability of communities and industries. But one of the main impact of sea level rise and extreme events regime shift is in the increase of coastal risks including erosion, flooding and destructions by strong winds. These result in

regular loss of coastal land, building and infrastructures or, even loss of lives and life support resources. During and after these events women and men needs and capabilities are different and it is also time to bring this issue into the public space at the international level. Issues of adaptation and mitigation to severe climate events bring upon questions such as: what kind of preparedness is required to reduce vulnerability of coastal population? What happens to coastal fisheries and fishers who have lost their means of production and infrastructures? What happens to their daily life, their practices and identities? What are the specific needs of women and men in adaptation or in rebuilding community life and their activities after an extreme event? How to include these aspects in the international negotiation on climate change and regional or local mitigation and adaptation plans?

This presentation will try to bring some answers to those questions based on available academic literature related to climate change and gender in fisheries and aquaculture from different parts of the world. The final objective is to integrate gender dimension within the on-going international debate about ocean and climate change.

I-ADApT a tool for coastal communities to respond to global environmental and food security challenges in Africa

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The I-ADApT tool is designed to enable decision-makers, researchers, managers and local stakeholders to: (i) make decisions efficiently; (ii) triage and improve their responses; and (iii) evaluate where to most effectively allocate resources to

reduce vulnerability and enhance resilience of coastal peoples to global change. Small-scale fisheries are highly vulnerable to global environmental change because of their geography, located in close proximity to low-lying or exposed coastal areas. They are likely to suffer from multiple simultaneous pressures, such as rising temperatures and sea levels. Threats to small-scale fisheries go beyond climate change to globalization, competition from industrial fisheries and rapid market shifts. The high dependency of coastal communities on fisheries for food and nutrition security and livelihoods adds to challenges in resource governance and environmental sustainability, especially when human rights and social justice issues are of concern. Fish protein contains more essential amino acids, omega oils and nutrients than meat, poultry, or legume equivalents. Small fish is fairly readily available in many riparian and coastal communities in Africa and could play an important role in enriching the vitamin and mineral deficient diets of many poor and vulnerable communities. However, environmental changes in the ecosystem such as rising temperatures can negatively impact on the fish availability, access and utilization to vulnerable and poor communities. This paper unpacks the food and nutrition security challenges in Africa in relation to the global environmental change. To withstand these challenges, coastal communities need to be prepared to adapt to change and ready to respond effectively and in timely manner. To what extent can I-ADApT be uses as is a tool to aid small-scale fishing communities to respond effectively and in a timely manner to the threats of global environmental change, livelihoods and food security?

Vulnerability of coastal fishers to disasters in Bangladesh

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Bangladesh is considered as one of the most disaster-prone countries in the world, mainly due to its geographical location and socio-economic context of vulnerable population. Of the vulnerable communities, coastal fishers are one of the most exposed and suffered community to natural disasters, because they live close to coast, their occupation related to climate sensitive water resources and they are among the most disadvantaged section of the society in Bangladesh. Using qualitative interview technique, the present study aims at unraveling disaster vulnerabilities of coastal fishers in Bangladesh. Primary data was collected from three fishing communities in the Patuakhali district from the central coast of Bangladesh. The vulnerability of coastal fishers is determined by three dynamic and interconnected dimensions: exposure, sensitivity, and resilience. Coastal fishers live flat low lying terrain next to coastal embankments, this makes them predisposed to multiple hazards such as cyclones, storm surges, floods and river bank erosions etc. causing substantial damage to their livelihood assets each year. Particularly every three year, one major cyclone strike Bangladesh coast and coastal fishers are the first victim both at home and sea. Limited finances make it difficult to restore homes, infrastructure and productive assets. Limited access to power, structure and resources, less involvement in politics and poor economic system are the root causes of vulnerabilities. Dynamic pressures such as lack of education, training and market facilities, limited options for alternative occupation etc. coupled with high population growth, low productivity of fisheries etc. make them very much sensitive to changing situation. Besides, dangerous location, unprotected areas, risky livelihoods, low income level, high debt bondage, weak disaster warning system and lack of disaster preparedness make them less resilient to disasters. Coastal fishers adopt multiple coping strategies (e.g. increasing fishing efforts to compensate loss, child labor) that erode their adaptive capacity in longer perspective. Finally, these empirical findings provide important insights for fishers' vulnerability that could help policy makers to take decisions to secure sustainable livelihood futures for coastal fisheries-dependent communities in Bangladesh.

Can FAO Small-Scale Fisheries Guidelines (2015) promote better community-based adaptation to rapid environmental change?

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Small-scale fishing is a large rural sector in many parts of the world, especially Asia and India. It provides jobs, livelihoods, food security, and cultural identity to a significant number of people. Some 90% of 38 million people recorded as fishers all over the world are classified as small-scale and this sector contributes to about half of global fish catches. Small-scale fisheries employ more than 90 percent of the world's capture fishers and fish workers, about half of whom are women. However, small-scale fisheries sector throughout the world is experiencing rapid changes through the impact of both environmental and human drivers resulting in large-scale dispossession of fishers from their livelihoods, property rights and cultural identity. Several forms of local adaptations to the changes in the social-ecological environments by the small-scale fishers have been recorded. The results of these adaptation strategies have been mixed with virtually no significant outcomes for the long-term sustainability of this sector.

This paper examines the key objectives and provisions of the FAO SSF Guidelines to offer some initial insights on the potential contributions it can make to enable and strengthen community-based adaptations to rapid changes within the small-scale fisheries sector. Main provisions of the guidelines, (e.g., Responsible governance of tenure; Sustainable resource management; Social development, employment and decent work; Value chains, postharvest and trade; Gender equality; and Disaster risks and climate change) will be analysed using the ongoing rapid social-ecological changes and community responses in the Bay of Bengal, India region as a case study. Additional data, generated through a regional consultation on the FAO SSF Guidelines with small-scale fishers of Bay of Bengal, Odisha coast, India, will also be used in this paper. In conclusion, it aims to highlight some of the key contributions of international instruments (e.g., SSF guidelines) in strengthening community-based adaptation amidst rapid social-ecological change.

Special session: Integrating gender considerations into climate change and disaster risk reduction strategies for fishing communities

Women and men are differently prepared against the risks of climate change and natural disasters. Research shows that women are, in general, more vulnerable than men to these risks, due to financial limitations, less access to resources, limited access to information and extension services (often targeted to men), and in general, less participation in the development of adaptation and disaster risk reduction related strategies and policies.

There may be several linkages between climate change and gender as climate change, on one hand, may exacerbate existing gender inequalities and gender inequalities, on the other hand, usually mean that women may face greater negative impacts due to climate change.

Additionally, despite the important contributions and important roles that women play in fisheries and aquaculture sectors, gender considerations have also been largely absent in fisheries governance and management, and hence are unlikely to be factored into actions and plans for climate change adaptation within these sectors.

This lack of attention to, and understanding of, gender and its role in defining and shaping aspects of vulnerability and resilience in fisheries and aquaculture sectors is preventing the successful implementation of measures for climate change adaptation and disaster preparedness.

Aim and Scope

To address this knowledge gap this session will try to gain a greater understanding of:

- Gender differentiated risks of climate change and natural disasters and related gender vulnerabilities in fisheries and aquaculture sectors.

- Perceived and potential effects/impacts of climate change on women in fisheries and aquaculture.

- The identification of strategies to harmonize the integration of gender among the different (although related) sectors (e.g. fisheries and climate change, aquaculture and disaster preparedness).

- Methodological and institutional frameworks for assessing gender related vulnerabilities to climate change and natural disasters in fisheries and aquaculture.

- The provision of guidance towards the implementation of international instruments (gender, climate, disaster and fisheries) into national policies and local plans.

The session will build on the research findings and gaps identified during the GAF6 Session on Climate Change and Disaster Preparedness.

The outcome of this session will be the identification of entry points for gender responsive strategies and approaches to support climate adaptation and disaster preparedness in fisheries and aquaculture sectors, based on specific examples from the field.

Special session: Charting a course after Paris: Leveraging NDCs for action to address climate challenges for fisheries and aquaculture in the Asia-Pacific region

The special sesion will consist of a briefing and facilitated discussion. The programme will include:

- Briefing on the INDC and NAP - processes and contents (Beau Damen).
- Fisheries and aquaculture sectors and national climate change planning in the region (David Brown and Cassandra De Young).
- Climate change in ASEAN
- Facilitated discussion on nextsteps to support national climate change planning processes.

Special session: Mangrove-based fisheries and aquaculture

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The global human population has grown at an alarming rate and continues to increase. It could reach 10 billion people by the 2050's. As a result of the population explosion and the major increase of carbon emitting technologies widely adopted by more and more people, the density of carbon dioxide in the atmosphere is increasing day by day. The uncontrolled use of fossil fuels, high rates of industrialization and indiscriminate deforestation are not abating. The increased density of carbon dioxide in the atmosphere is believed to be one of the major reasons for global warming and associated climate change, which is a matter of great concern to the scientists and politicians. Green plants once played a significant role in carbon sequestration, but areas planted have become reduced in many areas, owing to many anthropogenic interventions.

Intensive aquaculture, on which the world is hopefully looking to meet the protein demands of the growing population, is reported to be low on the scale of environment friendly technologies due to its higher carbon foot print compared to traditional low input sustainable aquaculture. Aquaculture practices have to be made more environment-friendly to play their part in achieving planetary sustainability, reducing the carbon foot print of fish production and maintaining the ecological integrity of the producing regions.

Mangroves are wetland forests mainly found in the estuarine areas of the world and characterized by special dynamic ecosystems coupled with rich aquatic and terrestrial biodiversity. Mangroves have a high tolerance of tough environmental conditions and can support fishery and aquaculture resources with low or no inputs. This plant group serves as a shield against cyclones, Tsunamis, soil erosion and also acts as natural nutrient filters protecting the coastal areas from sea water invasion. More importantly, mangrove ecosystems can protect the associated flora and fauna from extreme climatic conditions. Mangroves provide various livelihood opportunities to local populations by way of improved fisheries, provision of fire wood, fodder and different types of medicines. They have many adaptive features to overcome high salinity and muddy environments through ultra filtration, salt secretion and ion sequestra-

tion to maintain the systolic salt concentration of the cells. Globally, mangroves occur in 118 countries with an estimated area of 2 million hectares out of which 75% are concentratedin 15 countries. Between one and two million hectares of mangroves are estimated to have been destroyed in the recent past, especially in South East Asia, due to industrialization, urbanization and aquaculture development. This is one of the most endangered salt water ecosystems of the world because of the extensive destruction. Therefore, there is an urgent need to assess the status of different mangrove ecosystems and formulate programmes for their restoration and protection. The role of mangroves on resisting the climate change and the effects of climate change on this fragile ecosystem are to be thoroughly discussed. Utilization of mangrove based ecosystem for the production of organic sea food through mangrove integrated aquaculture systems also needs to be explored.

The concept of mixed fish-mangrove forest farming system for poverty alleviation and mangrove restoration: An experience from Sunderbans

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Aila, a devastating storm broke out in Coastal West Bengal in May 2009 caused massive destruction in Sunderban areas. It has been proved that areas protected with mangrove forests were less affected. But the mangrove swamps are less preferred as a site for aquaculture compared to many other areas. Besides the physical isolation, poor transport system, lack of electricity and high saline conditions the major drawback is the occurrence of acid sulphate soil in certain mangrove swamps. The draining from the swamp can be improved by the tidal canals built for the farm. If the mangroves are rationally managed, facilitating adequate regeneration, it would appear that large areas can be made available for aquaculture, where other developmental activities are not possible due to extreme biological and physical nature of the region. The concept of mixed fish-mangrove forest farming system has the potential for both poverty alleviation and mangrove restoration. In Vietnam, a number of State Forestry-Fishery Enterprises (SFFEs) integrating shrimp and fish culture and mangrove forestry were developed among coastal communities of the Mekong Delta with an objective of rehabilitation of mangroves and income generation through aquaculture (Johnston et al. 1999). Canal fishery is a popular and useful technique for increasing the aquatic biodiversity as well as for income generation of the weaker section of the local people with minimum capital investment and application of simple technology. In order to utilize the locally available resources in an eco-friendly manner and for providing the alternative livelihood, a case study was initiated in a portion of brackish water canal of 1 ha trapped portion of South 24 Parganas District of West Bengal, India. Culture was carried out for a period of five months using the locally available fish seeds and involving women of fisher folk belonging to the Below Poverty Line (BPL) who had been previously engaged with the wild collection of shrimp seed (Penaeus monodon) from the backwaters. The cost-benefit ratio was calculated as 1:1.34. Attempts have been made to develop the ecotourism ventures incorporating the canal fishery and mangrove ecosystem involving the local people in planting mangroves for the conservation of the resources.

The study revealed that necessary technological interventions coupled with policy support could lead to substantial increase in inland fish production and development of alternative livelihood through ecosystem conservation.

Vulnerability of Munroe Island, Kerala, India to the sea level rise: current concerns and thoughts for the sustainable future

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Munroe Island in Kerala, India is a small delta formed by Ashtamudi Lake and Kallada River with an extent of 13.37 sq. km lying in 8059'35.1" N latitude and 76036'42.8" E longitude. Latest census reveals that the Island is inhabited by 9599 people with 4636 males and 4963 females. The island though played a key role in maintaining the luxuriant economy and protein security of Kollam District through varied income generating activities like agriculture, aqua-culture, animal husbandry etc. now faces serious threats putting a question mark on its present and future. It has been noticed that many people left the Island in the recent past because of the severe issues of land subsidence. In an answer given in the Upper House of Parliament, the Government of India stated that "As per a study of the tidal gauge records of the northern Indian Ocean conducted by the National Institute of Oceanography, it is observed that the sea-level rose by 1.06-1.75 mm per year during the past century. Further, as per the India's Second National Communication submitted to the United Nations Framework Convention on Climate Change (UNFCCC) submitted in 2012, sea level is projected to further rise in the current century, which would result in saline coastal groundwater, endangering wetlands and inundating valuable land and coastal communities. The most vulnerable stretches along the western Indian coast are Khambat and Kutch in Gujarat, Mumbai, and parts of the Konkan coast and South Kerala". This phenomenon has been observed in this particular region at alarming levels. The saline water intrusion, reduced land availability for agriculture and allied activities, diminished spaces for house building, declining production levels, abandoned shrimp ponds etc. are the immediate results of the water level rise. It is feared that Munroe Island would be the first island in India which might be drowned due to global warming and associated sea level rise. Unfortunately, the Governments are

not taking proper initiatives to address this issue towards ameliorating the problems related to the livelihood of the inhabitants. The current paper will discuss the matter in detail and suggest the possibilities of scientific involvement including mangrove afforestation and initiating alternative livelihood strategies by various organizations and Governments for providing a better and fearless tomorrow for the 'islanders'.

Mangroves – climate change – industry perspectives

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This presentation will be an attempt to bring an industry perspective to the subject of Mangroves and Climate Change.

It will be a personal view as an industry actor with some forty plus years experience predominantly spent in the post harvest in Australia but worldly travelled.

Comprehending environmental issues such as Mangroves and Climate Change is a subject far away from the minds of people who need food to survive or who are trading products globally to sell so it is not a top of mind issue. There clearly needs to be more education and engagement in understanding the consequences. If we are not getting those important messages through to the industry then it will be even harder to get them through to the public.

We all need to take a backwards step. Stop the blame game and get a real global understanding of the issues and solutions and work collaboratively to spread knowledge through.

How can we achieve this? Some solutions will be put forward and we will welcome discussion and debate.

The organisations that I represent are interested in being involved successful outcomes relating to this and other important issues.

Exploring the impacts of future global change on mangrove-fishery-community linkages

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The estimated loss of global mangrove forest by 1-2 % annually is a cause for concern given the vital ecosystem services these systems provide to coastal communities across the tropics and subtropics. In particular, the continued capacity for mangrove forests to support coastal communities via the provisioning of fisheries products is a serious concern given the high number of people dependent upon them both economically and as a food resource. However, the impacts of mangrove degradation and loss (by both climatic and anthropogenic pressures) on mangrove-fishery productivity and subsequently coastal communities are not well understood, especially in a global context.

This study therefore seeks to investigate the potential impacts of future global change on mangrove-fisheries and explore the linkages between mangroves, artisanal fisheries productivity and community livelihoods in order to assess the vulnerability of economies and the impact on food security from a community to global scale. This will include exploring links between global catch data, commercial species distribution models and mapped global mangrove distribution as well as conducting a number of case studies at the local scale. Assessments of vulnerability of mangrove-fisheries and therefore coastal communities to global change will then be estimated based on aspects of sea level rise in relation to tidal range, sediment supply and accommodation space over a range of spatial scales.

Species diversification in the mangrove based ecosystem of Kannur District of Kerala, India

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Mangroves are the most productive wetland ecosystem which constitute heterogeneous group of halophytic trees, shrubs and other plants seen in the tropics. India holds approximately 3% of the world mangrove wetlands distributed along the East and West coasts of the country. Kerala, one of the maritime States in the West coast, comprising 10% of the country's coastline, holds more than 1% of the total mangrove ecosystem of the country. The mangrove forest in the State is distributed all along the Western coast in discrete and isolated patches. Paleontological studies reveal that the prevalence of mangroves and associated humid climate in Kerala has been present since Miocene era. This rich mangrove ecosystem was undergone severe depletion over the years because of the climate transition and marine regression. Currently, the State harbors only some vestiges of the system. Still, the Northern part of Kerala especially Kannur District supports ample mangrove patches all over its coastline compared to the Southern region. This study deals with the species diversification of the mangrove ecosystem present in the region. In general, the mangrove forest of Northern Kerala comes under 'inner estuarine mangals' and 'river mangals', but the hinterlands of the coastal stretch which are devoid of regular tidal flow and less salinity support transitional mangroves. Apart from these, the northern coast also supports 'Fringe mangroves' and 'Over wash island mangroves'. Fringe mangroves are characterized by the production of high amount of organic matter associated with better productivity status. The second group is usually seen close to the coastal waterways and can remain undamaged even in dry seasons. This coastal mangrove ecosystem of Kannur District is blessed with rich species diversity. The following true mangrove species shows wide distribution all over the area; Rhizophora mucronata, R. apiculata, Bruguiera cylindrica, Kandelia candal, Avicennia officinalis, A. marina, Aegiceras corniculatum, Excoecaria agallocha and Acanthus ilicifolius. It is noted that Bruguiera sexangula, Luminitzera racemosa and Ardisia littoralis are seen exclusively in and around the District. Nearly 25 species of crustaceans are identified in association with these mangrove ecosystems.

Apparently, more that 100 brackish water fin fish species were identified from this region during the study. It is clearly evident that this region acts as a major biodiversity hot spot of the wetland ecosystem of Kerala which needs urgent protection from further depletion.

Mangrove conservation: A source of sustainability and sustenance in Australia

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Abstract: Australia has the third largest area of mangroves in the world (around 11,500km2), or almost 6.4% of the overall world's mangroves. Although mangroves provide an ecosystem to sustain life and to harbour threatened species, the Australian mangroves themselves are threatened. Recently over 10,000 hectares of mangroves have died in Australia argued due to climate change impact, a new threat to mangroves as well as other threats due to development, pollution and other forces. An overview is presented of areas of Australian mangroves, who has responsibility for Australian mangrove care, and the role of communities, often in partnership with universities, in caring for and sustaining Australian mangroves. How communities work in caring for mangroves is considered as well as the diverse ways in which Australian mangroves are of value not just as an ecosystem to be sustained and as a source of food, but for other recreational, educational and restful experiences to enhance human life.

On mangroves and mangrove associates of Puthuvypin of Ernakulam District, Kerala (South India)

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Puthuvypin is a fast developing industrial area in Kochi in the Indian state of Kerala. Given its close proximity to the city and to the international sea route Puthuvypin has attracted many development projects in the near past. Further, of late, Government of Kerala decided to set up a mega oceanarium project together with a Marine Biological Research Centre at Puthuvypin with the objective of imparting awareness on the marine resources of the Arabian Sea. Though the various development projects contribute to a wide range of advancements in the social and economic fronts and overall growth of the region, they may also bring in adverse effects on the environmental quality, if adequate precautions are not taken to prevent them. Therefore, there is a pertinent need to collect information on the prevailing environmental conditions of the development area and surroundings prior to the implementation of the project. A comprehensive database on the baseline environmental characteristics is a pre- requisite for an integrated assessment of environmental impacts, if any, with respect to pre-construction, construction and post-construction phases of the project. The present study which forms part of a larger integrated study was meant to collect information on mangroves which are among the most dynamic but fragile eco systems. The main objective of the study was to document the mangroves and mangrove associates in and around Puthuvypin with a view to act as a baseline data for future studies on the impact of the project on the environment. In the study 11 species of true mangroves and 32 species of mangrove associates were found to occur in the area. Various bio diversity threats to mangroves and mangrove associates in the area were also identified and discussed in the paper.

Restoration and propagation are the challenges for mahseer and other cold water fish in tarai region of West Bengal, India

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In India aquatic resource of river constitute an important source of animal protein, but they have been rarely considered in rural development initiatives, perhaps because fish stocks are limited and easily overexploited. They are also vulnerable to activities resulting from human pressure on the environment, such as deforestation and water pollution. The number of indigenous, flora and fauna is declining every year due to the various manmade and natural calamities. Moreover, a number of mini hydroelectricity dams are under construction across the river Teesta that will further add to the decline of various fish species. The rampant destruction of different species of fish during spawning time especially in small streams & tributaries by the local people with the use of pesticides & chemicals and the destruction of their breeding ground with the help of dynamite has taken its toll. Mahaseer (Tor sp.) have been a legendary sport fish not only in West Bengal but also throughout the country with a very high table value. The Mahaseer (Tor tor and Tor putitora) are superior game fish of the cold water streams of the mountain stream illustrate vagaries of human taste better than the Mahaseer. Their sporting attributes plus good public image provide a background for expanding recreational fisheries in the cold waters. The Mahaseer fishery has declined much owing to ecological changes in waterways brought about by barrier effects of dams, in roads of pollution and harmful fishing practices. Barring a few tributaries of Teesta river, where the Mahaseer populations may be in good health, the overall status has invariably become endangered. At many places river courses have changed and spawning beds were destroyed. Destruction of spawning beds and resultant failure of spawning affected seed and fry resources greatly. If the natural spawning of Mahaseer goes unmonitored, the valuable Mahaseer fishery resource of West Bengal, India will become extinct. Mahaseer do not breed in a closed system of impoundments although they can grow to maturity there. They need free-flowing turbulent water fed by melting snow. Their spawning beds must have good-sized pools and rapids, sand bars and gravel. In a closed system of pond water, all these basic habitat needs are not met; therefore, Mahaseer refuse

to breed. In Teesta river of West Bengal originated from the Chsolhamo, North Sikkim, spawning beds are destroyed by dams which can never be compensated. To evolve the original spawning beds takes a long time. But a new spawning channel or incubation channel can be created by habitat manipulation, which can be done by diverting an original river course or side channel at a desirable spot. In Teesta rivers, such ideal places are many and can be utilized with little effort. The breeding places so created may act as fish sanctuary or buffer zone or escape area and help to conserve upstream migrating spawners year after year. Along the diversion side, a river can be tamed so as to create a full-fledged riverine fish farm, where migratory stock of Mahaseer can be regularly ranched. It is proposed to spawn Mahaseer in artificial breeding places alongside streams and rivers, to be followed by releases of fry and fingerlings into streams and rivers for their downstream migration and feeding in the lower reaches of rivers. In the effort to conserve Mahaseer resources artificial propagation of the fish by stripping the spawners is not always possible unless they are dependably obtainable from natural waters. Protection of growing fish will be essential, especially of the mature stocks migrating upstream for breeding. This will greatly help to conserve fish seed resources and bring back depleted fish stocks to the original level of abundance.

Special session: Preparing for climate change in European fisheries and aquaculture: Lessons learned and transferability to the global context

Preparing for sustainable fish production in Europe under climate change

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The overall goal of ClimeFish, an EU Horizon 2020 project, is to help ensure that the increase in seafood production comes in areas and for species where there is a potential for sustainable growth, given the expected developments in climate, thus contributing to robust employment and sustainable development of rural and coastal communities. The underlying biological models are based on single species distribution and production, as well as multispecies interactions. Forecasting models provides production scenarios for fisheries and aquaculture in marine and freshwater, which serve as input to socio-economic analysis where risks and opportunities are identified, and early warning methodologies are developed. Strategies to mitigate risk and utilize opportunities are identified in co-creation with stakeholders, and will serve to strengthen the scientific advice, to improve long term production planning and the policy making process. We address 16 case studies and study the predicted effects of pre-defined climate scenarios. Climate adaption plans coherent with the ecosystem approach and based on a results-based scheme will allow regulators, fishers and aquaculture operators to anticipate, prepare and adapt to climate change while minimizing economic losses and social consequences. As a container for the models, scenarios and adaptation plans we will develop the ClimeFish Decision Support Framework which also contains a Decision Support System; a software application with capabilities for what-if analysis and visualization of scenarios. The ClimeFish concept, approach and preliminary results on will be presented.

CERES – Climate change and European aquatic RESources

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The paper describes the conceptual framework of an EU Horizon 2020 project CERES designed to advances a cause-and-effect understanding of how climate change will influence Europe's most important fish and shellfish resources and the economic activities depending on them. CERES will provide the knowledge and tools needed to successfully adapt European fisheries and aquaculture sectors in marine and inland waters to anticipated climate change. We will identify and communicate risks, opportunities and uncertainties thereby enhancing the resilience and supporting the development of adaptive management and governance systems in these blue growth sectors. CERES strongly supports important European policy goals including self-sufficiency of the domestic supply of fish and shellfish.

Decision support for seafood production under climate change

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To thrive and prosper, and to achieve sustainable production, policy makers and operators need to make informed decisions in relation to many issues, including how to manage stocks and fisheries, what sites to choose for aquaculture production, what species to farm, type and amount of product to produce, etc. The gradual onset of climate change, with increased sea temperatures, more extreme weather, new invasive species and geographical movement of stocks will significantly influence these decisions, and what might have been the right decision a few years ago might be less optimal now. This presentation will summarize results and recommendations from 3 large ongoing EU projects; all aiming at supporting better decisions for policy-makers and operators in an uncertain environment. The MareFrame project seeks to remove barriers preventing a more widespread use of an Ecosystem-based Approach to Fisheries Management. The PrimeFish project aims to improve the economic sustainability of European fisheries and aquaculture sectors, and the goal of the ClimeFish project is to help ensure that the increase in seafood production comes in areas and for species where there is a potential for sustainable growth, given the expected developments in climate. All these 3 projects are currently developing decision support frameworks (DSFs) where expected changes in climate and weather is an important factor; this presentation outlines the content of the various DSFs, highlighting similarities, differences, and opportunities for non-participants to participate in -, and influence the outcome of the respective project development processes.