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8–10 August 2016
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Proceedings of FishAdapt: the Global Conference on Climate Change Adaptation for Fisheries and Aquaculture

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These proceedings present the outcome of the *FishAdapt: the global conference on climate change adaptation for fisheries and aquaculture*. The conference was organized by the FAO, supported through a Scientific Committee and hosted by the Network of Aquaculture Centres in Asia-Pacific (NACA) in Bangkok from 8 to 10 August 2016. The conference was financed through support from the governments of Japan, the Kingdom of Norway, and the United States of America; with contributions from the IAEA, WMO and RARE, whose support is gratefully acknowledged.

Abstract

Climate variability and change are affecting hydro-meteorological cycles and altering aquatic ecosystems, driving shifts in physical and chemical processes, ecological communities and the distribution and abundance of species. These changes have implications for fisheries management, food security and the livelihoods of more than 600 million people worldwide that are employed in fisheries and aquaculture, their value chains and related industries.

This conference, *FishAdapt: the global conference on climate change adaptation for fisheries and aquaculture*, held in Bangkok from 8 to 10 August, 2016, provided a forum for scientists, development professionals and natural resource managers working in the context of fisheries, aquaculture, rural development and related fields to share practical experiences in understanding the vulnerabilities associated with climate change and ocean acidification and the development of risk management and adaptation strategies. The conference bridged interdisciplinary gaps and provide a wider, shared perspective on the issues and the current state of knowledge. These proceedings share the experiences of the 110 participants from 27 countries and show that much can be done at the household, community and sector levels to support the resilience of the sector and its dependent communities in a changing climate.

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Abbreviations and acronyms

ADB	Asian Development Bank
CCRF	Code of Conduct for Responsible Fisheries
CIFE	Central Institute of Fisheries Education, India
COP	Conference of the Parties
DRM	Disaster risk management
EAF/A	Ecosystem approach to fisheries/aquaculture
EEZ	Exclusive economic zone
EIA	Environmental impact assessment
ENSO	El Niño-Southern Oscillation
EU	European Union
FAD	Fish aggregating device
FAO	Food and Agriculture Organization of the United Nations
GDP	Gross Domestic Product
GEF	Global Environment Facility
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit, the German Society for International Cooperation
IAEA	International Atomic Energy Agency
ICAR	Indian Council for Agricultural Research
INCAR	Interdisciplinary Center for Aquaculture Research
IPCC	Intergovernmental Panel on Climate Change
IUCN	International Union for Conservation of Nature
JNAP	Joint National Action Plans
LDC	Least developed countries
LMMA	Locally-managed marine area
NACA	Network of Aquaculture Centres in Asia-Pacific
NAP	National Adaptation Plans
NAPA	National Adaptation Programme of Action
NDCs	Nationally determined contributions (to reducing greenhouse gases)
NGO	Non-governmental organization
NOAA	National Oceanic and Atmospheric Administration
OSPESCA	The Central American Fisheries and Aquaculture Organization
PaCFA	Global Partnership on Climate, Fisheries and Aquaculture
SCCF	Special Climate Change Fund
SIDS	Small island developing states
UNFCCC	United Nations Framework Convention on Climate Change
WMO	World Meterological Organization

The FishAdapt conference 2016

CONVENOR'S MESSAGE

Dr Cherdsak Virapat, Director General, Network of Aquaculture Centres in Asia-Pacific

On behalf of the Network of Aquaculture Centres in Asia-Pacific (NACA), I am pleased that NACA could co-organize the FishAdapt Conference in collaboration with the Thailand Department of Fisheries, FAO, the Global Partnership for Climate, Fisheries and Aquaculture, and relevant partner organizations in Bangkok, Kingdom of Thailand. I would like to quote Mr Ban Ki-moon, the UN Secretary General, who stated:

> *Climate change is a global problem requiring a global solution... It requires urgent efforts on the part of every country, every citizen, every business community and civil society… The severity of cyclones, floods and other consequences of climate change are increasing. Strong disaster risk reduction and adaptation policies will be increasingly essential.*

INTRODUCTION TO THE CONFERENCE

Climate change – as defined by the IPCC as a change in the state of the climate that can be identified by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer (IPCC, 2014)[1] - is altering aquatic ecosystems, driving shifts in physical and chemical processes, ecological communities and the distribution and abundance of species. These changes have implications for fisheries management, food security and the livelihoods of the millions of people worldwide that are employed in fisheries and aquaculture or related industries.

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 overfishing, 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 because of high-dam construction is also an issue. There may also be positive opportunities in

[1] IPCC. 2014. Climate change 2014: Impacts, adaptation, and vulnerability. Intergovernmental Panel on Climate Change, Working Group II. http://www.ipcc.ch/report/ar5/wg2/

fisheries associated with locally improved ecosystem and productivity conditions and in aquaculture with sea level rise and expansion opportunities in salinized coastal margins, or with better temperature conditions for local stocks. Finally, although ocean acidification is not strictly related to climate change, its impacts are often discussed alongside climate change impacts because it is also linked to increasing CO_2 and may have feedback links to climate change. Thus, in this document some adaptation strategies to ocean acidification are also discussed through case studies.

In economies dependent on fisheries and aquaculture, coastal communities, fishers and fish farmers are expected to experience the direct effects of climate change in a variety of ways, such as increased risks of human diseases (for example, malaria and cholera) 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 distribution. One must note that many fishing communities (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. Communities dependent on fisheries and aquaculture often lack the 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 of 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, communities dependent on fisheries and aquaculture can receive targeted and improved weather and extreme event information, which can help ensure the safety of fishing vessels and fishers while 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 if necessary. Methods and zones of fishing and fish-farming 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 caused by 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 (EAFA), using natural defenses to erosion and storms and minimizing the 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. Policymakers 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.

This conference, *FishAdapt: Global conference on climate change adaptation for fisheries and aquaculture* (hereafter referred to as the FishAdapt Conference), targeted a wide range of professionals working in the context of fisheries, aquaculture, rural development and related fields. It provided a forum to share practical experiences in understanding the vulnerabilities associated with climate change and the development of risk management and adaptation strategies. The conference aimed to bridge interdisciplinary gaps and provide a wider, shared perspective on the issues and the current state of knowledge.

CONFERENCE OBJECTIVES

This FishAdapt Conference provided participants the opportunity to share their practical experiences in understanding vulnerabilities associated with climate change and in identifying, prioritizing and implementing adaptation and disaster risk management actions within the fisheries and aquaculture sector and dependent communities. The objectives of the global conference were to:

1. 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;
1. foster the exchange of information and experiences from case studies and projects that 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;
2. disseminate the wealth of experiences shared through the conference proceedings, which will include selected conferences papers;
3. support the development of policy briefs based on input from the conference to inform policymakers on best practices on climate change adaptation and risk management; and
4. increase awareness of the 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.

CONFERENCE THEMES

The Conference included a series of presentations in plenary sessions and four special sessions, with panels and discussion time. The 110 participants (see Annex 2) exchanged experiences and created 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 final, full conference programme is available in Annex 3.

The conference schedule included 45 presentations in plenary sessions covering four areas:

1. Applied risk/vulnerability assessments in fisheries and aquaculture.
   This theme addressed understanding vulnerability of fisheries and aquaculture and their dependent communities to climate change and variability along the value chain.

2. Climate change adaptation efforts in fisheries and aquaculture.
   This theme addressed identifying, prioritizing, negotiating, implementing, and monitoring adaptation actions to reduce vulnerability and to realize opportunities in fisheries and aquaculture now and in the future.

   The scope of adaptation actions could include:
   i. different scales (from individuals, to communities, sectors, regions and beyond);
   ii. ecological, social, economic, institutional, governance, technological and operational or informational aspects of adaptation;
   iii. climate variability versus long-term climate change;
   iv. extreme climate events or slow onset events;

v. reducing vulnerability to specific climate drivers or vulnerability contexts;
vi. different portions of the value chain (production/harvest, post-harvest and trade);
vii. different ecosystems (such as tropical and temperate) in marine, coastal and inland areas — the latter include lakes, reservoirs, rivers and wetlands; and
viii. different sub-sectors — commercial, subsistence, aquaculture, and recreational fisheries.

3. Linking fisheries and aquaculture adaptation to broader processes.
   This theme addressed issues related to:
   a. representing the sector and value chains in national, regional and global climate change adaptation planning processes;
   b. managing synergies and trade-offs between climate change adaptation and greenhouse gas mitigation action in other sectors; and
   c. accessing climate funding for improving resilience.

4. Communicating climate change issues and potential impacts.
   Targets of communication included policymakers, fishers, farmers, fish workers, scientists, development partners, industry and others for effective planning, implementation, and monitoring.

In addition to the plenary sessions, four parallel sessions were scheduled on Day 3:

- Climate change in small-scale fisheries: vulnerability, adaptive capacity and response.
- Integrating gender considerations into climate change and disaster risk reduction strategies for fishing communities.
- Charting a course after Paris: leveraging nationally determined contributions (NDCs) to reduce greenhouse gases, which were at the heart of the Paris Agreement, to address climate challenges for fisheries and aquaculture in the Asia-Pacific region.
- Mangrove-based fisheries and aquaculture in support of climate change adaptation.

Report of the conference

OPENING OF THE CONFERENCE

Dr Chonkolnee Chamchang, Senior Expert on International Fisheries Affairs opened the conference on behalf of the Director General of the Department of Fisheries, Kingdom of Thailand:

It gives me great honour and pleasure to welcome you to this global conference on climate change adaptation for fisheries and aquaculture. This is considered a historic gathering of the global experts on climate change relevant to fisheries and aquaculture.

The FAO's *State of the World Fisheries and Aquaculture 2014* reported capture fisheries production of 91 million tonnes and aquaculture production of 67 million tonnes giving a total of 158 million tonnes. Aquaculture production alone was valued at USD 137.7 billion. The Asia-Pacific region accounts for 88 percent of global aquaculture production.

The Asia-Pacific region is the most vulnerable to natural disasters with up to 70 percent of the disasters occurring in Asia and two-thirds of the victims. Water resources in Asia-Pacific, which are a key to food security, are affected by poor water quality — only 15 percent to 20 percent of wastewater receives some level of treatment before being discharged into water resources. The remainder is discharged with its full load of pollutants and toxic compounds. More than 4.2 billion people live in the Asia-Pacific region constituting 60 percent of the world population.

The Mekong River Commission stated that climate change is no longer just a threat in the Lower Mekong Basin. Its impact is present and is affecting the livelihoods of millions that rely on the river's natural resources. Changes in temperature, rainfall, river flow and flooding as a result of climate change affect agricultural and fisheries and, as a result, reduce food security, especially for the poor. Additionally, a predicted rise in sea level will increase salinity and floods in the Mekong Delta, causing damage to crops in the most productive area of the basin.

Today the world is already facing numerous political and economic crises and now with the impacts of climate change it will be even more difficult to achieve sustainable fisheries and aquaculture goals to increase fish production as food for human consumption to meet the needs of the growing world population.

I hope that the conference will provide a great opportunity for us to share ideas and experiences and recommend appropriate policy guidance, means and implementation for future activities concerning vulnerability assessment and adaptation to the impacts of climate change and related incidents.

Ms Xiangjun Yao, Regional Initiative Coordinator for Asia and the Pacific welcomed delegates on behalf of Ms Kundhavi Kadiresan, Assistant Director-General, FAO Regional Representative for Asia and the Pacific:

It is my pleasure to welcome you all to the first global conference on climate change adaptation for fisheries and aquaculture, which promises to be an exciting three days of learning, discussions, sharing, and networking.

The build-up of carbon dioxide and other greenhouse gases is changing the oceans, coasts and freshwater ecosystems. This is severely compromising the fisheries and aquaculture sector's ability to deliver food for current and future generations and to support the 2030 Sustainable Development Goals and the Paris Agreement of The Twenty-first Conference of the Parties (COP21) of the United Nations Framework Convention on Climate Change (UNFCCC). We must remember that fisheries and aquaculture are vital sources of nutritious food and protein for over four billion people and provide at least 50 percent of animal protein to 400 million people in the poorest countries, including small island developing states (SIDS). Fisheries and aquaculture also support the livelihoods of 10 to 12 percent of the global population, including many vulnerable fishing and fish-farming communities.

Preliminary data on increasing ocean water temperatures imply changes in distribution and production cycles of both freshwater and marine species, with the ranges of most marine species being driven toward the higher latitudes. This migration of commercial species will result in winners and losers, leaving serious deficits in tropical countries where marine fish availability is predicted to decrease by as much as 40 percent. This will have cascading effects on economic growth and jobs along the seafood value chain.

Greenhouse gas accumulation is also increasing the acidification of oceans, with particularly severe consequences for shellfish and squid, mangroves, tropical coral reefs and cold water corals. Coral reefs provide habitats for one out of four marine species and provide almost USD 6 billion/year in benefits through fisheries alone. However, rising temperatures and the recent El Niño event are putting the world's corals at great risk of coral bleaching.

Because of their location and type of livelihoods, fishers, fish farmers and coastal communities are physically at risk of natural hazards exacerbated by climate change, such as toxic algal blooms, floods, strong wave surges and cyclones that destroy infrastructure and make the act of fishing more dangerous, especially for artisanal fishers in small boats.

SIDS — which depend on fisheries and aquaculture for at least 50 percent of their animal protein intake — are in a particularly vulnerable position with respect to natural hazards and changes in availability of fish. In addition, sea level rise could lead to smaller exclusive economic zones (EEZs) as coastlines shrink, which would reduce SIDS' national jurisdictions and their access to marine species and have a direct impact on their economic survival.

Inland fisheries — most of which are in developing African and Asian countries and support direct food security — are also at high risk to changes in water availability and quality, threatening the food supply and livelihoods of some of the world's poorest populations.

We cannot leave these vulnerable communities without options. Communities dependent on fisheries and aquaculture will need our support to transition to new species or fishing zones to make better use of resources in the face of scarcity or to exit the sector if necessary.

There is much we can do at the household and community level to support the resilience of the sector from within — we should ensure they receive timely weather information even while at sea so as to improve the safety of fishing vessels and fishers. We should support them to monitor and analyse local changes and have access to global information. We should provide them with social protection when they need it and help them transition to new fishing and fish-farming methods and zones to adapt to the changes they are perceiving. We should improve post-harvest processes to improve their energy efficiency and to minimize losses resulting from spoilage and disease risks.

We should also provide them with enabling environments such as secure tenure and access rights to the natural resources upon which small-scale fisheries and aquaculture depend. We should promote adaptive fisheries co-management plans, legislate vulnerability assessments within the sector and ensure that our development strategies and policies are both climate proofed and disaster proofed.

We should ensure that the needs of the sector are included in national and regional climate change discussions and require that adaptation and mitigation measures in one sector do not negatively affect food security and livelihoods in other sectors, such as fisheries.

We should also promote climate resilient forms of aquaculture, especially of herbivore species and non-fed species, which when well planned and managed, have great potential for sustainable growth in the face of climate change. Not only can the aquaculture systems provide healthy food and nutrition with a comparatively low greenhouse gas footprint, but they can also provide an alternative food production system in areas no longer appropriate for land farming because of sea level rise or saltwater intrusion.

Fisheries and aquaculture and their dependent communities are at the frontline of climate change impacts. We must safeguard the most vulnerable who rely on the sector — already under stress from pollution, habitat degradation, overfishing and harmful practices — from greater threats caused by climate variability, climate change and ocean acidification. And we must also enable them to avail themselves of opportunities as they arise.

FAO and its partners are working together to reduce the vulnerabilities of those most dependent on fisheries and aquaculture for their existence. FAO is supporting countries in their implementation of the FAO Code of Conduct for Responsible Fisheries, the Ecosystem Approach to Fisheries and Aquaculture, and the recently adopted Voluntary Guidelines for Small-Scale Fisheries, which remind us to recognize and take into account the differential impacts of natural and human-induced disasters and climate change on small-scale fisheries. These will take us far in increasing the resilience of the most vulnerable populations, with livelihoods depending on fisheries and aquaculture in areas vulnerable to climate change.

During these three days, we will discuss efforts to support adaptation in fisheries and aquaculture in different parts of the world. Let us take this opportunity to engage in lively debates, widen our circle of colleagues and friends, and reflect on the next steps for ensuring a climate resilient sector.

Dr Cherdsak Virapat, Director General, Network of Aquaculture Centres in Asia-Pacific (NACA) extended a very warm welcome to the conference participants:

The FishAdapt Conference will provide participants the opportunity to share on the ground experiences in undertaking climate change vulnerability assessments and implementing adaptation actions within the fisheries and aquaculture sector and its dependent communities. The focus will be on applied vulnerability assessments and adaptation planning and implementation activities, but may also include sharing of experiences on how oceanographic, limnology, biological and bio-economic modelling applications have been used to support specific adaptation policies and planning activities within regions, countries, sectors and dependent communities.

The conference is expected to provide:

- increased understanding of plausible adaptation measures in different regional and ecosystem settings among researchers, practitioners and managers;
- conference proceedings documenting shared experiences and recommendations for the future;
- scientific journal articles reviewing adaptation measures in different ecosystems;
- a body of information to keep the FAO Committee on Fisheries abreast of developments; and
- input into UNFCCC processes through the Nairobi Work Plan, the UNFCCC Least Developed Countries Expert Group and the UNFCCC Adaptation Committee, etc.

On behalf of NACA, I would like to take this opportunity to express my sincere thanks to FAO and in particular to Ms. Cassandra De Young and NACA colleagues for their efforts in planning that made this conference possible. I'd also like to thank the Scientific Committee listed in Annex 1, all collaborating partners and each expert that has contributed already and will make further contributions to the success of this conference. I would also like to acknowledge our sponsors FAO, the Norwegian Agency for Development Cooperation, the Kingdom of Thailand's Department of Fisheries, the Government of Japan, National Oceanic and Atmospheric Administration Fisheries of the United States of America, the World Meteorological Organization, the International Atomic Energy Agency's Ocean Acidification International Coordination Centre, and Rare.

CONFERENCE SUMMARY

One hundred and ten participants from 27 countries attended the FishAdapt Conference, which comprised 45 presentations and plenaries, and four special sessions (see Annex 3 for a complete list of presentations). Discussions considered international, national and regional fisheries and aquaculture adaptation priorities, and supporting policy and investment. The diverse presentations raised key points that represent future directions and challenges for the sector in implementing climate change adaptation.

The scaling up of local and national adaptation to support and meet global adaptation goals set the scene for the conference. An overview by Paul Desanker, UNFCCC, of the evolution of global Conference of the Parties (COP) commitments, and scaling up local adaptation through National Adaptation Plans (NAPs), particularly for least-developed countries, highlighted the need for coordination to include all sectors. Global adaptation goals aim to enhance adaptive capacity, build resilience and reduce vulnerability in an effort to meet the global climate target of less than a 2°C temperature increase. The establishment of the Adaptation Committee has provided a process to establish NAPs to address issues associated with loss and damage. NAPs have two objectives: 1) reduce vulnerability; and 2) integrate adaptation into national planning. Future support for nations is available through the Green Climate Fund (GCF) — specific funding for the NAP process — and new guidance is emerging from the GCF Secretariat on accessing funding and ways to develop dedicated resources to access the GCF.

Gender dimensions in climate change adaptation, gleaning from 20 years of the gender working group in the Asia Fisheries Society, was presented by Meryl Williams and highlighted some key gaps and challenges. We were urged to re-think our concept of gender equity and advised how to incorporate gender into climate change adaptation, moving away from gender stereotypes. Gender dimensions are still not fully included in vulnerability assessments or adaptations for fisheries and aquaculture, and gender considerations are absent from the main policy tools (except the recent Small-scale Fisheries Guidelines). The gender lens provides the best opportunity to understand the system and implement effective adaptation solutions, and a greater focus on gender is needed in future work.

The role of science in informing policy and decision-making for climate change adaptation was highlighted in a number of presentations. A case study presented by Bill Dewey, Taylor Shellfish, demonstrated the impacts of ocean acidification on shellfish aquaculture on the west coast of the United States of America, and how collaboration with researchers and proactive responses to monitor ocean conditions have supported the industry's efforts to adapt to future ocean acidification events and change. Julia Sanders, Global Ocean Health, reported on how science is rapidly progressing on climate change and communication updates on ocean conditions and acidification and how this fills a need for practitioners and industry, and there is increasing demand for incorporating science into decision-making. Two presentations on ClimeFish by Michaela Aschan and Petter Olsen, Artic University of Norway, also demonstrated how science is providing decision-support for fisheries management and seafood production. Doris Soto emphasised the critical importance of long-term trends for decision-making to provide information for early warning and rapid adaptation, long-term behavioural change and investment predictability. Johanna Johnson, C_2O Pacific, presented examples from the Pacific region where science is informing fisheries and aquaculture planning and policy, and being downscaled to support resource-dependent communities. Maria Gasalla, University of Sao Paulo, provided key highlights from the International Council for the Exploration of the Sea/the North Pacific Marine Science Organization and the Intergovernmental Oceanic Commission (ICES/PICES/IOC) Third Symposium on the effects of climate change on the world's oceans held in Santos, Federative Republic of Brazil in 2015. Importantly, all these presentations highlight that having access to current scientific information is critical for effective adaptation in the fisheries and aquaculture sector.

THEME 1: APPLIED RISK/VULNERABILITY ASSESSMENTS IN FISHERIES AND AQUACULTURE

Theme 1 began with an overview by Cassandra De Young, FAO, of vulnerability assessment methods and contextual approaches, supported by many case studies demonstrating the utility of the approach to fisheries and aquaculture in different regions. Practical examples were presented from the Western Indian Ocean, the People's Republic of Bangladesh, Lake Chad, the Republic of Ghana, African Great Lakes, the Republic of India, Torres Strait, the Caribbean, and the Federative Republic of Brazil, in a range of ecosystems, including inland and marine capture fisheries. Iris Monnereau showed that method matters and can influence vulnerability outcomes, particularly with the indicators and weightings that are selected. There was a clear focus throughout all presentations on small-scale fisheries, which is not surprising since they are critical for resource-dependent communities and are most at risk from climate change.

A recurring message in Theme 1 sessions was the difficulty of disentangling climate change impacts from responses to other pressures. This was demonstrated for small-scale fisheries in Lake Tanganyika, Lake Chad Basin and the Lower Mekong, where dams, increasing population and demand for food, and agriculture are having significant impacts on freshwater systems, particularly modifying freshwater flows, that currently overshadow any climate change impacts. Future adaptations will need to focus on these immediate sources of impacts as a priority.

The integration of ecological, social and cultural information to understand and assess vulnerability to climate change was presented, with a case study from the Federative Republic of Brazil showing how fishers' perceptions of changes in climate and empirical data can complement each other. An integrated vulnerability assessment from Torres Strait presented by David Welch, C_2O Fisheries, also demonstrated how social indicators can be integrated into assessment methods, and cultural values applied to prioritize adaptation actions. A case study from India presented by Arpita Sharma, Indian Council for Agricultural Research-Central Institute of Fisheries Education (ICAR-CIFE), considered the different perceptions of climate change risk by men and women and found that women perceive greater livelihood vulnerability. Thus gender differences need to be taken into account when designing climate change adaptations. Cultural and gender aspects and traditional knowledge are increasingly being recognized as key information sources and important to assess vulnerability to climate change holistically and inform effective adaptation of fisheries and aquaculture.

THEME 2: CLIMATE CHANGE ADAPTATION EFFORTS IN FISHERIES AND AQUACULTURE

The participants continued sharing experiences on the ground in climate change adaptation in the fisheries and aquaculture sector. Case studies of local and regional adaptation initiatives were presented from the Republic of Indonesia, the Republic of Philippines, and the Republic of India. A series of presentations about community adaptation after Typhoon Haiyan outlined the success of strengthening the value chain and involving women to support the quick recovery of livelihoods in affected communities. However, it is important to have the right enablers and that requires human capacity building. Similar case studies were presented for fishing communities impacted by flooding in the Republic of India and the People's Republic of Bangladesh. Government support to fishing communities, including early warning systems, disaster preparedness, higher spending on infrastructure rebuilding, diversification initiatives and post-disaster loans were shown to reduce damages and support faster recovery.

Throughout the presentations some key messages emerged in terms of effective fisheries adaptations, including: implementation of best management practices (e.g. use of existing fisheries management tools to ensure sustainable use of resources such as an ecosystem approach to fisheries management (EAFM), ensuring adaptation is context specific, incorporating local knowledge into adaptation planning, and scaling up local actions to regional scale. Many good examples of on the ground aquaculture adaptations are available because it is easier to control the system inputs and environment, e.g. constructing deeper ponds, moving cages into deeper, cooler waters, co-culture with plants to reduce acidification. Furthermore, there are different types of adaptation: those within the sector that aim to decrease the impacts of climate change and those outside the sector that involve changes to external drivers of change or exit from the industry. These types of adaptations have variable success rates and are not well documented.

Another key message was that there are still gaps in moving from identifying and understanding impacts to implementing effective adaptations. This was in part demonstrated by a review of five years of peer-review scientific literature where the number of papers published on climate change adaptation increased but there were few examples of observed or implemented adaptations, partly because of knowledge gaps (or lack of documentation of on the ground activities).

THEME 3: LINKING FISHERIES AND AQUACULTURE ADAPTATION TO BROADER PROCESSES

A number of presentations explored the links between the fisheries and aquaculture sector and broader processes, such as financial and insurance mechanisms. Integrating climate change impacts and vulnerability into domestic development planning and budgets is critical to secure sufficient support for adaptation, e.g. setting up bridging credit funds. These efforts at integration should be supported by training and capacity building in sectors outside fisheries and aquaculture to understand the implications of climate change for food security and livelihoods.

Consideration of insurance measures to assist fisheries and aquaculture adapt to climate change or recover from climate disturbances revealed that most mechanisms are not adequate, and alternative insurance measures are needed that are tailored to the specific needs of the sector.

THEME 4: COMMUNICATING CLIMATE CHANGE AND POTENTIAL IMPACTS

Communicating and disseminating accurate information about climate change impacts, vulnerability and adaptation is important for ensuring informed decision-making and eliciting behavioural change where necessary. A number of presentations provided insight into current efforts to communicate climate change information. These included presentations on:

- Organization of the Central American Fisheries and Aquaculture Sector (OSPESCA) efforts to add climate change to the political agenda in Central America and support the development of a sub-regional climate change strategy;

- NGOs using social marketing to promote behavioural change and sustainable practices in fisheries;
- the importance of sharing scientific knowledge and creating accessible outreach material for communicating climate change information to communities;
- avoiding misleading and alarming messages, and highlighting positive actions to empower communities;
- the importance of early-warning systems for climate events that affect fisheries and aquaculture sectors; and
- how effective communications can engender social cohesion, networking and collective action to support adaptations.

SPECIAL SESSIONS

Four parallel special sessions were held on the following topics, with selected summary papers available in the contributed papers section.

1. Climate change in small-scale fisheries: vulnerability, adaptive capacity and responses.
2. Integrating gender considerations into climate change and disaster risk reduction strategies for fishing communities.
3. Charting a course after Paris: leveraging NDCs for action to address climate challenges for fisheries and aquaculture in the Asia-Pacific region.
4. Mangrove-based fisheries and aquaculture in support of climate change adaptation.

GAPS AND FUTURE DIRECTIONS

The conference provided a forum to share practical experience on climate change vulnerability assessment and adaptation initiatives, and demonstrated that much can be done at the household, community and sector levels to support the resilience of the sector in a changing climate. However, some key knowledge gaps emerged that need to be considered, specifically: incorporation of gender dimensions into future assessments and adaptation actions; post-harvest methods to enhance livelihood opportunities; access to markets and international trade; the need for small island states and inland fisheries to be better represented in global initiatives; the role of governance and institutions; and comparisons of short-term versus long-term adaptations that can address different timescales and therefore impacts. These areas provide future directions for research and management, as well as themes for future conferences in this field.

CONTRIBUTED PAPERS

The PowerPoint presentations for all plenary talks, themed and special sessions during the Conference can be downloaded from:

http://www.fishadapt.com/modules/conference/

Contributed papers and summary papers focusing on specific topic areas presented at the Conference are provided below.

Theme 1

Applied risk/vulnerability assessments in fisheries and aquaculture

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

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ABSTRACT
This paper provided an overview of the Third International Symposium on the Effects of Climate Change on the World's Oceans, which was held from 23 to 27 March, 2015 in Santos, Brazil. Almost 300 scientists participated in thematic sessions covering biogeochemistry aspects and evolutionary responses on biodiversity, pathways to sustain marine ecosystem services under climate change, and coastal communities and management objectives. The parallel symposium workshops covered mostly processes on projecting climate change impacts, acidification, carbon pumps, upwelling, climate-ready fishery systems and regional comparisons. Relatively few presentations mentioned adaptation to climate change, and, while several discussed effects for capture fisheries, aquaculture and gender were underrepresented.

INTRODUCTION
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 São Paulo as the local organizer (ICES, 2014). As the third of a series that started in Gijon, Spain - with the aim to capture the latest scientific knowledge on ocean change as a preparation to the Intergovernmental Panel on Climate Change and followed by a second symposium in Yeosu, Korea - the symposium in Brazil showed new scientific developments and challenges, some of which have implications for the fisheries and aquaculture sector. The symposium provided aAn overview of scientific contributions that inform footprints to the fisheries food production and security, highlights knowledge gaps and societal and political challenges relevant to develop adaptation at the local community scale. Here, some key general messages are pointed out as well as several lessons learned that may orientate future global-scale symposia on this topic.

SUMMARY RESULTS
The uncertainties about future vulnerability, exposure and responses of interlinked marine human and natural systems are large, which motivates the exploration of a wide range of socioeconomic futures in all the assessments of risks. This seems particularly challenging due to the number of interacting social, economic, and cultural factors, which have been incompletely considered to date. These factors include wealth and

its distribution across society, demographics, migration, access to technology and information, employment patterns, the quality of adaptive responses, societal values, governance structures, and institutions to resolve conflicts. International dimensions, such as trade and relations among states are also important for understanding the risks of climate change at regional scales.

Modelling ocean behavior is an important scientific contribution to the fisheries and aquaculture sector and the speed of impact of climate change in the oceans seems to depend on the stressor considered (e.g., temperature, oxygen, and primary production). Some of the global models' projections show that model resolution matters: low resolution models are still useful to generate hypotheses but high resolution models are increasing important to projecting changes in fisheries catches.

During the symposium, predicted changes in marine species' distributions were shown, emphasizing a generic poleward shift. Between 25-85% of animals monitored are shifting where they live, but these changes are heterogeneously distributed.

Phenology was also an important topic for the symposium, and its impacts seem to depend on species life history. For example, in the case of small pelagics in Japan, Pacific sardine size at age is predicted to remain the same, because it can utilize more of the subarctic region as a feeding ground. Pacific saury, on the other hand, has already exploited the subarctic region for its feeding ground and, thus, size at age may decrease as a result. The match/mismatch theory seemed resurrected within the research presented and included trends in blooms initiation/delays and spawning durations. The big unknowns were the upwelling systems, which show complex phenological responses.

Important confirmations were seen on ocean acidification, where acclimation periods and rates matter and can also be transgenerational: experiences by parents influencing offspring responses in some fish.

All regional comparisons of climate adaptation in marine fisheries were predominantly more developed country-oriented, and the session on impacts to coastal communities more developing country-oriented. There is still a question on which countries are really moving towards climate-ready fishery systems? From the presentations, it seems that those more focused on top-down approaches (government-science-users) should be in that process. Considering some lessons from developed nations such as Australia, United States, United Kingdom and France, some key points:

- Anticipatory planning, early-observations, seasonal distribution forecasts, supply chains modelling, and input/output controls are part of the adaptation, technical support and conservation measures proposed in Australia. But even there, options seem moderate, with few long-term actions.
- The United States was more focused on fisheries management and harvest control rules (HCR), risk management, and adaptation behavior. Agencies seem to be opened to improve their management systems and to incorporate climate change.
- In the United Kingdom, collaborative monitoring, best practices to more abundant species, methods to increase flexibility, diversification of consumer demand seem to be part of a solid organizational adaptive capacity scheme.
- From France, projections for tuna stocks in the Pacific Ocean showed impacts by shifting habitats east and poleward towards international waters, where fishing effort is increasing and control is more difficult. One example of a developed country capability applied to developing countries was highlighted.

The impacts of climate change on marine ecosystem production across nations was also highlighted; underscoring the importance of jobs, economy and food security. Dependency determines impacts, and in societies dependent on fisheries, the potential catches are predicted to change.

Climate change has increased the frequency of cyclones in Asia, and climatic variables have severe impacts on coastal aquaculture of prawn and shrimp farming, reduced export earning, impacts on livelihoods of coastal poor, effects on households' income, and impacts on economic growth. Thus, increased poverty and vulnerability in coastal nations may be expected.

On the importance of communicating climate change, "non-threatening images that relate to every-day emotions and concerns tend to be the most engaging" (O'Neill and Nicholson-Cole, 2009).

On the symposium's participation, there were about 290 delegates, quite gendered-balanced with 45% female participation, predominantly from North America and Oceania (Australia), and only 3% from South America (except Brazil) and 1% from Africa. Theme sessions covered mostly biogeochemistry aspects and evolutionary responses on biodiversity, pathways to sustain marine ecosystem services under climate change, and one session on coastal communities and management objectives. The symposium workshops covered mostly processes on projecting climate change impacts, acidification, carbon pumps, upwelling, climate-ready fishery systems and regional comparisons, with only 16 presentations mentioning adaptation, 32 fisheries, just one on aquaculture and gender. There were no presentations on fisheries and aquaculture adaptation from South American countries.

CONCLUSIONS

- Oceans are important climate integrators (role in CO2 absorption, atmospheric heat accumulation, continental waters recipient), the cost of which being: ocean acidification, ocean warming, deoxygenation, sea level rise, etc.
- Climate change in oceans poses serious questions on various human-related dimensions including food security.
- Ocean changes due to climate change are an urgent matter for the Sustainable Development Goals (SDGs).
- Climate change management is about managing risk. Science can explain the need for change, characterize the types of things that are expected to happen, but we cannot answer questions about exactly what will change by how much and when. We should be looking to support policies of transition and adaptive response. Precaution is managing risk, not avoiding it.
- Much needed research includes adaptation that goes beyond conservation strategies, (adaptation plans mostly responsive to conservation plans) and more ground experiences reporting (from the sector: what factors are important to climate change adaptation?) Also, more research is needed on the understanding of people's behaviour, beliefs, and perceptions of climate change. More research is also needed to help moving from impacts to adaptation: understanding vulnerability is extremely important, but what about the plans to reduce vulnerabilities at the different scales? As resilience components are non-linear relationships, complexity science will also be important.
- The fisheries and aquaculture sector should benefit from marine sciences although the topic remains secondary in the Climate/Oceanography community (e.g. ICES/PICES/IOC).
- There are still several gaps in adaptation research to fisheries and aquaculture. And there are also opportunities for new technologies and social movements, as well for a broader science integration.
- South America and Africa were the least-covered regions, even within a scientific symposium organized in Brazil.
- Aquaculture and fisheries are part of marine sciences: interactions and inclusions should be explored further. Different communities of scientists that often do not match in symposia should be more integrated. If we aim to cope with the effects of climate change on the word's marine fisheries and aquaculture production and food security, that integration should be important.

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Vulnerability assessments in fisheries socio-ecological systems: some experiences in their development and implementation for adaptation planning

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ABSTRACT

From relatively limited and narrow use two decades ago, the concept of vulnerability has emerged as a key dimension of the development debate. Whether in relation to climate change, natural hazards, globalization and economic development, or socio–ecological system changes more generally, vulnerability is a complex and multifaceted concept that has attracted the attention of scholars and development practitioners from all disciplines. The many interpretations of vulnerability and its many scales (e.g. individual, community, ecosystem, countries, and continents) and fields of application have led to a wide array of propositions regarding ways and means by which vulnerability could be studied, characterized, understood, and acted upon. This multitude of approaches and methodologies of assessment has enabled new insights into the causes and consequences of vulnerability, but has also caused some confusion among practitioners and led to the voicing of a need for clarification and guidance on how best to approach the study of vulnerability. This paper, primarily based on earlier work by Brugère and De Young (2015), provides a brief overview of vulnerability assessment concepts and methodologies. It sheds light on the different vulnerability assessment methodologies that have been developed and how these methodologies have been applied in the context of fisheries and aquaculture, with illustrative examples of their application.

INTRODUCTION

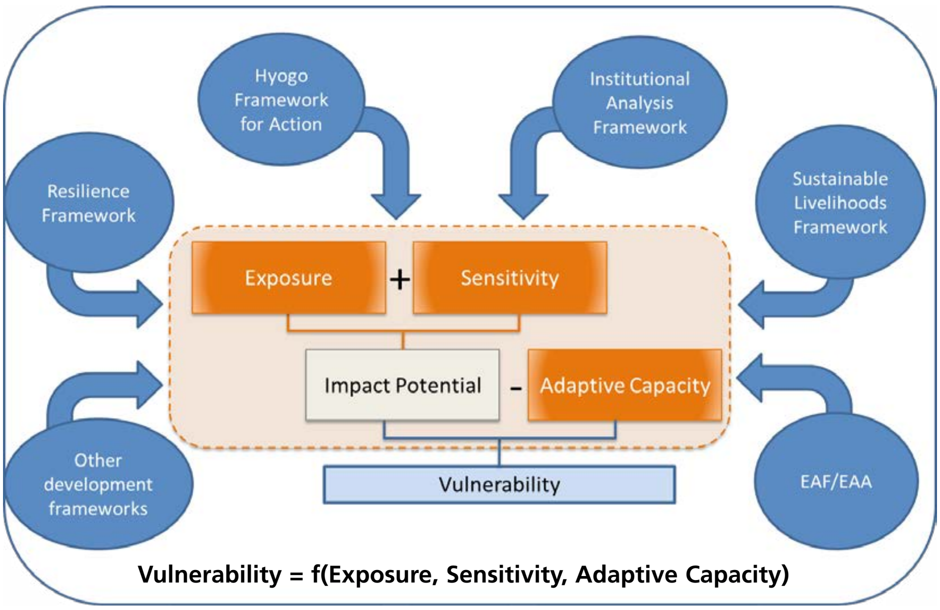
Vulnerability assessments play an important role in the climate change adaptation process (UNFCCC, 2011) in that they link physical changes (either current or projected) with the ability of aquatic and human systems to cope or benefit from such changes. In general, a vulnerability assessment helps to target adaptation actions by better understanding:

1. who the vulnerable people\species are and how their vulnerability can be reduced;
2. where the vulnerable ecosystems are and whether resource management can improve their capacity to adapt;
3. where the economic consequences of the vulnerability of fishery systems will be felt most and how we can plan to minimize those consequences; and
4. where climate change will create new opportunities and bring benefits and, importantly, for whom.

In 2001, the Intergovernmental Panel on Climate Change (IPCC) developed a generic model to assist in understanding the multiple facets of vulnerability as "a function of the sensitivity of a system to changes in climate (the degree to which a system will respond to a given change in climate, including beneficial and harmful effects), adaptive capacity (the degree to which adjustments in practices, processes, or structures can moderate or offset the potential for damage or take advantage of opportunities created by a given change in climate), and the degree of exposure of the system to climatic hazards" (IPCC, 2001). The specific vulnerability questions asked (i.e. vulnerability of whom/what? and what changes and why?) and the methodologies used to answer these questions are often influenced by the background and disciplinary training of the assessor. That is, an assessment stemming from risk/hazard, resilience or political economy traditions may place different emphasis on the various elements underlying vulnerability, such as whether the hazard itself and its impacts are the main elements of concern or, perhaps, whether differential susceptibility to such change is important or whether there are tipping points to such susceptibility. In addition, different disciplines (i.e. natural or social sciences) may also frame the vulnerability assessment in different ways, such as focusing on the vulnerability of the natural system or the human system or whether underlying and existing vulnerability to change determines a system's ability to adapt to a climate related driver (focusing on the source of vulnerability) versus a more linear impacts assessment approach. Understanding the array of different perspectives and methodologies (Figure 1) is necessary to support integrated fisheries and aquaculture vulnerability assessments that combine multidisciplinary factors influencing socio-ecological systems.

The fisheries and aquaculture sector is gaining experience in applying the IPCC framework; allowing for the development of initial guidance on vulnerability assessment processes for the sector (FAO, 2013). Seven examples in capture fisheries and aquaculture that show a breadth of different purposes for the assessment, scales, scopes and methodologies are provided below.

FIGURE 1
The basic IPCC vulnerability framework supported by other frameworks



Source: FAO (2013).

EXAMPLE 1 – National economies' vulnerability to climate change [2]

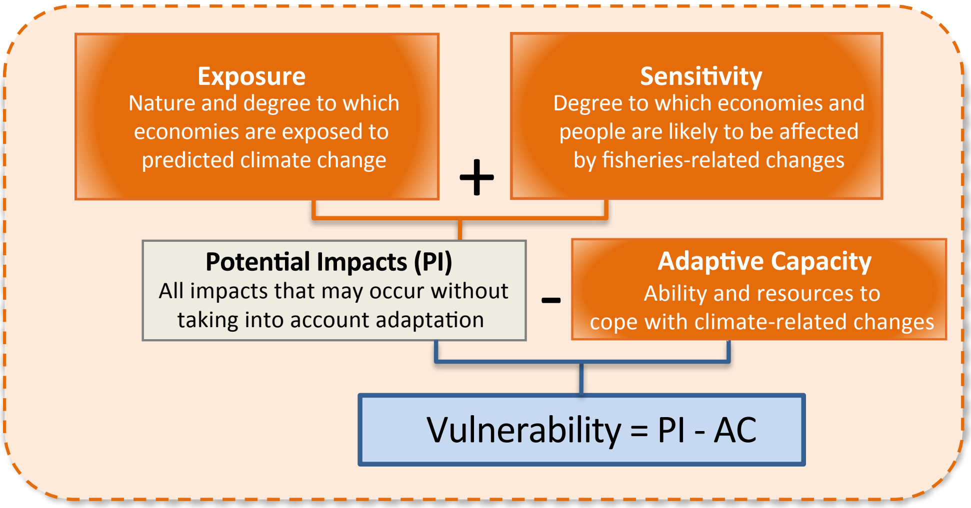
Vulnerability question

How are national economies vulnerable to potential climate change impacts affecting their fisheries?

Purpose of the assessment

As the first global assessment for the fisheries sector, the purpose of this assessment was to raise general awareness within the sector and within the climate change world of potential impacts from increasing temperatures. It also aimed to show how the vulnerability of national economies to changes stemming from the fisheries sector is not limited to areas of greatest temperature changes but also to those economies with high dependence on the sector and low adaptive capacity. The vulnerability framework used for the study is shown in Figure 2.

FIGURE 2
Vulnerability framework used for the fisheries sector



Data and methods

Indicator based for 132 nations
Exposure: 2050 surface temperatures (using the Hadley Centre Coupled Model, version 3,[3] 2 scenarios)

Sensitivity: (Fisheries dependency, both marine and inland) — landings and contribution of fisheries to employment, exports and dietary protein (FAO, World Bank)

Adaptive capacity: Human development indices (health, education, governance, and economy size).

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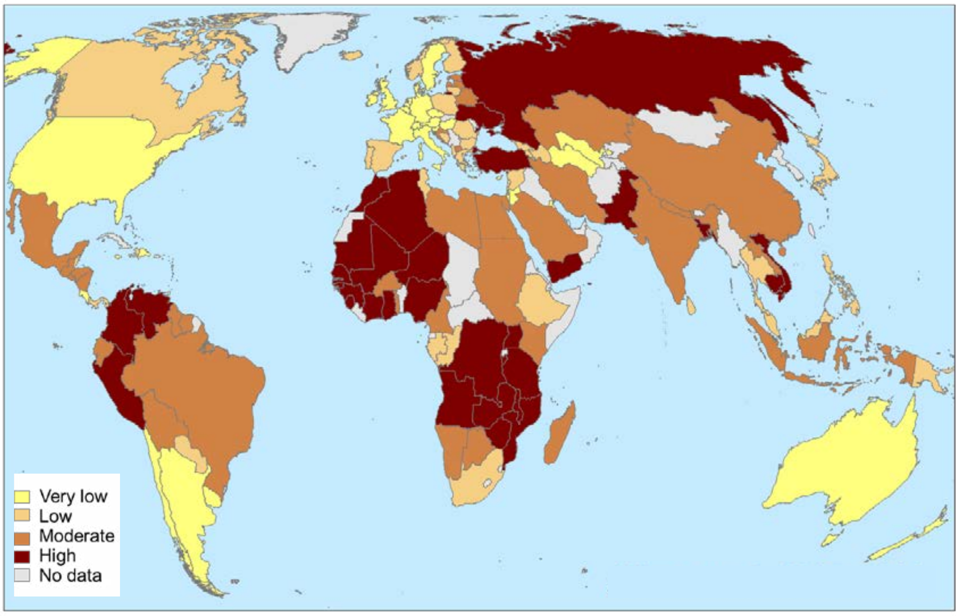
[2] Based on Allison *et al.* (2009).
[3] A coupled atmosphere-ocean general circulation model developed by the Hadley Centre in the United Kingdom.

Presentation of results

Global mapping of relative vulnerability of national economies is shown in Figure 3.

FIGURE 3
Global map of vulnerabilities



Source: Allison *et al*., 2005: 2009.

The boundaries and names shown and the designations used on this map do not imply the expression of any opinion whatsoever on the part of FAO concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers and boundaries. Dashed lines on maps represent approximate border lines for which there may not yet be full agreement

EXAMPLE 2 – Climate change vulnerability of Pacific SIDS economies[4]

Vulnerability question

How are the economies of Pacific small island developing states (SIDS) vulnerable to climate change through potential changes in tuna fisheries?

Purpose of the assessment

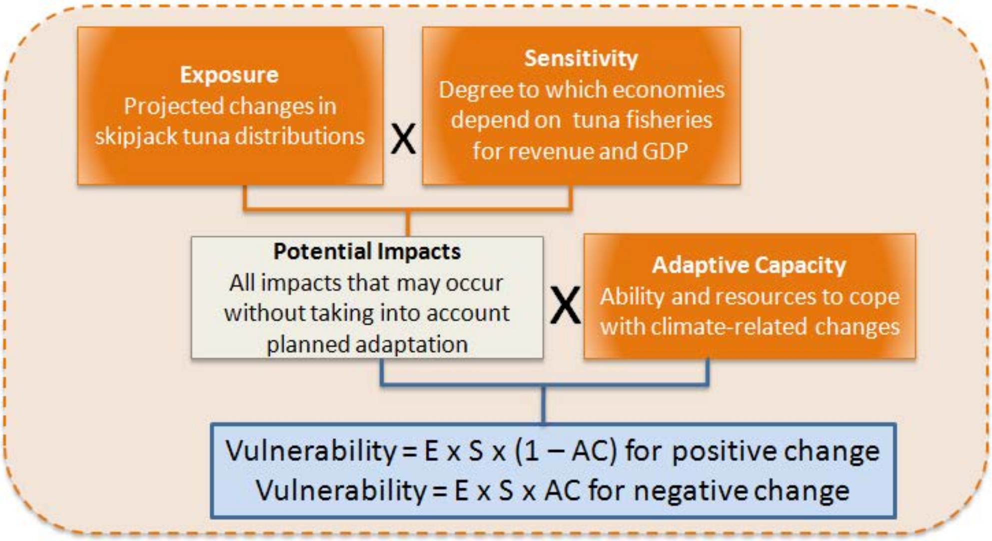
One of a series[5] of vulnerability assessments for the region that had several purposes. The first purpose was to provide information to fisheries managers and policymakers on the vulnerability to climate change of fisheries and aquaculture resources in the Pacific. Recommendations were provided on how best to adapt and ensure that the benefits from fisheries and aquaculture are maintained in the years to come. The second purpose was to produce a valuable resource for anyone wanting to learn about the diverse oceanic, coastal and freshwater fisheries and aquaculture activities of the Pacific Islands region, and the environmental conditions and habitats that support them, thus raising awareness about the immense value of this socio–ecological system.

4 Based on Bell *et al.* (2011).

5 The authors also evaluated the vulnerability of fisheries-dependent livelihoods through projected effects of climate change on all fisheries resources and aquaculture, and the vulnerability of coastal communities to changes in food security resulting from climate change.

Vulnerability framework

FIGURE 4
Framework for vulnerability assessment for the SIDS study



Data and methods

Exposure: estimated from projected change in tuna catch.

Sensitivity: estimated as average contribution to government revenue and GDP.

Adaptive capacity: estimated from four indices: health; education; governance; and the size of the economy.

Presentation of results

The results of the SIDS study are presented in Table 1.

TABLE 1
Comparative benefits and vulnerabilities of selected Pacific Island countries and territories

PICT	2035	2050	2100
PNG	+ Very low	- Very low	- Very low
Solomon Islands	+ Very low	- Very low	- Low
FSM	+ Low	+ Very low	- Low
Kiribati	+ Very high	+ Very high	+ Very high
Marshall Islands	+ Low	+ Low	+ Low
Nauru	+ Moderate	+ Moderate	- Very low
Palau	+ Very low	+ Very low	- Very low
Tokelau	+ High	+ High	+ Very high

(+) benefit, (-) vulnerability to negative economic impacts.

EXAMPLE 3 – Vulnerable fisheries in the Torres Strate[6]

Vulnerability question

What are the most vulnerable fisheries in the Torres Strait region to future climate change?

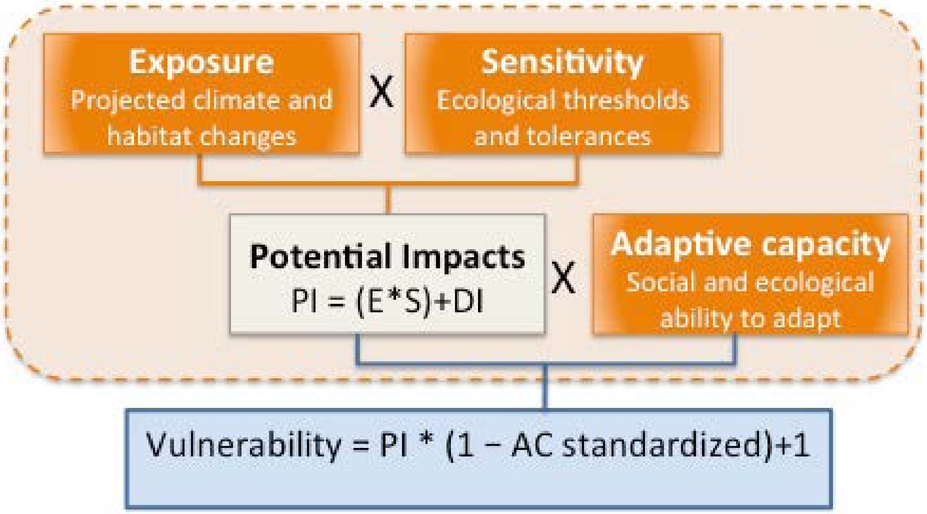
Purpose of the assessment

The assessment was carried out to fulfil a national priority to better understand the likely effects of climate change on Australia's fisheries. The main purpose though was to provide information to fisheries managers on the vulnerability to climate change of fisheries in Torres Strait, and to identify the priority fisheries on which to focus resources. In addition, the results were communicated to Torres Strait Islanders, fishers and managers to help them understand what the main climate change impacts are likely to be, what fisheries are expected to be most vulnerable, and to help them use this information to prepare for and adapt to negative effects and to capitalize on opportunities.

Vulnerability framework

The framework for the study is shown in Figure 5.

FIGURE 5
Framework used for vulnerability assessment of the Torres Strait region Data and methods



Data and methods

The assessors used a semi-quantitative approach to address specific management objectives with multdisciplinary indicators for exposure, sensitivity and adaptive capacity. The indicators and scoring criteria underwent a rigorous selection and expert review process. Indicators were scored using: (1) available literature; (2) expert assessment; and (3) local Indigenous fisher knowledge.

Exposure — 8 indicators:

1) Surface temperature increase
2) Rainfall change
3) pH decline
4) Salinity decrease
5) Habitat changes
6) Altered wind/currents
7) Tropical cyclone intensity
8) More extreme riverflow

[6] Based on Welch and Johnson (2013) and Johnson and Welch (2016).

Sensitivity — 7 indicators:
1) Fecundity
2) Average age at maturity
3) Generalist versus specialist
4) Early development duration
5) Physiological tolerance of stock
6) Reliance on environmental cues
7) Reliance on temporal cues

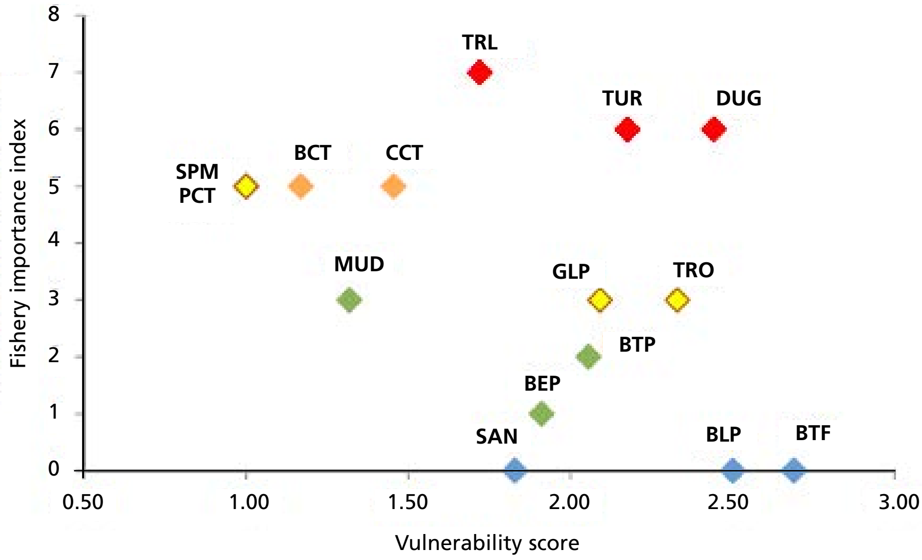
Adaptive capacity — 9 indicators:
1) Stock status
2) Replenishment potential
3) Ability to range shift
4) Species mobility
5) Non-fishing pressures on stock
6) Resource dependence (occupational mobility)
7) Willingness to change practices
8) Climate change awareness
9) Governance structure.

Prioritization was based on a fishery importance (FI) index calculated using: FI index = Ec + (2*C). Where Ec is the economic value and C is the cultural value.

Presentation of results

Prioritization of 15 fisheries' vulnerability against an index of importance is shown in Figure 6. Euclidean distances highlighted adaptation priority: <20th percentile (very high)◆; 20th percentile (high)◆; 40th percentile (moderate)◆; 60th percentile (low)◆; 80th percentile◆(very low).

FIGURE 6
Results of the study of the Torres Strait region



Species codes: BTF – black teatfish, BLP – black-lipped pearl oyster, DUG – dugong, TRO – trochus, TUR – turtle, GLP – gold-lipped pearl oyster, BTP – brown tiger prawn, BEP – blue endeavour prawn, SAN – sandfish, TRL – tropical rock lobster, CCT – common coral trout, MUD – mud crab, BCT – bar-cheek coral trout, SPM – Spanish mackerel, PCT – passion fruit coral trout.

EXAMPLE 4 – Socio-ecological vulnerability of Kenyan coral reef fisheries[7]

Vulnerability question

What is the socio-ecological vulnerability of coral reef fisheries to climate change?

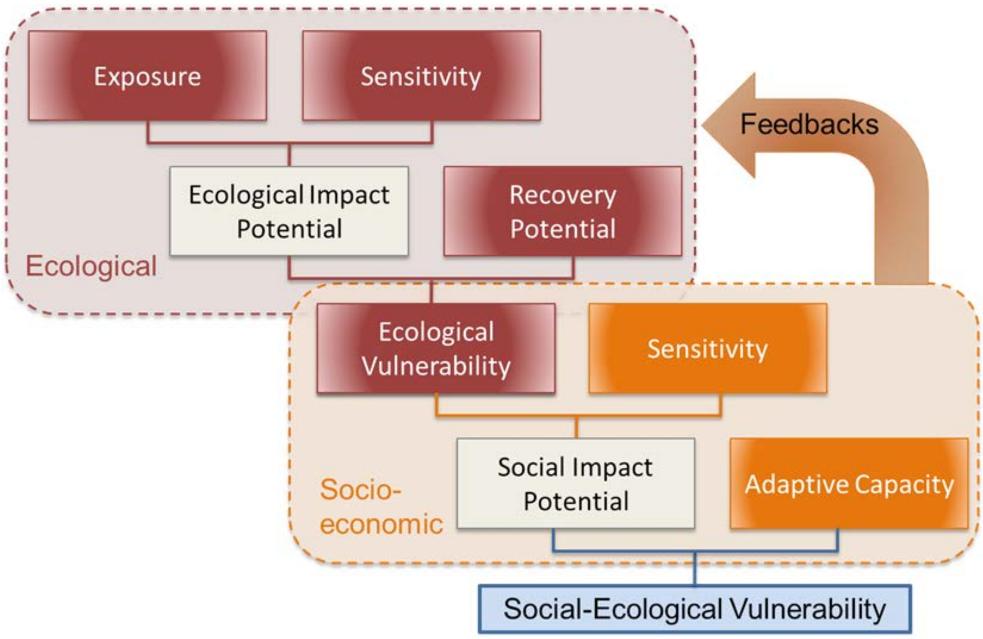
Purpose of the assessment

This study piloted a VA method to help countries, development agencies and their staff, researchers and fisheries professionals to understand how to define and measure vulnerability within complex fisheries systems, using risks of coral reef bleaching in Kenyan reef-dependent fishing communities as an example. Ultimately, the scope of this work was to improve resilience of fisheries systems and dependent communities to multiple drivers of change including climate change and ocean acidification.

Vulnerability framework

The framework is shown in Figure 7.

FIGURE 7
Framework used to assess vulnerability in the coral reefs study



Data and methods

Ecological exposure — based on temperature, currents, light, tidal variation, chlorophyll, water quality - Site-specific index of bleaching stress

Ecological sensitivity — 2 indicators:
Susceptibility of coral community to bleaching
Susceptibility of fish community to population declines associated with coral habitat loss from bleaching

Ecological recovery potential
5 indicators for corals, 6 indicators for fish species

[7] Based on Cinner *et al.* (2013).

Social exposure - is directly defined as exposure through Ecological vulnerability

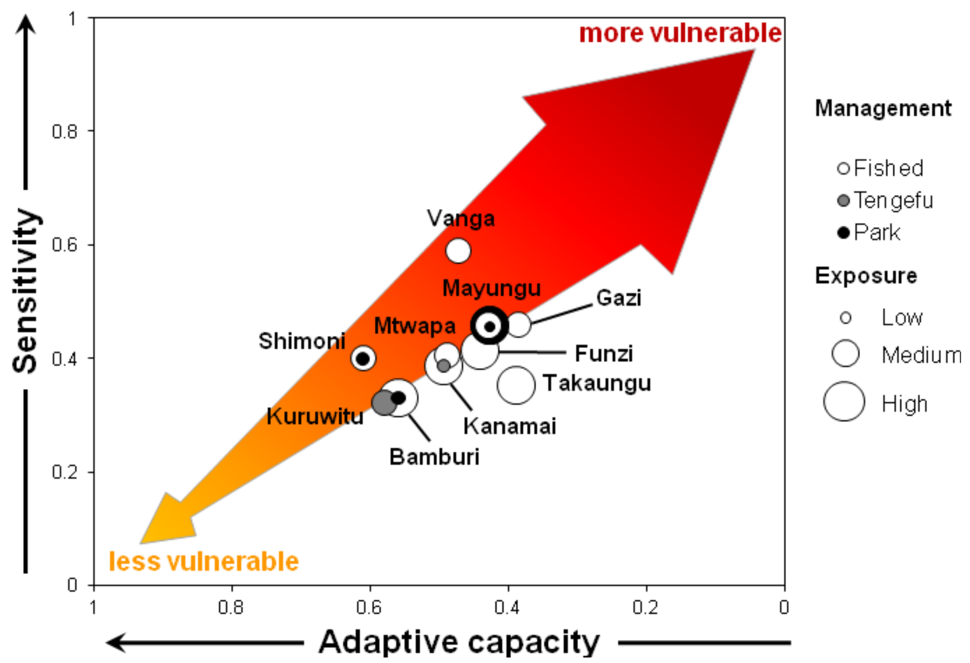
Social sensitivity — 2 indicators:
1) Livelihood sensitivity: dependence on marine resources
2) Gear sensitivity: data on how susceptible the catch composition of different gears is to coral bleaching

Social adaptive capacity — 11 indicators:
1) Recognition of causal agents impacting marine resources
2) Access to credit
3) Occupational mobility
4) Multiplicity of occupations
5) Social capital
6) Material assets
7) Technology
8) Infrastructure
9) Debt levels
10) Trust of community members, local leaders, police, etc
11) Capacity to anticipate change and to develop strategies to respond.

Presentation of results

The results of the study are shown in Figure 8.

FIGURE 8
Social-ecological vulnerability for 10 Kenyan communities



EXAMPLE 5 – Socio-ecological vulnerabilities of fisheries-dependent communities in the Benguela Current Region[8]

Vulnerability question

What are the socio-ecological vulnerabilities of fisheries-dependent communities in the Benguela Current region in relation to climate change and environmental variability, including impacts of other sector activities that may exacerbate vulnerability?

Purpose of assessment

The rapid assessment allowed communities to identify potential threats, strengths and opportunities as well as existing coping mechanisms and adaptation strategies as part of a community-based adaptation process.

Vulnerability framework

Vulnerability was defined as the extent to which a socio-ecological system (coastal fishery system) is susceptible to various socio-ecological changes (including the effects of climate change) and the system's capacity to adapt to and cope with these changes and effects from the viewpoint of local communities. Here, vulnerability is inherent in a social system, i.e. social conditions, historical circumstances and political economy of groups, and is in effect independent of climate aspects. The conceptual framework used was the "360° (degrees) integrated assessment" to assess vulnerability to different social and ecological stressors, and to map out linkages between these factors, i.e. influence of one factor on another.

Data and methods

In each community, using participatory assessment tools, a profile and map of the socio-ecological system were drawn up, perceptions of threats from all sources were identified, and vulnerabilities were assessed in terms of geographical location, fishery, and post-harvest activities as well as the different groups affected such as children, women groups, and institutions. Coping and adaptation mechanisms were then discussed and key adaptation options were highlighted. This rapid assessment was done during a two-day workshop consisting of several dedicated plenary discussions, group exercises and key informant interviews or focus group meetings.

Presentation of vulnerability assessment findings

The results of each step in the assessment are compiled through graphics and tables of current and needed adaptation strategies (See Figure 9). These were then used to identify existing adaptation strategies as well as additional strategies needed.

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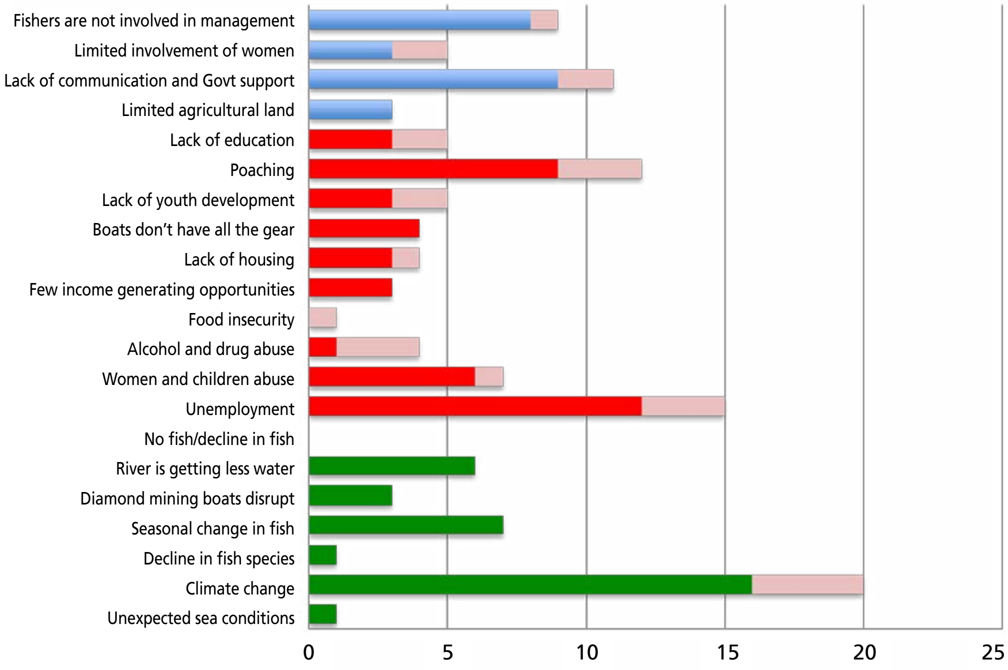
[8] Based on Raemaekers and Sowman (2015).

FIGURE 9
Example results of the study on fisheries-dependent communities



Notes: Women votes = pink; ecological stressors = green; socio-economic stressors = red; governance stressors = blue.

EXAMPLE 6 – Species and production systems' vulnerabilities in the Lower Mekong Basin[9]

Vulnerability question

How are Lower Mekong Basin fisheries and aquaculture species and production systems vulnerable to predicted climate change impacts?

Purpose of assessment

Under the Mekong Adaptation and Resilience to Climate Change (ARCC) project, a series of climate change vulnerability and adaptation studies were undertaken for the water resources, food security, livelihoods, and biodiversity of the Lower Mekong Basin (LMB). The studies laid the foundation for the whole USAID Mekong ARCC project by providing the scientific evidence base for identifying highly vulnerable and valuable agricultural and natural systems assets in the LMB, defining adaptation options and priorities, and guiding the selection of focal areas for enhancing existing adaptation strategies and demonstrating and testing new approaches.

Vulnerability framework

The definitions of vulnerability adopted for the studies were based on the IPCC model of vulnerability tailored to the fisheries and aquaculture species and production systems.

Data and methods

Depending on the eco-zone, drivers of change included: increased temperatures; increased or decreased precipitation; decreased water availability; drought; flooding;

[9] Based on ICEM (2015).

storms and flash flooding; sea-level rise; and increased salinity. These exposure variables, using available projections to 2050 for each zone, were matched to information, such as: status of the species (IUCN red list status – invasive, least concern, vulnerable, endangered); water quality requirements and tolerances; migratory patterns; breeding season; diet; current trends and threats. Expert judgement was used to examine exposure, sensitivity and adaptive capacity of capture fisheries species and aquaculture systems (e.g. extensive pond culture, semi-intensive pond culture, cage culture) and related species (e.g. tilapia, silver barb and carps).

Presentation of vulnerability assessment findings

For each eco-zone, results of information compilations were provided in tables listing evaluations (high, medium, low rankings) of the exposure, sensitivity and adaptive capacity of species and processes to each environmental threat (see Table 2 and Table 3 for examples). Vulnerability assessments for evaluated species and systems were then presented for comparison based on low, medium, high, and very high vulnerability rankings. Adaptation options were then proposed for species/production system relative to their relevance in each eco-zone studied.

TABLE 2
Aquaculture CAM example results for Chiang Rai

System component or assets	Thread	Interpretation of threat	Exposure	Sensitivity	Impact level	Impact summary	Adaptive capacity	Vulnerability
		Written description of how the threat relates to the system component	*refer to table*			*Written explanation of what the impact is, and why it was scored (high, med, low)*	*refer to table*	*refer to table*
SEMI INTENSIVE POND POLYCULTURE OF TILAPIA, SILVER BARB AND CARPS	Increase in temperature	Maximum temperatures increases of up to 10% in the wet season. 5-7% during other seasons. Even higher relative changes in minimum temps 3-27%, highest in the cool season.	High	High	High	Reduced oxygen levels. Poorer water quality. Disease incidence. Reduced survival rate and growth of fish.	Low	High
	Increase in precipitation	Increased precipitation in the period March-December, highest in the months of Aug & Sept and Oct. Highest percentage increase in precipitation occurs in December (40%).	Medium	Low	Medium	Reduced water quality through turbidity. Reduced productivity of pond and growth of fish	High	Medium
	Decrease in precipitation	Decreases in precipitation are projected to occur during the months of Jan & Feb, (although these are low rainfall months they are not the driest months).	Medium	Very high	High	Stagnation of pond water. Ammonia accumulation. Water column stratification. Potential die offs.	Very low	Very high
	Decrease in water availability	Reduced soil water availability in period Feb-May and Aug & Sept. The dry season decrease may affect stream water flows.	Low	Medium	Medium	Accumulation of wastes in pond. Poorer water quality. Capacity to fill ponds. Reduced survival and growth of stock.	Medium	Medium
	Increase in water availability	No negative effect.	-	-				
	Drought	Droughts (>60% of years for 6 months) resulting in poorer water quality, increased fishing pressure in refuge areas. Negative effects compounded by temperature increase.	Medium	Very high	High	Difficulty in maintaining pond water levels. Stratification. Reduced survival and growth of stock.	Low	High
	Flooding	No negative effects anticipated	High	Very high	Very high	Control of pond water levels. Maintenance of pond fertility. Loss of stock from pond.	Medium	Very high
	Storms and Flash floods	Increase in the number of days with daily precipitation above 100 mm, from 7-10 days. Increase in the highest single daily precipitation; 160 mm	Medium	Very high	High	Control of pond water. Maintenance of pond fertility in pond. Loss of stock from pond. Damage to pond infrastructure.	Low	High
	Sea level rise	n/a						
	Increasing salinity	n/a						

TABLE 12
Capture fisheries and aquaculture summary vulnerability results for Chiang Rai

Species	Threat	Vulnerability
1. *Tor tambroides* UPLAND FISH, SOME MIGRATION, IMPORTANT FOR FOOD SECURITY IN SOME AREAS	Increase in temperature	Very high
	Increase in precipitation	Medium
	Decrease in precipitation	High
	Decrease in water availability	Medium
	Increase in water availability	-
	Drought	Medium
	Flooding	-
	Storm and Flash floods	High
	Sea level rise	-
	Increasing salinity	-
2. *Cyclochcilichthys enoptos* MIGRATORY, MEDIUM, WHITE FISH IMPORTANT FOR FOOD SECURITY	Increase in temperature	Very high
	Increase in precipitation	Medium
	Decrease in precipitation	High
	Decrease in water availability	Medium
	Increase in water availability	-
	Drought	Medium
	Flooding	-
	Storm and Flash floods	Medium
	Sea level rise	-
	Increasing salinity	-
3. *Trichogaster pectoralis* NON MIGRATORY, SMALL BLACK FISH, IMPORTANT FOR FOOD SECURITY	Increase in temperature	Medium
	Increase in precipitation	Medium
	Decrease in precipitation	Low
	Decrease in water availability	Medium
	Increase in water availability	-
	Drought	Medium
	Flooding	-
	Storm and Flash floods	Medium
	Sea level rise	-
	Increasing salinity	-

System & species	Threat	Vulnerability
INTENSIVE POND MONOCULTURE OF CLARIAS CATFISH	Increase in temperature	High
	Increase in precipitation	Low
	Decrease in precipitation	Medium
	Decrease in water availability	Very high
	Increase in water availability	-
	Drought	Very high
	Flooding	Very high
	Storm and Flash floods	High
	Sea level rise	-
	Increasing salinity	-
SEMI-INTENSIVE POND POLYCULTURE OF TILAPIA, SILVER BARB AND CARPS	Increase in temperature	High
	Increase in precipitation	Medium
	Decrease in precipitation	Very high
	Decrease in water availability	Medium
	Increase in water availability	-
	Drought	High
	Flooding	Very high
	Storm and Flash floods	High
	Sea level rise	-
	Increasing salinity	-
EXTENSIVE POND POLYCULTURE OF CARPS & TILAPIA	Increase in temperature	Medium
	Increase in precipitation	Low
	Decrease in precipitation	Medium
	Decrease in water availability	High
	Increase in water availability	-
	Drought	High
	Flooding	High
	Storm and Flash floods	Medium
	Sea level rise	-
	Increasing salinity	-

EXAMPLE 7 – Marine fish and invertebrate species vulnerabilities in the United States of America[10]

Vulnerability question

Which marine fish and invertebrate species have life histories and exposures that may leave them vulnerable to large changes in abundance or productivity?

Purpose of assessment

A VA methodology was created to be applicable across marine ecosystems of the United States of America. The results provide insight into which species are likely to be the most vulnerable to climate change and identify the key drivers behind the vulnerability. Scientists, managers and fishers are expected to use this information as they prepare for and adapt to future conditions.

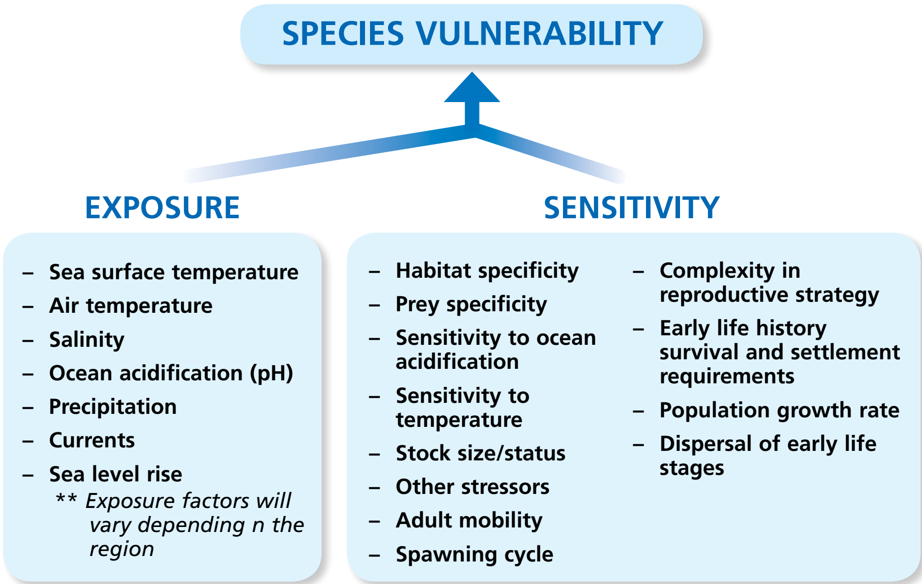
Vulnerability framework

The basic IPCC model of vulnerability was modified such that vulnerability is a combination of exposure and sensitivity, where sensitivity includes the adaptive capacity of the species. The sensitivity component was divided into 12 sensitivity attributes and the exposure component was divided into a number of exposure factors (Figure 10).

Climate exposure was defined as the overlap between the species distribution and the magnitude of the expected environmental change. Exposure factors considered

[10] Based on Morrison *et al.* (2016) and Hare *et al.* (forthcoming).

FIGURE 10
Framework used to assess the vulnerability of marine and vertebrate species



varied depending on what environmental factors are important to the region of interest, but included sea surface temperature, air temperature, pH, salinity, precipitation, currents and sea-level rise. Sensitivity was defined as the inherent biological attributes of a species that are predictive of their ability/inability to respond to potential environmental changes.

Data and methods

The methodology relied on technical experts using species profiles, based on the scientific literature and general knowledge to provide a score for each species for each sensitivity attribute and for each exposure factor. Both individual and group expert elicitation practices were used to minimize bias and increase precision of the results. The methodology allowed experts to account for their uncertainty when assigning a score. Experts had five "tallies" for each sensitivity attribute and exposure factor, which they distributed among four scoring bins (low, moderate, high or very high) depending on their confidence in the score as well as a data quality score for each attribute.

The authors used three steps to combine expert tallies into a final vulnerability rank for each species. First, they calculated the sensitivity attribute and exposure factor means based on the distribution of all expert tallies across the four scoring bins. Second, they calculated component scores for exposure and vulnerability based on a logic model. Finally, exposure was multiplied by sensitivity to calculate the overall vulnerability score.

Presentation of vulnerability assessment findings

Results of the first implementation of the assessment for 82 species found in the Northeast United States Continental Shelf Large Marine Ecosystem were presented to summarize results as a whole as well as for individual species (Table 4 shows the results for Spanish mackerel). Species narratives were provided, detailing overall vulnerability rank, the exposure factors and life-history attributes that led to that rank, as well as a discussion of data quality and future research priorities.

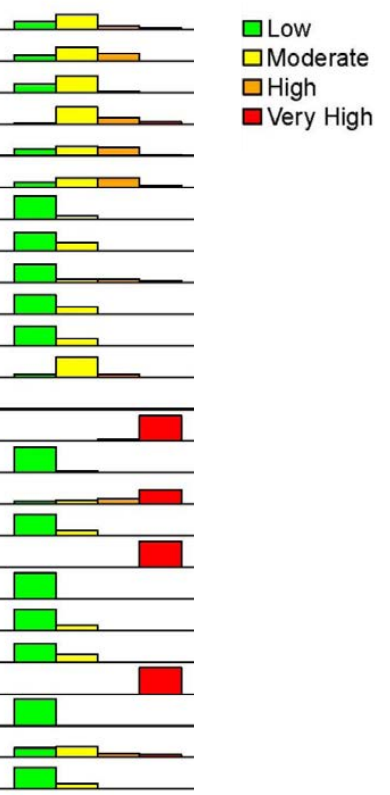
TABLE 4
Example of vulnerability assessment output for one species (Spanish mackerel)

Spanish mackerel – *Scomberomorus maculatus*

Overall Vulnerability Rank = Moderate

Biological Sensitivity = Low
Climate Exposure = Very High
Data Quality = 83% of scores ≥ 2

Scomberomorus macultus	Expert scores	Data quality	Expert scores plots (portion by category)
Stock status	1.9	2.2	
Other stressors	2.1	1.8	
Population growth rate	1.7	2.6	
Spawning cycle	2.4	2.8	
Complexity in reproduction	2.1	2.6	
Early life history requirements	2.3	1.2	
Sensitivity to ocean acidification	1.1	2.2	
Prey specialization	1.3	2.8	
Habitat specialization	1.6	3.0	
Sensitivity to temperature	1.3	3.0	
Adult mobility	1.3	2.4	
Dispersal & early life history	2.0	2.6	
Sensitivity score	Low		
Sea surface temperature	4.0	3.0	
Variability in sea surface temperature	1.1	3.0	
Salinity	3.2	3.0	
Variability salinity	1.2	3.0	
Air temperature	4.0	3.0	
Variability air temperature	1.0	3.0	
Precipitation	1.2	3.0	
Variability in precipitation	1.3	3.0	
Ocean acidification	4.0	2.0	
Variability in oa	1.0	2.2	
Currents	2.0	1.0	
Sea level rise	1.2	1.5	
Exposure score	Very high		
Overall vulnerability rank	Moderate		



Notes: Expert vulnerability scores: 1 = low, 2 =medium, 3 = high, 4 = very high.
Data quality scores: 0 = no data, 1 = expert judgement, 2 = limited data, 3 = adequate data.

CONCLUSIONS AND FUTURE DIRECTIONS

The recommendations that stem from these examples and existing experiences include:

a) the importance of clearly defining the vulnerability question to be answered and the purpose of the assessment as the starting points of any assessment;

b) understanding that the scale, approach and method of vulnerability analysis should be determined by its purpose but will be influenced by resources, time, expertise and availability of data;

c) the benefits of combining top-down and bottom-up analyses, linking social and ecological vulnerabilities, keeping indicators simple, clearly defining pathways of impact and keeping policy/practice objectives in focus; and

d) acknowledging that a vulnerability assessment is a means to an end and that a detailed and costly vulnerability assessment may not be necessary as many climate-change adaptations are "no regrets" actions.

The IPPC simplified framework for vulnerability is evolving and gaining application in fisheries and aquaculture. There is much learning to come as we gain more experience in undertaking vulnerability assessments as part of broader adaptation planning processes.

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Potential effects of climate change on livelihoods of fishers of Bhadra reservoir, Karnataka: a gender analysis

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ABSTRACT

To explore if women and men in fisheries-dependent livelihoods perceive climate change vulnerability differently, a study was undertaken in the Bhadra reservoir, Karnataka State of the Republic of India. The reservoir, which is a source of fresh water, is under stress because of climate change (temperature and precipitation changes), continuing growth in human freshwater consumption and rising needs of agricultural and energy development. A composite livelihood vulnerability index with exposure, sensitivity and adaptive capacity parameters, was computed. This incorporated the sustainable livelihoods approach to understanding sensitivity and adaptive capacity along with rainfall and temperature trends representing exposure to climate drivers. It was found that women and men experience climate change vulnerability differently. Normalized vulnerability scores ranged from 0 (not vulnerable) to 1 (extremely vulnerable) and women had a highly vulnerable score of 0.40 and men with a score of 0.34 were moderately vulnerable. Women perceived that they were more at risk than men regarding the perceived effects of climate change on livelihood assets. Both men and women reported that financial capital will be affected in most of the livelihood asset categories. The differences in perception of men and women were found to be statistically significant, suggesting a need to have gender assessments. Fishing communities are dependent on natural resources and women and men experience climate change differently, because of their social and economic roles.

INTRODUCTION

Calls to take action to meet the interlinked global challenges of climate change and sustainable development are being made continuously. Sources of fresh water, for example, have been put under tremendous stress from the continuing growth in human fresh water consumption, as well as the rising water needs of agricultural and energy development. This is a concern for the Indian economy, which is tied to natural resources and can be severely impacted by climate change effects on the natural resource base. One of the most potent impacts of climate change in the country is alteration of the monsoon patterns and it has been reported on the website of the Republic of India's Meteorological Department that there is a wide range of spatial variation because of orographic influences and preferential occurrences of rain bearing systems in certain regions. Increased variability in monsoons can lead to water level fluctuations in Indian reservoirs as they are very dependent on rainfall in catchment areas. As Indian reservoirs preserve a rich variety of fish species, which supports commercial fisheries (Thirumala *et al.*, 2011), water level fluctuations in reservoirs will certainly affect the fisheries and impact fishers' livelihoods. Bruinsma (2003) and FAO (2009) have reported that fisheries in fresh-water systems could be affected by climate variability and change. Climate change may affect the livelihoods of its people and Rao and Basuray (2006) have reported that climate change impacts are likely to be most severe for those who have reduced capacities to adapt to climate variability.

This study assesses the vulnerability of fisheries-dependent livelihoods to climate change and whether perceived vulnerability is gender specific. The study site, the Bhadra reservoir, is located in the state of Karnataka. It is likely to be more vulnerable to climate change than other states and 54 percent of its geographical area is already drought prone, making the state second only to one other region, Rajasthan. The state possesses the third highest area of total inland water bodies with over 500 000 ha, comprising 73 reservoirs (IISc, 2014). Hydrologic modelling by Rao *et al.* (2006) of major river basins in the Republic of India predicts that the most severe reduction in runoff will occur in the Krishna Basin, which feeds the Bhadra reservoir. In addition, a considerable portion of the population in Karnataka is dependent on fisheries.

METHODS

Bhadra reservoir is one of the largest reservoirs in Karnataka. It is located at Chikkamagalore district and is a multipurpose project for power generation and irrigation. Bhadra basin gets inflows from the southwest monsoon (June to September) and the northeast monsoon (October to December). Average rainfall of the area is 117 cm to 513 cm. The depth of the reservoir is about 186 feet and total length is 1 445 feet. As reported by Bhaktha and Bandyopadhyay (2008), the fish diversity of the reservoir is on a decline and a few species have been lost already from this freshwater ecosystem. Similar results are reported by Shahnawaz et *al.* (2010), Thirumala *et al.* (2011) and the Indian Institute of Sciences (IISc), Bangalore (IISc, 2014). Jain and Kumar (2012) have reported that because of uneven distribution of rainfall there is mismatch between water availability and demand. As per the Department of Fisheries (DoF), Karnataka, nine villages with about 250 to 300 fisher households are dependent on Bhadra reservoir. For the study, 120 fisher respondents (60 men and 60 women from the same households) were randomly selected and information was collected on various parameters with the help of an interview schedule and household discussions.

To assess the vulnerability of fisheries-dependent livelihood assets, a perceptions-based composite vulnerability index approach was developed based on the assumption that vulnerability "is a function of the character, magnitude and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity" (IPCC, 2001). Livelihood assets were defined using the sustainable livelihoods approach (Conway *et al.*, 2002) and included human capital, natural capital, financial capacity, physical capital. Exposure of livelihood assets was evaluated through the perceived impacts of change in fish availability on household livelihood assets.

Information on the community's exposure, sensitivity and adaptive capacity to these climate drivers was gathered through interviews consisting of questions relating to the above characteristics. Respondents were asked to rank themselves on these parameters on a 5 point scale, which ranged from no effect (score 0) to extremely high effect (score 4).

Vulnerability was calculated by using the formula V = E * S * (1 – AC) (IPCC, 2001). Respondents were asked how vulnerable they perceived themselves on these parameters on a 4 point scale which ranged from no effect (score 0) to extremely high effect (score 4). Primary data obtained were normalized and rescaled from 0 - 1 using the formula:

$$\text{IndexXi} = \frac{\text{Xi} - \text{Xmin}}{\text{Xmax} - \text{Xmin}}$$

Where IndexX_i is a normalized value of an indicator of a household; X_i is the actual value of the same indicator, and X_{min} and X_{max} are the minimum and maximum values across the respondents, respectively, of the same indicator. Thus, scores ranged from 0 to 1 with 0 = not vulnerable, above 0 but below 0.2 = less vulnerable, above 0.2 to 0.4 = moderately vulnerable, above 0.4 to 0.6 = highly vulnerable, above 0.6 to 0.8= very highly vulnerable, and above 0.8 to 1 = extremely vulnerable.

To test the hypothesis that there was a significant difference between the perceptions of men and women, a Mann-Whitney U test was done, and to test whether differences exist among the nine villages, a Friedman test was done.

RESULTS

It can be seen from Table 1 that the overall vulnerability score was 0.37, suggesting fishers perceived their livelihood assets to be moderately vulnerable as, although their exposure and sensitivity to climate drivers are perceived as very highly vulnerable, adaptive capacity is also perceived to be very high. The average score for men was 0.34 (moderately vulnerable) and for women it was 0.40 (highly vulnerable).

TABLE 1
Livelihoods vulnerability scores for fishers of Bhadra reservoir

Parameters	Men	Women	Men & Women
Exposure	0.66	0.75	0.71
Sensitivity	0.64	0.72	0.68
Adaptive capacity	0.80	0.72	0.76
Average vulnerability scores	0.34	0.40	0.37

Based on the results of the Mann Whitney U test used to compare perceptions between men and women (Table 2) no significant differences for exposure were found as climate itself was not perceived differently between men and women. However, the differences in perceived sensitivity and adaptation capacity between men and women were statistically significant. This is likely a result of differences in socio-economic settings within the household for men and women and, as per Smit and Wendel (2006), sensitivity can be altered by socio-economic changes.

TABLE 2
Mann-Whitney U test results

Parameters	Z value	P value	Decision
Exposure	-0.970	0.332	Accept H_o
Sensitivity	-2.872	0.004	Reject H_o
Adaptive capacity	-3.504	0.000	Reject H_o

The Friedman Test was done to test differences between respondents of villages and the results are presented in Table 3.

TABLE 3
Test statistic for Friedman test

N	5
Chi-Square	6.061
Df	8
Asymp. Sig.(P)	0.640

No significant difference was found in perceptions of respondents residing in different villages, probably because of their dependence on the same reservoir for their livelihood and being economically and socially a similar type of group.

Breaking down impacts by livelihood assets, Table 4 and Figures 1 and 2 present scores of perception about the impacts of climate change on the five livelihood assets categories.

TABLE 4
Average scores for perceived impacts of climate change on livelihood assets

Livelihood assets categories	Score of men	Score of women	Score of men and women	Rank
Financial	3.16	3.16	3.16	1
Human	2.89	2.93	2.91	2
Physical	2.69	3.06	2.88	3
Natural	2.59	2.93	2.76	4
Social	2.68	2.60	2.64	5
Total score	2.80	2.94	2.87	

Note: Potential scores ranged from 0 to 4.

FIGURE 1
Perceptions of men about potential effect of climate change on livelihood assets

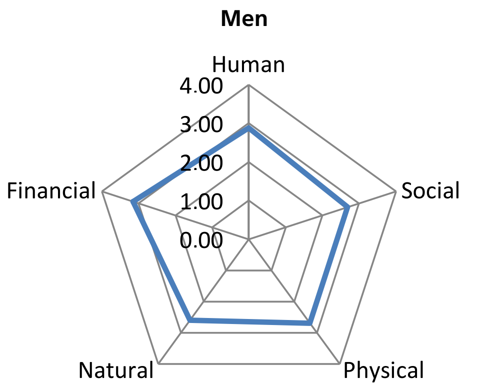
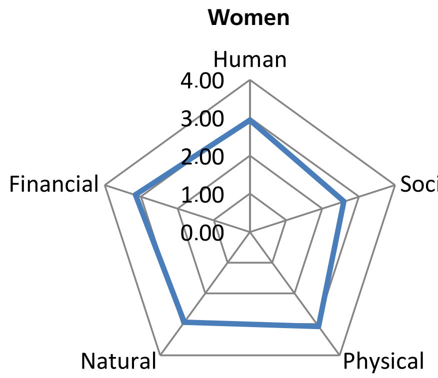


FIGURE 2
Perception of women about potential effect of climate change on livelihood assets



The average score for potential impacts of climate change on livelihood assets was 2.87, suggesting that fishers perceived climate change to have a moderate effect on their livelihood capitals. Women perceived climate change to have a slightly higher effect on their livelihood capitals. Both men and women perceived that financial capital will be affected more, relative to other assets.

The hypothesis that men and women perceived impacts differently was tested using a Mann-Whitney U test (Table 5). Statistically significant differences between the perceptions of men and women were found for natural, physical and social capital assets, but no statistically significant differences were found for human capital and financial capital assets.

CONCLUSIONS AND DISCUSSION

The study has shown that fishers in the Bhadra reservoir perceived their livelihoods assets vulnerable to climate change. Women, with an average vulnerability score of 0.40/1, perceived themselves as slightly more vulnerable to climate change because of higher sensitivity and lower adaptive capacity to change relative to men. Regarding effects on livelihood assets, the average scores on a 4 point scale were 2.94 and 2.80 for women and men, respectively, suggesting that women perceive that climate change

TABLE 5
Mann- Whitney U test result

Parameters	Z value	P value	Decision
Human capital	-0.244	0.808	Accept H_o
Physical capital	-3.634	0.000	Reject H_o
Natural capital	-2.585	0.010	Reject H_o
Social capital	-2.513	0.012	Reject H_o
Financial capital	-0.240	0.810	Accept H_o

will have a greater effect on women's livelihood assets. Both men and women reported that financial capital assets are most affected among their livelihood assets. Differences in perceptions between men and women were found to be statistically significant, suggesting that there is greater need to have gender specific assessments which will help in designing better intervention strategies benefiting both men and women. Fishers' reported reductions in weight of Indian major carps over the years and attributed these decreases to increases in water temperatures. Dependency of fishing communities on this reservoir is high and possible impacts because of the changing environment are reducing their livelihood options.

To attain effective and equitable adaptation, an understanding of the dynamics of vulnerability is required. Gender influences these dynamics, and therefore vulnerability assessment must take gender differences into account. In a nutshell, this study has revealed that women perceive that they experience greater hardship than their male counterparts because of climate change.

FUTURE DIRECTIONS

This study has shown that fishing communities, who often find themselves in vulnerable situations, perceive themselves to be affected by climate change too. Gender differentiated vulnerabilities and adaptation strategies need to be mainstreamed into climate change policies as impacts and adaptive capacities are perceived differently by men and women. Such mainstreaming of gender issues would help ensure that policy and operational responses to climate change go further in terms of meeting the needs of vulnerable members of society. As livelihood assets are perceived to be vulnerable to climate change, there is a need to mainstream climate change adaptation into poverty reduction programmes and integrating fisheries-specific needs into these. Increasing fishers' awareness of climate change and providing targeted assistance to cope up with changes will help in ensuring the adaptive capacity of fishers.

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

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INTRODUCTION

The Republic of Bangladesh's fisheries sector supports the livelihoods of millions of people and contributes significantly to GDP and nutrition. It is also considered one of the most vulnerable sectors in a country that is highly vulnerable to climate change impacts (Allison *et al.,* 2009). The country has 64 districts with diversified fisheries resources categorized into inland capture, inland culture and marine capture. The degree of exposure to various climatic hazards and adaptive capacity is different among districts. The major climatic shocks faced by the fishing communities of coastal districts in the country are sea-level rise, salinity intrusion, cyclones and storm surges. In addition, the fishing communities in the southwest and northwest regions are particularly susceptible to drought (Shahid and Behrawan, 2008).

A number of studies have investigated climate change impacts, vulnerability or adaptation of fisheries at national or regional levels (e.g. Allison *et al.*, 2009), and other assumption-based studies or case studies have been conducted (e.g. Islam *et al.*, 2014a and b). However, to date no research has been conducted to measure the district level vulnerability of fisheries to climate variability and change in the Republic of Bangladesh. As such, the objective of this study was to measure the degree of vulnerability of the fisheries sector to climate variability and change in 64 districts using a composite vulnerability index approach and GIS.

METHODS

To measure district level vulnerability, this study first developed indicators for the components of vulnerability (exposure, sensitivity and adaptive capacity), followed by collection of indicator data and calculation of vulnerability. The exposure indicators included: variation in historic maximum temperature (°C); variation in historic minimum temperature (°C); future temperature projections (°C); variation in historic rainfall (mm); future precipitation projections (% change); historic sea level change (mm/year); historic land erosion; storm surge and cyclones. The sensitivity indicators were fish production in overall fisheries and total water area used by fisheries. The adaptive capacity indicators were poverty, GDP, literacy, access to electricity, housing structure, household expenditure, road infrastructure, availability of primary school, availability of secondary school, and access to clean water from tube-wells.

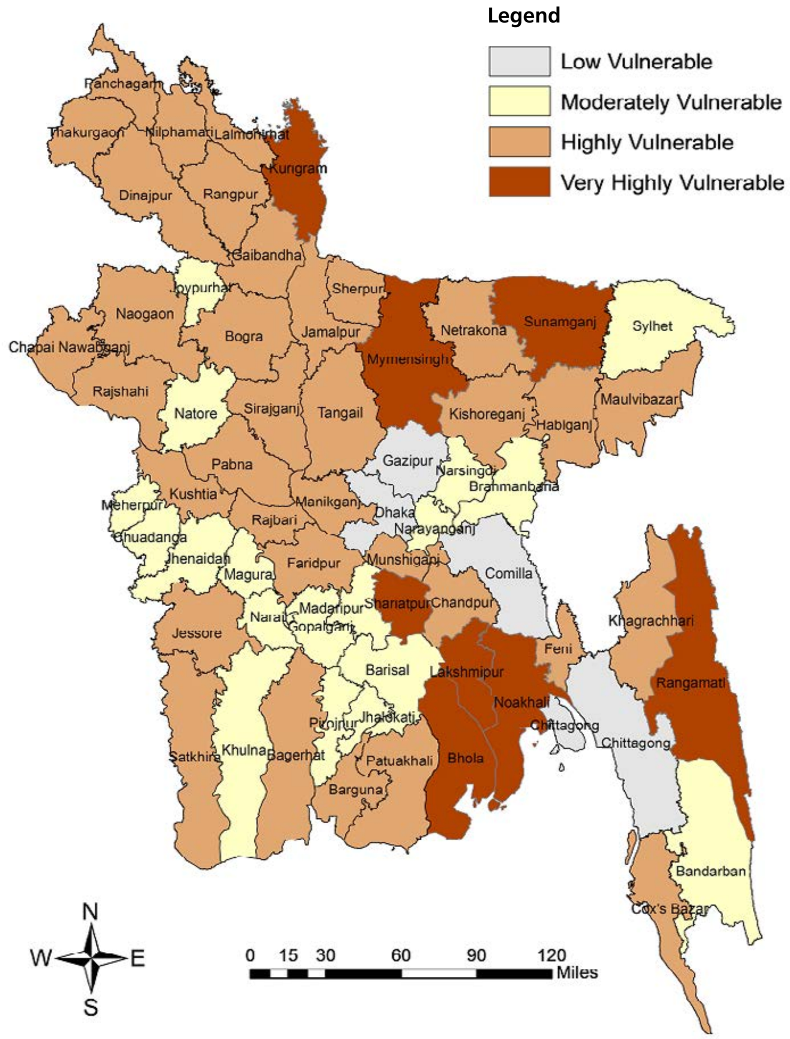
Data on exposure, sensitivity and adaptive capacity were entered into the Statistical Package for Social Science (SPSS) data editor, and all variables were computed to get a standardized value (0 to 1) for each variable. The vulnerability of the fisheries sector was calculated as: vulnerability = [(exposure + sensitivity) – adaptive capacity]. The vulnerability values were also normalized (0 to 1). The normalized values for exposure, sensitivity, adaptive capacity, and vulnerability were divided into four quartiles, where quartiles 1, 2, 3 and 4 were categorized as low, moderate, high and very high, respectively. These values were used to create exposure, sensitivity, adaptive capacity, and vulnerability maps by district using ArcMap 10.3.

SUMMARY RESULTS

A total of 21 climatic, environmental and socio-economic indicators were identified to reflect the three components of vulnerability; that is exposure, sensitivity and adaptive capacity. The results show that the very highly vulnerable districts (higher to lower order) in the fisheries sector are Sunamganj, Rangamati, Mymensingh, Lakshmipur, Shariatpur, Noakhali, Bhola and Kurigram (Figure 1). This vulnerability has emerged because of very high/high exposure, moderate sensitivity and low/moderate adaptive

FIGURE 1

Vulnerability of fisheries to climate variability and change in the 64 districts of Bangladesh



The boundaries and names shown and the designations used on this map do not imply the expression of any opinion whatsoever on the part of FAO concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers and boundaries. Dashed lines on maps represent approximate border lines for which there may not yet be full agreement capacity. The low vulnerability districts are Dhaka, Chittagong, Comilla and Gazipur. Interestingly, the vulnerability of fisheries to climate change varies spatially in the country with East Bengal, coastal districts, North Bengal, and districts adjacent to rivers being highly vulnerable, whereas most divisional districts have low vulnerability because of their low sensitivity and high/very high adaptive capacity. This study concludes that inland areas are not always less vulnerable compared to coastal areas, which challenges the commonly held notion.

CONCLUSIONS AND FUTURE DIRECTIONS

This study has identified district-level vulnerabilities of fisheries in Bangladesh to climate change. The findings will allow policymakers to easily identify the most vulnerable districts and focus efforts to decrease this vulnerability and increase the adaptive capacity. The Bangladesh government has allocated specific funding for climate change mitigation and adaptation (e.g. Bangladesh Climate Change Trust Fund (BCCTF) and Bangladesh Climate Change Resilience Fund (BCCRF)). The aims of these two funds are to reduce climate change vulnerability and increase resilience to the adverse effects of climate change. Utilizing the findings of the study, policymakers can easily identify where to target funding and effort to support the fisheries sector. Moreover, other organizations, such as NGOs and donors, can also target their effort toward the most vulnerable districts to reduce their vulnerability to climate change. Finally, the very highly vulnerable districts can learn from the low vulnerability districts about how to reduce their level of vulnerability.

Although in the context of fisheries and climate change, this study has determined the differential level of vulnerability in different districts in a rigorous way, the results are not without issues. In some cases, deficiency of district level data was prominent, and almost all of the organizations produce mostly national level data. Future studies should use more district level data to determine the level of vulnerability.

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

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INTRODUCTION

Reduced fisheries production in Africa's Great Lakes region has been attributed to human-induced changes to climate conditions. Temperature measurements on Lake Tanganyika over a 100-year period show increases over time at different rates and at different depths. Observed changes in wind patterns could also have caused variations in upwelling intensity and frequency. At the same time, increasing human pressures, including fishing effort, around the lake have contributed to accelerated nutrient loading and pesticide/fertilizer run-off that has changed the lake's water quality and could be a factor influencing fisheries outputs. Estimates published in 2003 of climate change impacts and the potential effect on primary (i.e. plankton) and secondary (fish) production in Lake Tanganyika predict a 30 percent reduction in fish harvest without taking into account the fishing capacity in the four countries that share the lake resources (the Republic of Burundi, the United Republic of Tanzania, the Republic of Zambia and the Democratic Republic of Congo). Consideration of increased fishing effort and decreased fish harvest may also explain this reduction in harvest rather than the rise in lake water temperature.

Fish catches are critically important for the riparian countries of Lake Tanganyika with consumption high and many communities depending on fisheries for their livelihoods. In the 1990s, fish consumption in the Republic of Burundi was 6 kg/year per capita, which declined to 2 kg/year in 2012. Declining fish catches and the disappearance of an industrial fleet are the result of a rapid increase in artisanal fishing effort. The growth in the artisanal fleet has been accompanied by improved efficiency using light attracting devices, although artisanal fishers used lift-nets instead of purse seines. This paper investigates whether declining harvests can be attributed to climate-induced changes or overharvesting of Lake Tanganyika fisheries resources.

SUMMARY RESULTS

Lake Tanganyika Authority

The establishment of the Lake Tanganyika Authority (LTA) in 2009 led to the resumption of fisheries management following a gap of about 10 years. One of the functions of the LTA is to monitor fisheries production in the lake. To that end, a lake-wide frame survey was conducted in 2011 and its results compared with an earlier fisheries inventory in 1995 (Paffen, Coenen, Bambara, Wa Bazolana, Lyoma and Lukwesa, 1995; LTA, 2012; Van der Knaap, Katonda and de Graaf, 2014).

From 1995 to 2011 the fishing capacity in terms of numbers of fishermen and canoes doubled, whereas the total annual fish harvest, which was estimated to be between 165 000 and 200 000 tonnes in the 1990s (Mölsä, Reynolds, Coenen, and Lindquist, 1999), decreased to between 110 000 and 120 000 tonnes in 2012. The latter result was obtained from a tailor-made data collection system, harmonized for the four nations bordering the lake, and based on the latest frame survey results. A full-year's coverage was accomplished in the Republic of Burundi, the United Republic of Tanzania and the Republic of Zambia, and only a partial year was covered in the Democratic Republic of Congo.

The artisanal fisheries sector that particularly targets pelagic resources outcompeted the industrial sector over these 10 years. The industrial sector disappeared completely in the late 1990s in the Republic of Burundi and around 2010 in the Republic of Zambia as the number of artisanal fishing units continued to increase, leading to reduced catch rates by the industrial boats. The use of illegal fishing gear, such as beach seine and monofilament gillnets that do not discriminate between mature and immature fish, has also contributed to fish harvest decreases by reducing the stock below the maximum sustainable yield. In the Republic of Burundi, strengthened co-management activities had an immediate effect on the annual production in 2013 with a 15 percent increase in catch as compared to 2012 (unpublished data). It should be noted that natural variation in recruitment could also be the reason for the increase. Lake-wide harmonized co-management approaches and active enforcement of fishing regulations would likely contribute to the removal of illegal fishing gears, particularly beach seines and monofilament gillnets. It was expected that the LTA Secretariat would play a crucial role in this but political developments in one of the bordering countries since 2014 made it difficult for the LTA Secretariat to have a positive impact on the lake's fisheries management. The ongoing Tuungane Project, supported by The Nature Conservancy (TNC), contributes significantly to strengthened co-management in part of Tanzanian waters.

Another fishing activity that has adversely affected sustainable fisheries management is the collection of fish larvae, mainly clupeids, in the inshore waters of the Democratic Republic of Congo by women and children for food or to process it into dried fish cakes. Recent investigations indicate that the negative impact of this activity on the adult clupeid stocks is significant and should not be underestimated (Mulimbwa *et al*., 2018).

Climate change or overfishing?

The main question remains whether the reduction in secondary production (i.e. fish) is caused by climate change, overfishing or a combination of the two. However, this huge lake (with 17 percent of global fresh surface water) is likely to have a stabilizing effect on the regional (micro)climate, as suggested by various researchers (Langenberg, Sarvala and Roijackers, 2003).

Changes in wind patterns that have been observed should be monitored to determine if they are a result of global climate change or natural variation. An interesting example is the *saba-saba* (meaning "seven-seven" in Kiswahili), indicating a period of two weeks of stormy winds during which fishing and transport activities are seriously hampered by waves and strong winds. There are indications that this event, normally occurring in July, is shifting to other periods in the year. Such winds are directly linked to upwelling phenomena, which according to some limnologists are becoming less intensive because of stratification of the water column caused by warming. As a result, it is expected that primary production will decline, leading to reduced secondary pelagic production.

Changes in fish harvests may therefore be partially caused by climatic effects, but exacerbated by the increase in fishing capacity and effort on the lake by the artisanal sector. Despite the adoption of the FAO/LTA regional action plan to reduce the fishing capacity on Lake Tanganyika in 2016 by the Conference of Ministers of the LTA, the numbers of fishermen and canoes are still on the increase.

CONCLUSIONS AND FUTURE DIRECTIONS

This paper recommends that in addition to strengthened co-management, some form of harmonized licensing system should be introduced in the four countries in order to call a halt to the open-access character of the fishery that leads to overfishing, also known as the "tragedy of the commons." Such a system requires enforcement by a combination of state and community interventions, which is not currently in place among the riparian states.

A number of development partners — the UN Food and Agriculture Organization, World Bank/Global Environment Facility, the International Union for the Conservation of Nature, the African Development Bank plus bilateral partners and universities — accompanied the process of establishing the Lake Tanganyika Authority for many years and conducted much research on the lake. In fact, with all the knowledge and information obtained it has become clear what action is needed but financing stagnated at a crucial point when important decisions needed to be made for the coming decades.

Further monitoring of the fisheries and limnology, as well as meteorological conditions is needed to identify the specific cause of declines in fish catches. Remote sensing data can also be used to further study temperature distribution at the lake's surface and chlorophyll information. Such activities however, are not current priorities for investment by the LTA or riparian governments. Lake Tanganyika belongs to these countries, thus it is a responsibility of the four countries as well as the international community to monitor and manage this important natural resource. This paper highlights the problem of inland fisheries, in particular Lake Tanganyika, which is crucial for livelihoods and food security for populations of the four countries bordering the lake. Adaptation to climate-induced shifts in lake resources requires improved fisheries management, including control of artisanal fishing fleets, as well as good coordination among the countries that share the resource.

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Climate change impacts on livelihood vulnerability assessment: adaptation and mitigation options in marine hot spots in Kerala, India

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ABSTRACT
Climate change, a global challenge facing all humanity necessitates governments to develop mitigation and adaptation plans. Climate change has multi-dimensional impacts on environmental, fisheries, social, economic and development drivers. Marine hot spots are defined regions that warm faster than the global average temperature. Southwest India has been recognized as one of the 24 hotspot regions identified globally. According to a study by Shyam *et al*. (2014a), the districts of Thiruvananthapuram and Ernakulam are the most vulnerable villages in Kerala based on the vulnerability index table formulated by using the method described by Patnaik and Narayin (2005). This paper assessed the climate change vulnerability of over 800 fisher households in two major fishing villages of Kerala *viz.,* Elamkunnapuzha village of Ernakulam district and Poonthura village of Thiruvananthapuram district, from the southwest hotspot region of the Republic of India. The factors that determine vulnerability of households, such as exposure (E), sensitivity (S) and adaptive capacity (AC), were captured using a structured questionnaire and 198 indicators were identified. These comprised 36 related to exposure, 37 indicators related to sensitivity, and 125 related to adaptive capacity, and were used to construct vulnerability indices. The study revealed that the majority of fisher households in both villages are highly vulnerable to climate change impacts and are also unaware of 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 that the livelihoods of fishers and sustainable development of the fisheries sector include the proactive participation of fishers.

INTRODUCTION
Climate change has been one of the most debated topics over the last few decades and impacts are already being observed. Governments around the world are looking for practical and time-bound plans to cope with the changing environment (Shyam *et al*., 2014b). Climate change has multi-dimensional impacts on environmental, fisheries, social, economic and development drivers (Shyam *et al*., 2015). Even though the consequences of climate change are being experienced in both inland and coastal regions, the coasts are the transition zone between land and sea and experience more changes than other zones. However, climate change is not impacting all ocean regions equally — with sea surface temperature warming faster in about 24 regions globally

above the average global rate of warming. Ocean warming "hotspots" are regions characterized by above-average temperature increases over recent years, for which there are significant consequences for both marine resources and the societies that depend on them (Popova *et al*., 2016, Hobday *et al*., 2016). As such, they represent early warning systems for understanding the impacts of marine climate change, and trial locations for developing adaptation options for coping with climate change impacts. Identification of these marine hotspots and the associated biological impacts suggests that coastal communities in these hotspot regions may be at higher risk compared to other regions.

Kerala, one of the major coastal states, contributes about 16 percent of the total fish production of the country. The total marine fish landings in Kerala were estimated at 576 000 tonnes in 2014, registering a decline of 15 percent compared to the 671 000 tonnes landed in 2013 (CMFRI, 2015). According to global assessments of marine hotspot regions (Ridgway, 2007a; Cai *et al.,* 2005; Cai, 2006), southern India is situated in a region that is predicted to warm substantially faster than the global average. As such, the impacts of climate change are expected to be observed and documented earlier in this region, making it a sentinel of climate impacts for other regions in the country as well as globally. Shyam *et al.,* (2014b) reported low levels of climate change awareness among fisherfolk of Kerala owing to the fact that climate change causes and impacts are entangled with other developmental issues and the communities could not decipher climate change issues specifically. Hence the study supports advocating a bottom-up approach in developing location-specific plans with the proactive participation of fisherfolk.

METHODS

On the basis of historical observations of sea surface temperature, Hobday and Pecl (2014) identified 24 fast-warming marine areas or so-called "global hotspots". They suggested that these hotspot regions could serve as "natural laboratories" where the mechanistic links between ocean warming and biological responses could be studied in advance of wider-scale impacts predicted for later in the 21st century. The marine area in the southwest of India has been recognized as one of the 24 hotspot regions identified globally. This study collected fisher data in two villages in southwest India in 2014 using a multi-method approach. Exposure, sensitivity, and adaptive capacity data were collected using structured household questionnaires. A simple random sampling technique was used to obtain information from fisher households. Participants were typically the household heads. When the household head was absent, another adult member of the household was interviewed. Local people from the respective communities (mostly educated and committed women and proactive college students) were selected as enumerators for the survey.

In the initial part of the survey, focus group discussions were conducted with local government officials, officers from related departments and women self-help groups within the communities. Later, the officers from the local government of each district involved in the study identified local people for further training as enumerators, prior to the implementation of the survey. The selected enumerators were trained in topics covering climate change, vulnerability, exposure, sensitivity, adaptive capacity and resource management. They were also specifically trained in conducting household surveys with fishers. Face-to-face interviews were conducted at the household level, which took about 1 hour for each person. 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 (Hajkowicz, 2006; IPCC, 2007; Islam *et al*., 2014; Johnson *et al*., 2016) and were the focus of data collected using the household questionnaire.

The aim of this study was to identify the extent of vulnerability and the component structure of the vulnerability category measured using a Likert-type response scale and to summarize the data into one or more sub-scales of vulnerability category that can be used for further models. Based on the availability of data, 198 indicators were used in the construction of the vulnerability indices, that is 36 indicators related to exposure, 37 related to sensitivity, and 125 related to adaptive capacity. A composite vulnerability index approach (Patnaik and Narayin, 2005) was used to evaluate relative exposure, sensitivity, and adaptive capacity. The study quantitatively assessed the vulnerability of fishery-based livelihood systems using the combination of individual indicators. Since each indicator was measured on a different scale, they were normalized (rescaled from 0 to 1). After normalization, the values were transformed into a four-point scale, categorized as 0—0.25, 0.26—50, 0.60—0.75 and 0.76—1.00 which were assigned score values 1 (low), 2 (medium), 3 (high) and 4 (very high), respectively. These values were averaged to yield the three sub-indices for exposure (E), sensitivity (S) and adaptive capacity (AC) to ultimately calculate vulnerability (V). Sub-indices were combined to create a composite vulnerability index by using the following additive (averaging) equation: V=E+S-AC.

SUMMARY RESULTS

The overall vulnerability of the villages was assessed and the analysis revealed that Poonthura fishing village of Kerala has a higher vulnerability when compared to Elamkunnapuzha fishing village. The results also revealed that the majority of the fisher population in both the villages were highly vulnerable to climate change, which is a major cause of concern. Fishery-based livelihoods in households of Elamkunnapuzha and Poonthura have high exposure to climate-related shocks and stresses because the communities are located near the coastline. Even though both the study villages were found to experience similar vulnerability shocks, Poonthura village is more vulnerable compared to Elamkunnapuzha (Shyam *et al.*, 2017). The proximity of Poonthura village to the sea was attributed as the major factor driving high vulnerability compared to Elamkunnapuzha. In addition, higher exposure to environmental changes, occurrence of drought and shoreline changes also contributed to higher vulnerability in Poonthura. The vulnerability index of Poonthura was calculated to be 2.85 whereas that of Elamkunnapuzha was 2.80. Even though the adaptive capacity indices of both villages were similar (2.57 and 2.52 for Elamkunnapuzha and Poonthura, respectively), considerable variation was found in exposure (2.67 and 2.80 for Elamkunnapuzha and Poonthura, respectively) and sensitivity indices (2.70 and 2.57 for Elamkunnapuzha and Poonthura, respectively), which may explain the variation in the overall vulnerability of the two fishing villages.

One of the major findings of the study is that the majority of respondents from both the study villages are unaware of climate change. The respondents admitted that they are experiencing changes with respect to their fisheries and the environment, but don't understand the reason. According to respondents, the depletion of fisheries resources as well as natural disasters in the area are because of overfishing by foreign vessels and other human activities, such as marine pollution, illegal fishing activities, and juvenile fishing. Exposure, sensitivity, and adaptive capacity influence the vulnerability of fishery-based livelihoods in a variety of ways. An understanding of how these components and indicators influence the overall vulnerability of livelihoods provides an important basis for directing future research and climate change coping and adaptation strategies in developing countries, particularly those with small-scale fisheries that are similar to those of Kerala in southern India.

CONCLUSIONS AND FUTURE DIRECTIONS

Vulnerability to climate change varies between places, communities, and social classes. The contextual nature of livelihood vulnerability and considerations of spatial and temporal scale make it challenging to develop robust indicators. The selection of indicators often involves a trade-off between specificity, transferability, accuracy, and certainty (Vincent, 2007). In the future, the vulnerability of fishery-based livelihoods may markedly increase because of climate change. In the absence of adaptation, increased frequency and intensity of storms and floods could result in greater loss of life at sea and in the coastal zone, greater damage to fishing gears and household assets, and a loss of fishery related income. If sea-level rise accelerates as projected during this century, coastal areas of the Republic of India will also experience inundation and accelerated erosion in coastal communities. Future livelihood vulnerability is closely linked with technological, demographic, and socio-economic trends and how these factors influence the ability of fisheries-dependent households and communities to adapt. This study advocates the need for a bottom-up approach in developing location-specific plans to ensure that the livelihood of fishers and sustainable development of the fisheries sector include proactive participation by fishers. In the meantime, awareness campaigns are needed, as communities are unaware of climate change implications for their resources. Proper adaptation-mitigation strategies should be developed and implemented to minimize the adverse impacts of climate change.

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Vulnerability and adaptation strategies of fisherfolk: A study from Mumbai, India

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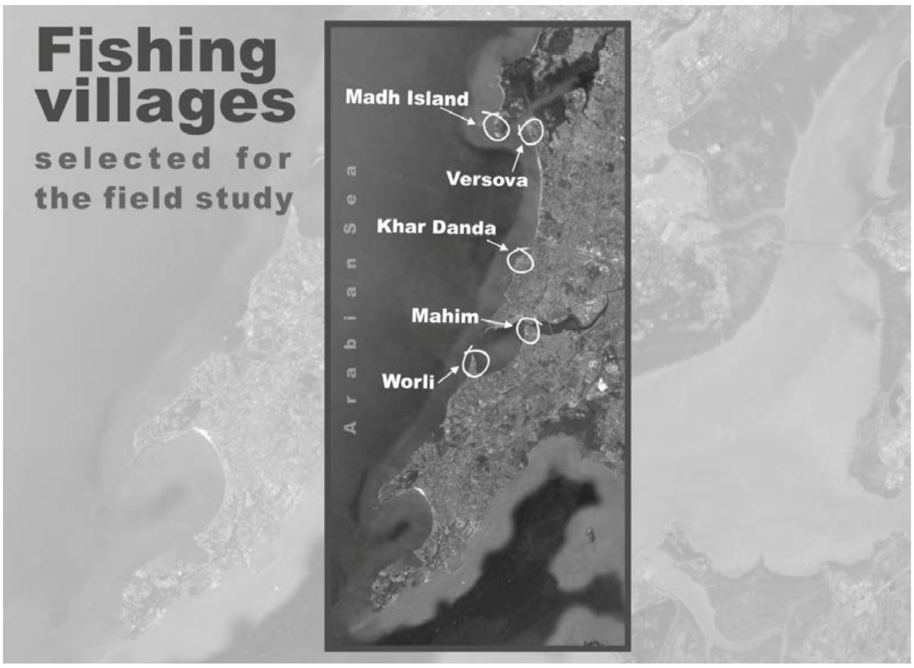
INTRODUCTION

Fishing communities from developing countries are often more vulnerable to environmental and climate changes and variability because of their lack of adaptive capacity. The capacity to adapt depends on a number of social, economic, technical and physical factors, and high vulnerability persists because of lack of financial and technical support for modernization, insufficient knowledge of marketing and irregularity in subsidies. However, not all communities are vulnerable to the same degree, with small-scale fisheries that are highly dependent on traditional ways of fishing being more vulnerable than others (Senapati and Gupta, 2017). Furthermore, increases in economic activities near the coast place additional pressures on fisher communities (McGranahan *et al.*, 2007). These changes have resulted in declines in fish availability, migration of fish species, and reduced access to particular target species (Coulthard, 2010; Badjeck *et al.*, 2008). This research provides a case study of the vulnerability and adaptation of fisher communities living in Mumbai, the Republic of India (Figure 1),

FIGURE 1
Map of Mumbai region and five study sites in western India



known as Koli communities. Koli communities are the earliest inhabitants of the city, however their livelihoods are now threatened by irregular rainfall, changes in wind patterns and changing ocean currents. Floods and rising sea level are also threatening the communities and making it difficult to sustain their livelihoods through fishing.

SUMMARY RESULTS

The fisheries-dependent population in Mumbai is exposed to significant environmental, climate and socio-economic pressures. The socio-economic implications of climate change on fisheries livelihoods were assessed using a primary survey of 182 fisher families from five fishing villages (Khardanda, Madh, Mahim, Versova, and Worli as shown in Figure 1) known as "Koliwada" in Mumbai. A total of 30 indicators were selected for the study using the Sustainable Livelihoods Approach (SLA) (Ekin and Tapia, 2008) and multicriteria analysis (MCA) (Satty, 2008) to select indicators and to allocate weightings to the selected indicators (Senapati and Gupta, 2017). Vulnerability indicators were selected for sensitivity/exposure (Table 1) and adaptive capacity (Table 2).

TABLE 1
Sensitivity and Exposure indicators used for the study

Sensitivity/Exposure	
Livelihood	**Perceived changes and variability**
Percentage of household income from fishing	Reduced availability of fish
Type of occupation	Less availability of a particular fish
	Increase in number of storms
Other sources of income	Change in rainfall pattern
Occupation of female	Rise in temperatures
	Sea level rise

The sensitivity/exposure indicators were divided into two categories: livelihood and perceived changes. Similarly, the indicators for adaptive capacity were grouped into five categories comprising the five capitals: human, physical, financial, social and governance (Smith and Wandel, 2006; Ekin and Tapia, 2008; Senapati and Gupta, 2017).

TABLE 2
Adaptive capacity indicators used for the study

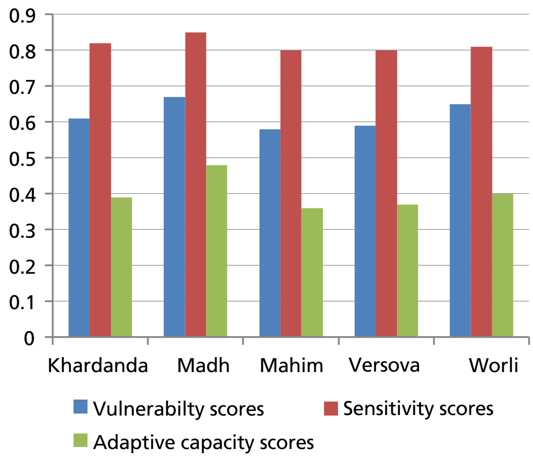
Adaptive Capacity				
Human	**Physical**	**Financial**	**Social**	**Governance**
Age	Type of house	Total income	Type of family	Training
Education	Type of fishing boat	Total savings	Access to community hall	Access to climate information
Number of adults in the household	Access to electronic equipment	Total subsidies received	Children in school	Access to insurance
Health	Distance to hospital	Total expenditure on fishing		
		Sale of fish to distributor		
		Total loans/debt		

The study used primary data obtained through household surveys for deriving vulnerability scores. The data collected through the primary surveys were standardized using value functions (Beinat, 1997). The indicator scores were calculated by applying a simple indexing non-weighted method and comparing survey data with expert scores derived through MCA (for details see Senapati and Gupta, 2017). The vulnerability scores for "physical capital" and "financial capital" differ among villages, demonstrating varying adaptive capacity between these villages (Figure 2). Madh village was found to be the most vulnerable because of its high sensitivity and low adaptive capacity scores, and Worli village was the second most vulnerable community.

CONCLUSIONS AND FUTURE DIRECTIONS

The vulnerability scores can be useful in considering various policy measures in fishing villages to determine if they target the main sources of high vulnerabiity. Among the fishers surveyed, this study found that large-scale operators (those who own mechanized boats) and fishers with financial resources are able to adapt more effectively to changing climate in comparison to small-scale fishers. Their high adaptive capacity is driven by physical and financial resources (e.g. mechanized boats, advanced electronic equipment), allowing these fishers to alter their target fish species, for example, from traditional Bombay duck to tuna. They also have greater access to climate information and are more aware of climate change, so they can change their practices to more intensive fishing for two to three months, hence maximizing their catches, although this method raises issues about fisheries sustainability. To assist fisheries that have low adaptive capacity, local governments need to develop strong policies that support small-scale fishers, such as restricting mechanized boats in nearshore areas, enforcing larger net sizes, providing subsidies and providing training to small-scale fishers to target new varieties of fish.

FIGURE 2
Adaptive capacity, sensitivity and vulnerability scores for surveyed villages



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Theme 2

Climate change adaptation efforts in fisheries and aquaculture

Climate change adaptation: vulnerability and challenges facing small-scale fisheries on small islands

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ABSTRACT

Traditionally, small island communities around the world have had a strong association with their marine resources, depending on small-scale fisheries for food security, livelihoods, cultural practices and economic and rural development. This reliance on marine resources stems from having access to large ocean areas and therefore small islands are often described as “large ocean states”. They include island nations as well as islands that are part of larger mainland nations, for example, Hawaii (United States of America), Torres Strait (Australia), São Sebastião, Fernando de Noronha and Trindade and Martim Vaz (Brazil), and the islands of Kerala (the Republic of India). Despite this heterogeneity, small islands share similar socio-ecological characteristics that make them highly vulnerable to climate variability and change and, as a consequence, many of their marine resources are projected to decline. Although climate impacts on small islands are rarely recognized in global assessments, the effects of climate variability and change are expected to have critical consequences by decreasing small-scale coastal fisheries production, directly impacting fisheries livelihoods and infrastructure and exacerbating other pressures that are a function of their relative isolation, generally small economies and limited access to markets. To maintain the contributions of small-scale fisheries to sustainable social and economic development in the face of climate change, practical adaptations are needed that suit the specific socio-ecological characteristics and challenges of small islands, which by their nature, can both help and hinder adaptation. Collectively, key lessons from successful adaptations can help to identify the suite of options most appropriate to small islands and their fisheries. These lessons can also guide international and regional initiatives and investment to address the specific needs of small islands and provide practical solutions that support the adaptation of small-scale fisheries.

INTRODUCTION

Small island nations are the worst and first impacted by climate change (Betzold, 2015) because of their unique characteristics that make them highly exposed and sensitive to the effects of climate change and, at the same time, enable flexibility and adaptation to future change (e.g. Johnson and Welch, 2016; Monnereau *et al.*, 2017). Small islands share similar sustainability challenges related to specific characteristics including their small size, relative isolation, susceptibility to extreme events, vulnerability to external economic and political shocks, coastal concentration of population and infrastructure, high level of endemic species, high dependence on marine resources, and significant dependence on international trade (Mimura *et al.*, 2007; Guillotreau *et al.*, 2012; Nurse *et al.*, 2014; Polido *et al.*, 2014). As a result, small islands are expected not only to be most at risk from climate change (Nurse *et al.* 2014) but also the "first adopters" of adaptations, providing lessons for actions elsewhere (Betzold, 2015). The direct and indirect impacts of climate change and variability on marine capture fisheries is of increasing concern (Brander, 2010; Cheung *et al.*, 2010; Mora, 2013), particularly for small island states (Nurse, 2011; Bell *et al.*, 2015a), with biophysical and socio-economic impacts expected (Allison *et al.*, 2009; Johnson and Welch, 2010; Nurse, 2011; Pörtner *et al.*, 2014; Welch *et al.*, 2014; Bell *et al.*, forthcoming). Critically, climate impacts will exacerbate unprecedented challenges marine ecosystems already face as a result of *inter alia* fisheries overexploitation, pollution of coastal waters (e.g. sewage and agricultural runoff), illegal, unreported and unregulated fishing, invasive species, habitat destruction, and coastal erosion.

These cumulative pressures are particularly detrimental to small islands fisheries that depend so heavily on the marine resources from their large ocean areas and it is therefore not surprising that these "large ocean states" are considered highly vulnerable to climate change (e.g. UN-OHRLLS, UNESCO, UN-DOALOS, 2014; Johnson *et al.*, 2017). For example, in the tropical Pacific island region there are 22 national Exclusive Economic Zones that cover 27 million km^2 and only 2 percent of the area is land. As a result, these large ocean states are critically dependent on marine ecosystems; consuming fish at 98–147 kg/person/year (3–5 times the global average), sourcing 50–90 percent of their protein from reef fisheries (in rural communities), and providing 47 percent of coastal households their first or second income from small-scale reef fisheries (Bell *et al.*, 2011 and forthcoming).

Adaptation of fisheries to climate change impacts on small islands is often limited by their remoteness, insufficient human and financial capital, and high dependence on marine resources. This underscores the difficulty small islands face in effectively adapting to climate change when facing barriers in perceptions and awareness, institutions, and (lack of) resources (Betzold, 2015). However, there is a wide range in capacity for effective marine resource management and challenges in fostering development depending, in part, on whether islands are nation states or territories. Many small islands have proposed and critiqued diverse policy and practice responses to climate change, from human migration, hard and soft engineering options, mainstreaming of climate change into natural resource policies and regulations, and societal changes, with an emphasis on integration with sustainable development planning (e.g. SAMOA Pathway, 2014). How these changes will be implemented and their ultimate success in minimizing climate impacts on small island fisheries and communities remains unclear.

Although attention on the unique challenges faced by small island states because of climate change and their social construct is gaining momentum, inadequacies in data, and in institutional and local capacity remain major problems. This is especially true for the world's most impoverished and vulnerable small island communities, which paradoxically are frequently neglected or under-represented even in research about small island climate change impacts and adaptation (Monnereau *et al.*, 2017). It is clear that for future adaptation on small islands to be effective and sustainable, these challenges need to be overcome, in particular by providing information, capacity and resources at the local level through targeted support (Betzold, 2015).

This paper explores how small-scale fisheries on small islands are both vulnerable and resilient to the impacts of climate change. It identifies practical adaptations specific to small islands that assist small-scale fisheries to cope with projected climate change and continue to provide food and livelihoods for coastal communities. The paper aims to highlight the challenges that small islands face in confronting climate change, and provide lessons for practical adaptations that are relevant to other small-scale fisheries and locations. It is hoped that this will facilitate implementation of relevant and effective climate change adaptations in small islands to maintain ecological and social well-being.

ADAPTATION OF SMALL-SCALE FISHERIES ON SMALL ISLANDS TO CLIMATE CHANGE

Key adaptations for small-scale fisheries on island states must focus on minimizing exposure and sensitivity to climate change impacts, and maximizing adaptive capacity. Since most small island communities focus their fishing effort close to the coast in nearshore habitats, adaptation interventions need to focus on these locations and the practices therein. Increasingly it is recognized that destructive fishing and overfishing of coastal marine resources is occurring on small islands (as in other locations) primarily because of rapidly increasing human populations (Sale *et al.*, 2014) coupled with limited local capacity for effective fisheries management (e.g. Gillett *et al.*, 2014). Together, these are increasing the vulnerability of marine ecosystems to climate change. Climate-informed, ecosystem-based approaches to fisheries management that incorporate community awareness of the effects of changing climate on coastal fish stocks and habitats are required. Therefore, actions to use coastal fish and invertebrates sustainably in the face of a changing climate are key to minimizing vulnerability and supporting adaptation (Bell *et al.*, 2015a,b, forthcoming; Johnson *et al.*, 2016). Most critical, however, is the need to support responsible fisheries transitions (e.g. to different species, gears, techniques) with alternative protein and income sources as small island states have limited options when harvest controls increase.

As well as sustainably managing harvest levels, adaptation success will depend on disaster response management that reduces exposure of small-scale fisheries, increasing awareness and knowledge of climate change impacts on the sector. Action must minimize direct impacts on island communities (e.g. reinforcing natural coastal barriers, supporting changes to post-harvest practices, and early warning systems), and mainstream climate change into fisheries policies, plans and legislation. Importantly, improving the capacity of fisherfolk and aquaculturists to adapt will rely on customary marine tenure and other institutions of social capital, local governance, traditional knowledge, and self-enforcement capacity to provide the most effective way forward (Heenan *et al.*, 2015). Although many of these adaptations are largely about improving current practices and implementing best practices (e.g. “no regrets actions”), specific climate change information should be incorporated to target key areas of vulnerability for small island states (e.g. Johnson *et al.*, 2013).

Climate-aware coastal fisheries management: Climate-aware ecosystem approaches to fisheries management is critical to ensure sustainable production of coastal fish and invertebrates in small island communities where scientific catch monitoring and stock status analysis are not possible (Cochrane *et al.*, 2011; McClanahan *et al.*, 2014; Heenan *et al.*, 2015). Although fisheries management will need to incorporate observed and expected changes that are the result of climate change, for many small island states the adoption of basic fisheries management measures alone represent a key climate change adaptation. For example, decreasing fish sizes, changing species composition or distribution, and altered spawning (spatial or temporal) are some of the predicted climate change impacts, however these impacts are already widespread because of overfishing. Therefore, “primary” fisheries measures will have to be applied in a flexible and conservative manner because of the uncertainty of long-term climate change; this will support stocks' replenishment potential over the longer term and increase resilience to future impacts (Hobday *et al.*, 2008; Madin *et al.*, 2012).

Primary fisheries management employs simple harvest controls (e.g. size limits, gear restrictions) thus limiting the local supply of fish and invertebrates in the short-term (Cochrane *et al.*, 2011). Addressing this shortfall through alternatives will be essential to support adaptation. Monnereau and Oxenford (2017) examined the bio-ecological and socio-economic changes that can be expected for the four main fisheries in the Caribbean region and found that community-based approaches that incorporate extensive local consultation, co-management and education can foster the necessary cultural and attitudinal change. This will be key to the successful implementation of climate-aware fisheries management approaches in small island states.

Minimize degradation of coastal habitats: Coastal fish habitats are already impacted by current activities, and protecting them by prohibiting destructive activities will maintain habitat condition in the short-term and build their resilience to future climate change in the long-term (Hoegh-Guldberg *et al.*, 2011; Waycott *et al.*; 2011) thereby supporting sustainable fisheries. Actions are needed that prohibit or minimize: (1) sewage, chemical and waste pollution; (2) activities that physically damage the structure and function of habitats, such as destructive fishing practices, careless boating practices, and poorly-designed coastal infrastructure and tourist facilities; and (3) extractive activities, for example mining sand or coral for building materials, harvesting mangroves for timber or charcoal, and dredging of channels.

Appropriately designed spatial management: Ensuring that small island states create areas of sufficient size to help protect spawning biomass for replenishment of coastal fish stocks and to conserve biodiversity is required (Rice *et al.*, 2012). These areas need to be designed to take account of the ecology of target fish species (Green *et al.*, 2014), e.g. sequential use of different habitats (Nagelkerken *et al.*, 2000; Sheaves *et al.*, 2006), and the dependence of species on structurally complex habitats (Rogers *et al.*, 2014). Mosaics of these habitats likely to persist under climate change will need to be protected so that connectivity is maintained between habitats for successful recruitment of juvenile fish and invertebrates, and to provide a diverse range of feeding areas for adult fish (Bell *et al.*, forthcoming). Well-designed protected area networks have the potential to increase the resistance of habitats to future climate change (Mellin *et al.*, 2016), and when applied flexibly can allow for cooperative trading of access after natural disturbances or other impacts on fish stocks (e.g. cyclones/hurricanes) to improve food security. Flexible mechanisms are needed to allow for change and ensure adaptive management, such as institutional instruments that initiate a review or alternative spatial rules based on a set of pre-agreed criteria, such as declines in habitat condition or increasing human use. Fishers in the Grenadines islands have proposed this since their marine protected areas are very small and their effectiveness relies on a connected network of areas and optimized access for all users.

Diversify catches of coastal fisheries: Climate change is expected to alter the structure of local fish assemblages because of changes in species' distributions (Cheung *et al.*, 2010) and the structure of coastal habitats (Pratchett *et al.*, 2008 and 2011, Hoegh-Guldberg *et al.*, 2011). Transferring fishing effort from species projected to be most impacted by climate change to those species expected to be least impacted (e.g. those predicted to increase in local abundance) or that are more resilient to environmental change (e.g. higher productivity species), can help to maintain the overall catch of fish. For example, small pelagic fish (mackerel, anchovies, pilchards, sardines, scads and fusiliers) are generally resilient to high levels of fishing and currently provide a seasonal bait and/or food resource in many small island regions. Targeting these species provides an alternative catch for small-scale fishers (Pratchett *et al.*, 2011; Roeger *et al.*, 2016) but only if any new fisheries implement sustainable ecosystem-based management to account for climate sensitivities and prevent overfishing, particularly given the role of such species in linking ecosystem function and energy transfer (Pikitch *et al.*, 2012). In applying such an adaptation, attention should be placed on limiting the harvest of species with important ecological functions, for example herbivorous fish (Bozec *et al.*, 2013) and apex predators) and/or those that are most vulnerable to overfishing (Graham *et al.*, 2010).

Improve fish handling and shelf life of fish catches: An important consideration for small island communities is the variability of catch rates between seasons and years, and wastage because of poor fish handling and/or preservation; issues that are predicted to be exacerbated by climate change. Improving food safety and fish handling from the fisher up the chain to distributors will reduce fish waste and improve the availability of fish for food to households. Improving the ability of households to store fish for those times when conditions are not suitable for fishing or as fish assemblages and conditions change because of climate change, is an important adaptation that can use and improve on traditional methods for smoking, salting and drying fish. Improved preservation methods can also create new opportunities to trade or sell seafood products, particularly in large island nations, such as the Independent State of Papua New Guinea and the Republic of Cuba, that have inland communities without access to fish. Programmes that reinvigorate traditional smoking, drying (including solar dryers) and storage techniques can reduce local loss and waste, and additional support can introduce new facilities for alternative post-harvest practices, such as vacuum-sealing or freezing seafood thus supplying products for export to high-end markets and institutional customers (e.g. government schools). Coupled with sustainable fisheries management, this approach can add value to catches and improve economic benefits and job opportunities for fishing communities, especially women (e.g. Sumagaysay, 2017 in this volume).

Increased use of aquaculture: Aquaculture has become increasingly important in meeting natural marine resource deficits and is trying to meet the increasing demand for fish in domestic and international markets because of lifestyle and economic factors. Aquaculture could allow for more control over the production environment, reducing communities' risks to environmental factors. Therefore, aquaculture presents an opportunity to assist small islands in terms of food security, employment and foreign exchange earnings, yet it is still underdeveloped and faces its own climate risks and opportunities that will require focused adaptation planning. For example, aquaculture planning would need to consider challenges in terms of the need for fresh water, which is often scarce on small islands, and electricity that is usually expensive, unreliable and vulnerable to extreme weather events. Climate-sensitive aquaculture would need to incorporate designs that make very efficient use of scarce water resources (e.g. aquaponics, which uses a recirculation system) and energy efficient or self-generation options, such as solar panels.

Education, awareness and capacity building: Small island states tend to be overwhelmingly limited in resources and capacity and therefore require significant support for implementation of adaptation options. Fundamental climate awareness, particularly how climate change and variability will impact the sector, is critical to enable informed adaptation. When coupled with associated capacity building and education, such as on the impacts of increasing human population on the availability of fish for food (Bell *et al.*, forthcoming) and technical skills, this awareness can engender change and facilitate effective adaptation in small island states. Comprehensive communication, education and public awareness programmes should be prepared for targeting a variety of audiences, primarily focusing on fisherfolk, aquaculturists, fisherfolk associations and fishing communities to increase support for and ownership of adaptation actions. The key to underpinning this and all adaptation initiatives is the need to support the necessary capacity for implementation and governance of management systems.

Adaptations that depend on specific local circumstances and conditions are not discussed here, but include: scaling-up marketing and distribution to increase access to small-scale fisheries products in rural and remote locations; developing specialty (niche) products for access to high-value markets (e.g. eco-certified seafood); enhancing access to finance, technology and markets through the use of regional collectives and cooperative mechanisms; and improving early warning systems, preparation and fishing practices in response to projected climate change effects on fishing infrastructure and communities, fisheries catches and safety at sea.

INCREASING REGIONAL AND INTERNATIONAL AWARENESS OF AND SUPPORT FOR ADAPTATION

Small island states have been one of the first areas affected by climate change and are therefore the first places where adaptation is required (Betzold, 2015). The United Nations Development Programme (UNDP) has supported a substantial number of climate change adaptation projects in small island developing states (SIDS) across a number of different thematic areas (UNDP, 2017). Over 100 SIDS projects received support on climate change adaptation and mitigation through the UNDP-GEF Green Low Emission Climate Resilient Development Strategies team, and a similar number of initiatives received support from the UNDP-GEF Ecosystems and Biodiversity team. An additional 18 projects supported by the UNDP-GEF Water and Oceans team were specifically funded to focus on sustainable fisheries in SIDS. Other groups, such as the Adaptation Fund, Green Climate Fund, Least Developed Countries Fund and Pilot Programme for Climate Resilience allocated over USD 1 085 million to SIDS between 2003 and 2016 to finance 187 projects in 38 countries (Table 1) (Overseas Development Institute, 2016). In spite of this, climate change adaptation remains poorly funded at less than 7 percent of all global climate finance and fulfills only a small portion of the actual need.

TABLE 1
Funds supporting small island developing states (SIDS) from 2003 to 2016

Funds and Initiatives	Amount Approved (Current USD millions)	Projects approved
Pilot Programme for Climate Resilience (PPCR)	217.18	17
Least Developed Countries Fund (LDCF)	187.22	49
Green Climate Fund (GCF)	170.68	4
Adaptation Fund (AF)	72.78	10
Global Climate Change Alliance (GCCA)	71.59	16
Norway's International Climate Forest Initiative (ICFI)	65.95	1
Global Environment Facility (GEF 5)	41.1	19
Scaling up Renewable Energy Programme (SREP)	39.4	5
Global Environment Facility (GEF 6)	36.97	13
Special Climate Change Fund (SCCF)	36.1	6
Clean Technology Fund (CTF)	36	6
Global Environment Facility (GEF 4)	32.21	17
Germany's International Climate Initiative (ICI)	27.73	9
Forest Carbon Partnership Facility (FCPF)	27.7	9
Adaptation for Smallholder Agriculture Programme (ASAP)	11.5	3
United Nations REDD+ Programme (UNREDD)	6.93	2
Australia's International Forest Carbon Initiative (IFCI)	3.04	1

Source: Overseas Development Institute (2016).

Whereas the adaptation projects discussed above have begun to address the complex challenges posed by climate change, demonstrated tools and approaches that focus specifically on small island communities are not common. In spite of the obvious impacts of climate change on small-scale coastal fisheries and other key resources in small islands, there is limited current investment in adaptation. There is also little agreement on the factors needed to support local scale adaptation or guidance on how adaption should proceed (McLeod *et al.*, 2015). Community-based (bottom-up) adaptation (Reid *et al.*, 2009) has emerged as an important part of the response to this need and an increasing number of case studies are emerging that focus on the development of adaptation tools and the application of locally relevant data collection methods. This includes examples in the Coral Triangle where social learning, networking and empowerment was found to support community adaptation efforts (Butler *et al.*, 2016); community-based adaptation actions that emphasise local knowledge to complement and validate scientific data at appropriate spatial and temporal scales (Leon, 2016); and integrated multi-sector planning efforts that seek to enhance community benefits (Wongbusarakum *et al.*, 2015). These local studies support the overall development of adaptation tools, improve the prioritization, funding, and completion of adaptation projects in small island communities, and support an understanding of how climate change impacts on small island communities and associated fisheries can be best addressed.

Several consultative processes are underway globally to amplify the voices of small-scale fisheries in the international forums associated with bringing Sustainable Development Goal SDG 14 (Life Below Water) to the attention of policymakers. SDG 14 includes a target and indicators specifically about small-scale fisheries, and the Fifth Assessment Report of the United Nations Intergovernmental Panel on Climate Change (IPCC AR5) noted the high vulnerability of small-scale fisheries and coastal populations, thus they remain a focus through these linked initiatives. Adaptation to climate change and variability is one of the areas in which fisherfolk, such as the Caribbean Network of Fisherfolk Organizations (CNFO), advocate that more resources should be allocated. Such additional resources, if linked to the implementation of the Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries in the Context of Food Security and Poverty Eradication (FAO, 2015), could be aimed at strengthening fisherfolk self-organization and leadership through experiential learning rather than exacerbating dependence on external subsidies or inputs and initiating additional studies that are devoid of practical adaptation.

CASE STUDY 1

Caribbean region

The Caribbean has a high number of small island states that are among the 17 member states of the advisory regional fisheries body known as the Caribbean Regional Fisheries Mechanism (CRFM) in which all countries have small-scale fisheries (Haughton *et al.*, 2004). The CRFM, along with several other state and non-state fisheries, climate and disaster organizations, operates within the large area of the FAO Western Central Atlantic Fishery Commission (WECAFC). To achieve bottom-up inputs into regional and international fisheries policy and practice, the fisherfolk organizations in CRFM countries formed the still-growing Caribbean Network of Fisherfolk Organizations (CNFO) (McConney and Phillips, 2011). This fisherfolk network is becoming a civil society leader, regionally and internationally, in fisheries climate change adaptation initiatives within the implementation of an ecosystem approach to fisheries management and the Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries in the Context of Food Security and Poverty Eradication (FAO, 2015).

CASE STUDY 1 (CONTINUED)

Through collective action, the CNFO is informing and influencing regional and international climate change adaptation projects and programmes that address matters as diverse as fisheries governance, gear and vessel technology, physical infrastructure, livelihoods, leadership, gender, implementation of ecosystem approaches, information and communication technology, and more. In so doing, the CNFO is increasing awareness and support for adaptation via collaborative fieldwork at sea level through to high-level conferences at the FAO, all with a practical focus on small-scale, small island fisheries (McConney *et al.*, 2016). The model of the CNFO civil society collaboration with several state and non-state actors, including academia, in pursuing its goals to improve the well-being of fisherfolk offers lessons for other regions and stakeholders that wish to engage at multiple levels with the juggernaut of international climate change negotiations and initiatives, but prefer not to do so single-handedly.

SUPPORTING POLICIES

In order for climate change adaptations on small islands to be successful, policies that mainstream climate change adaptation, allow for inevitable change, and promote the implementation of specific adaptation actions to address key vulnerabilities are essential (McConney *et al.*, 2015). Implementing policies based on the range of topics covered by the SSF Guidelines (FAO, 2015) is important; and engagement of the fisheries and aquaculture sectors will be critical. Disaster risk assessments and management at the local scale assist community preparedness, but it is imperative that the specific characteristics of the fisheries and aquaculture sector are clearly understood from technical, social and economic points of view (Westlund *et al.*, 2007). Policies that support responsible fisheries, human rights and sustainable social and economic development with an emphasis on small-scale fishers, fish workers, and vulnerable populations are recommended.

Responsible governance of small-scale fisheries and aquaculture is critical and can support sustainable development goals (SDGs). Fisherfolk and fisheries authorities in many small island states have advocated ***strengthening regional and national marine resource governance***, policies, programmes, plans and legislation to ensure that the fisheries sector is included in National Action Plans (NAPs), and that climate and disaster responses are integrated into fisheries management plans based on an ecosystem approach to fisheries management (McConney *et al.*, 2015; SPC, 2015). A major initiative in the Caribbean in this direction is the Ten-year Strategic Action Programme agreed to by over 20 countries in the Wider Caribbean. The Programme aims to improve transboundary governance of shared living marine resources in the areas of the Caribbean and North Brazil Shelf Large Marine Ecosystems (the CLME+ region). Multi-level policy cycles are being designed, tested and strengthened to address issues that include fisheries and climate in the CLME+ region, where small islands predominate (Mahon *et al.*, 2014). Important institutional arrangements within this programme are national inter-sectoral consultative mechanisms. These mechanisms, which can range from powerful sustainable development commissions to small fisheries advisory committees, all serve the purpose of bringing attention to the efforts of small-scale fisheries to engage in adaptation across sectors. For example, tourism can seldom be separated from fisheries in the Caribbean islands in terms of coastal space use and economic interactions. These sectors need to adapt collaboratively to climate change for optimal benefits. Policies and projects that promote marine spatial planning are among those that support inter-sectoral climate change adaptation initiatives, and are also favoured by environmental interests (McConney *at al.*, 2014).

Although evidence supports the premise that declining coastal fish resources can be attributed to climate change impacts, given the lack of resource management in many small island states, it is certain that this is also caused by overfishing as a result of increasing population growth and demand for food. Primary fisheries management has been identified as the key to the success of small-scale fishery adaptation efforts. Many small island states have a tradition of using customary management practices (e.g. taboo areas or no fishing zones), however with increasing cumulative impacts driven largely by increasing human population, effective management to maximize resilience will require national intervention and coordination. Therefore, any adaptation efforts to mitigate future impacts on coastal resources must be complemented with robust and effective ***primary fisheries management legislation***. Successfully implementing such legislation will require support for fisheries transitions (to different gears, techniques and species). Market assessments of value adding in the fish chain, skills training, and collaboration between harvest and post-harvest fisherfolk can support the transition to alternative techniques and (underutilized) species. For example, fisherfolk in Barbados have marketed less familiar species by selling them to consumers as fillets so they are not surprised by the appearance but still they are being offered a high quality semi-processed product.

The ***revision of national and regional policies and plans*** to reduce climate and non-climate impacts on small-scale fisheries and initiatives to prioritize their contribution to food security and livelihoods are critical on small islands (e.g. McConney *et al.*, 2015; Bell *et al.*, 2015a and forthcoming). Pressures on small-scale fisheries that originate upstream, e.g. terrestrial pollutant runoff, urbanization and changes to river flow regimes because of dams and irrigation, can have significant direct impacts on coastal habitats and fisheries (Waycott *et al.*, 2011; Pratchett *et al.*, 2011) as well as exacerbate climate impacts (Heenan *et al.*, 2015). For example, climate change adaptations in watersheds aimed at other sectors, such as agriculture, and urban centres, can negatively impact small-scale fisheries downstream if additional water extraction for irrigation, dams or the development of hydropower significantly alter river and estuarine flows. Therefore, an integrated and holistic approach through national and regional policies is essential to ensure future sustainability of small-scale fisheries (Aswani and Ruddle, 2013; Sale *et al.*, 2014). Such approaches must address land-based pollution sources, as well as other local and global pressures, such as marine-based pollution, overfishing, and destructive and illegal fishing practices.

CASE STUDY 2

Addressing non-climate impacts on coastal fisheries in Fiji

The small land area of the Pacific island states has resulted in historically high levels of clearing and land-use change that have downstream impacts on coastal habitats and fisheries. Sustaining coastal fish production therefore depends on effective coastal fisheries management as well as good land-management practices to maintain coastal water quality and habitats (Foley *et al*., 2005; Wilkinson and Brodie, 2011; Koshiba *et al*., 2014). In the Republic of Fiji, the development of Integrated Catchment Management Plans for select watersheds on Viti Levu and Vanua Levu aim to reduce the negative impacts of land-based activities on coastal habitats and species. The plans focus on mangrove protection, the adoption of sustainable land use practices and riparian restoration in adjoining upstream watersheds, and restoration and rehabilitation of forests. These initiatives will also contribute to Fiji's REDD+ (Reducing Emissions from Deforestation and Forest Degradation) strategy through an increase in forest carbon stocks and mitigation of climate change.

Supporting policies that addresses direct climate impacts are also critical, and the climate and disaster provisions in the SSF Guidelines (FAO, 2015) are of particular interest to fisherfolk. They have engaged in influencing policies so that they incorporate more fisheries perspectives in regional climate arrangements that have been endorsed at the highest ministerial levels (McConney *et al.*, 2015). Such influence is intended to mobilize resources beyond those normally allocated to small-scale fisheries on small islands. Climate change adaptation provides the leverage required to obtain additional resources.

CASE STUDY 3

Incorporating climate change into Caribbean fisheries policy

In the Caribbean, the CNFO is advocating a protocol to the Caribbean Community Common Fisheries Policy that incorporates the SSF Guidelines (FAO, 2015). Fisherfolk are aiming for the protocol to be formulated by a small partnership of organizations willing to collaborate with the CNFO as part of their network approach to developing adaptive capacity (McConney *et al.*, 2011).

Conversely, many small island states have made slow progress with policies incorporating and addressing climate change in a meaningful way, and further assistance and support is required to mainstream climate change into legislation.

CONCLUSIONS AND FUTURE DIRECTIONS

Climate change impacts have been identified as a major threat to small island fisheries, particularly in the tropics (Bell *et al.*, forthcoming; Johnson and Welch, 2016; Monnereau *et al.*, 2017). These small island fisheries are particularly vulnerable because they are highly exposed to climate-related impacts, experience other impacts associated with over-exploitation of resources, pollution and urbanization, and in many cases have limited alternatives for food and income. Further, their resilience tends to be compromised because of a lack of effective management, and in many cases no management. Small islands have limited land area and generally large ocean areas, and as a result tend to be geographically remote, isolated from global markets, have a high dependence on marine resources, are vulnerable to external economic and political shocks, and generally have small economies based on tourism and/or service delivery rather than production.

Small-scale fisheries have a vital role to play in continuing to supply nutritious food and income for rapidly growing populations on geographically isolated and economically disadvantaged small islands. These fisheries have unique characteristics that make them highly exposed and sensitive to the effects of climate change, but also possess flexibility and the capacity to adapt to future change. Investigating the strengths and weaknesses of small island fisheries requires a strategy that documents people or places that are most susceptible to harm (Downing *et al.*, 2002; Polsky *et al.*, 2007), identifies the capacity of island systems to adapt to changing climate conditions, and provides adaptation strategies that incorporate diverse environmental and social drivers within a common framework.

For fisheries on small islands, ensuring the implementation of effective primary fisheries management is a fundamental action that will underpin all other adaptation efforts. Without it, effective adaptation will be compromised. However, there are multiple adaptation options suitable for small island fisheries, and it is likely that a suite of options will be needed to ensure that small island communities are best prepared for future climate impacts. This paper provides a brief synopsis of adaptation options to inform choices for local adaptation efforts.

The track record of small island states in implementing sustainable fisheries management is variable but generally poor, largely because of a lack of resources and capacity. Therefore, there is an imperative for assistance to small island states with limited capacity to fill these gaps and facilitate local government and community efforts to adapt to the challenge of climate change. Further, these efforts must also be supported as much as possible with relevant and appropriate policy and/or regulation to help ensure decisions translate into affirmative action. Similarly, incorporating climate change into the policy of small island states has been slow and may require further support and capacity. Therefore, support is not only needed in policy development and identification of tools, but also in moving to implementation of policy and development of simple but effective governance systems to support ongoing management.

As profound as the effects of climate change are expected to be on small island fisheries, they will be overshadowed by the effects of population growth on the availability of fish for food (per capita) and income for many years to come. The onus is on governments, communities and their development partners to implement a suite of adaptations as soon as possible to address both of these important drivers and minimize negative outcomes. Incorporating local knowledge, capacity and governance will be key components of successful adaptation to minimize climate change vulnerability and enhance the resilience of small-scale fisheries in small islands states.

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Impact of climate change and variability on fishing and aquaculture in Central American Integration System participating countries: strategic action

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ABSTRACT

In 2009, the Food and Agriculture Organization of the United Nations (FAO) noted that there was a strong emphasis on the issue of climate change specifically related to agriculture. However, there was no work focused on adaptation and mitigation of climate change impacts on fishing and aquaculture, even though global fishing and aquaculture production provided 110 million tonnes of fish for human consumption in 2006, equivalent to a theoretical per capita supply of 16.7 kg (equivalent in live weight) a figure that was among the highest up to that point (SOFIA/FAO 2008). Furthermore, FAO noted that it was essential to consider that alterations in the aquatic environment caused by global warming would impact in the first instance on hydro-biological resources, particularly those of interest to fishing or aquaculture; therefore, it was important to incorporate climate change issues into the fisheries and aquaculture sector. The Organization for the Fishing and Aquaculture Sector of the Central American Isthmus (OSPESCA) raised the issue to the level of the Ministers responsible for fisheries and aquaculture as well as to the level of Presidents of the States of the Central American Integration System (SICA), so that the issue of impact of climate change and variability in fishing and aquaculture was officially incorporated into the Fisheries and Aquaculture Integration Policy 2015—2025.

Within the framework of the aforementioned policy and under the command of the Central American Agricultural Council (CAC) and the United Nations' Sustainable Development Goals, OSPESCA has designed a Regional Action Plan for Climate-Smart Fisheries and Aquaculture with eight actions: creating and/or strengthening of capacities; promoting the development of fisheries and aquaculture with the ecosystem approach in the framework of the Code of Conduct for Responsible Fishing and the Code of Ethics; establishing a baseline on regional fishery and aquaculture production and variability and climate change; creating mechanisms to improve conditions of water resources and renewable energies usage; organizing territories to optimize the use of resources; using the market; disseminating information; ensuring financial sources.

INTRODUCTION

Central America is a region particularly vulnerable to the impacts of climate extremes, with losses and damage amounting to millions of dollars after each extreme event. One of the most recent events, tropical storm 12E (2011) resulted in losses of about USD 2 billion (Table 1).

TABLE 1
Cost of loss and damage from Tropical Storm 12E

Central America: Quantification of damages and losses from Tropical Storm 12E (USD)			
Country	**Damages**	**Losses**	**Total**
Costa Rica	57 938 533	25 988 763	83 927 296
El Salvador	569 442 665	333 019 392	902 462 057
Guatemala	81 899 491	251 226 463	333 125 954
Honduras	117 586 112	86 470 188	204 056 300
Nicaragua	315 701 326	129 761 742	445 463 068
TOTAL	1 142.6 million	826.5 million	1 969 million

Source: CEPAL 2011.

Other climate events have also been very destructive, for example: Mitch (1998) left the Central American region with USD 5 000 million in losses and Agatha (2010) caused USD 1 500 million in losses and 194 deaths. In the Global Climate Risk Index 2017 (Kreft, Eckstein and Melchior, 2016) some countries of the Isthmus have been classified among the most vulnerable in the world.

In the specific case of fisheries and aquaculture the region is particularly vulnerable in areas such as shrimp aquaculture, inland fishing and marine fishing. Tropical Storm 12E caused four countries in the region to suffer losses of USD 6 million. In the case of shrimp aquaculture, farms are mostly located on the Pacific coast of Central America that suffer from excess rainfall generated by tropical storms and depressions, hurricanes, among others, but shrimp aquaculture and tilapia also suffer from droughts generated by events such as El Niño.

Both continental and small-scale marine fisherfolk reduce their activities when storms, tropical depressions or hurricanes occur because of the risks of the winds, sea behavior and waves, associated with these phenomena. During droughts, the reduction of water inputs in inland waterbodies concentrates the load of pollutants they receive, with consequences for the health of both humans and animals, as well as for productivity.

The Organization for the Fishing and Aquaculture Sector of the Central American Isthmus (OSPESCA)[11] as a regional intergovernmental organization addresses various topics in coordination with other SICA organs, among them climate change and variability in relation to fishing and aquaculture. This topic has been included in the Regional Strategy on Agro-environment and Health – ERAS – (CAC/COMISCA/CCAD/SICA 2009) and in the Regional Strategy on Climate Change (CCAD-SICA 2010).

The participating countries in the OSPESCA/SICA are: Belize, the Republic of Costa Rica, the Republic of El Salvador, the Republic of Guatemala, the Republic of Honduras, the Republic of Nicaragua, the Republic of Panamá and the Dominican Republic.

OSPESCA, a member of the Global Partnership for Climate, Fisheries and Aquaculture (PaCFA), for its part, includes nine strategic areas in its regional policy:

- institutional and organizational strengthening;
- regional governance;
- management of fisheries and aquaculture;
- climate change in fisheries and aquaculture;
- sustainable fisheries and aquaculture;
- aquatic and fishing safety;
- intra regional trade and extra regional trade;

11 Acronyms and abbreviations of all Central American organizations and strategies used in this text are derived from their Spanish names.

- fisheries and aquaculture with tourism; and
- international relations.

The climate change in fishing and aquaculture component includes actions such as:

- strengthening interaction with regional and international entities that directly address variability and climate change;
- adopting measures to prepare SICA countries to deal with and mitigate the impacts that natural phenomena such as red tides, acidification of the oceans, hurricanes, tsunamis can have in the short-term, medium-term and long-term on fishery resources and aquaculture;
- making efforts to continue and strengthen information-gathering initiatives with the participation of regional associations of fishermen and fish farmers;
- establishing a working group of experts from the SICA countries to advise the national and regional fishing and aquaculture institutions by proposing regional measures to manage the effects of climate variability; and
- strengthening regional dissemination mechanisms so that the citizens, particularly those engaged in fishing and aquaculture can be adequately informed about climate variability and the measures being taken to mitigate its impacts.

This paper describes the steps taken to include climate change and variability in relation to fishing and aquaculture in the Fisheries and Aquaculture Integration Policy 2015—2025.

METHODS

To consider the impacts of climate change and variability in fishing and aquaculture on the sustainable use of hydro-biological and aquaculture resources, and to include them in a regional governance model with binding agreements, as well as to develop cooperation, investigation, training, promotion, among others, it has been necessary to perform the following steps:

1. take into account the proposals of fishers and aquaculture workers about the impact of climate change and variability in fishing and aquaculture activities;
2. include the topic in regional discussions about the Integration Policy for Fisheries and Aquaculture (2015—2025);
3. gain the approval of the Policy by the Council of Ministers responsible for fisheries and aquaculture activities in the Central American Integration System; and
4. support the Policy through an Agreement at the Forty-fifth Summit of Heads of State or Heads of Government of country members of SICA.

RESULTS

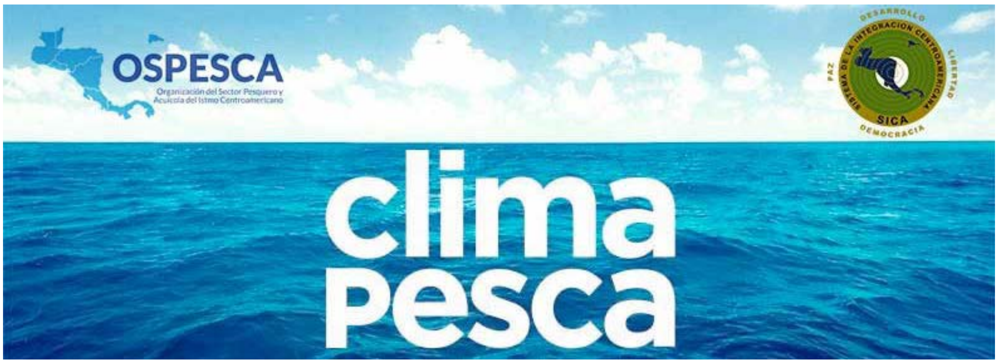
In The Regular Meeting of Ministers of the Central American Agricultural Council (CAC), held on 20 August 2015 in the Republic of San Salvador it was agreed to take medium-term and long-term actions to adapt to climate change and through a Regional Action Plan for Climate-smart Agriculture (including agriculture, fisheries, aquaculture, livestock, forestry). OSPESCA is making efforts to follow such a mandate.

Moreover, OSPESCA has worked to integrate the issues of climatic variability and climate change into the activities of fishermen and fish farmers through the following actions:

- establishing a regional working group on climate variability and climate change implications for fisheries and aquaculture;
- initiating dialogue and exchange of information with fisheries and aquaculture stakeholders in the countries of SICA about these topics;
- strengthening the information gathering initiatives with the participation of regional fishing and aquaculture associations; and
- strengthening mass media communications on the subject.

OSPESCA/SICA publishes the weekly newsletter "CLIMAPESCA" in collaboration with other agencies related to analysis and application of climate forecasts in the fishery and aquaculture sector (Figure 1).

FIGURE 1
Translated cover of CLIMAPESCA for No. 11 on 12 March 2017



CLIMAPESCA
Informative Note, year 4 N° 11
12/03/2017

SECTIONS	CONTENT
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Note: Content changes weekly.

CLIMAPESCA partners include:

- Regional Committee on Hydraulic Resources (CRRH/SICA).
- Forum for the application of climate forecast to food and nutrition safety.
- Climate Change Regional Program, USAID.

So far, the route to incorporate the issue of climate change and variability into the agenda of decision-makers and the knowledge and understanding of fishermen and fish farmers from the countries of the Central American Integration System (SICA) has been presented.

These major objectives have been achieved; however, there is a need to increase knowledge on climate phenomena and their relationship to fisheries and aquaculture, as well as gain concrete support from authorities, producers, civil society and international cooperation to achieve levels of adaptation and resilience that allow maintaining and increasing productive levels for a growing population through the responsible and sustainable use of natural resources.

SICA-OSPESCA strategy to address climate change in fisheries and aquaculture

OSPESCA, within the framework of the Fisheries and Aquaculture Integration Policy 2015—2025, under the mandate of the Central American Agricultural Council (CAC) and the Sustainable Development Objectives, has designed the Regional Action Plan for Climate-Smart Fisheries and Aquaculture summarized below:

Action Plan for Climate-Smart Fisheries and Aquaculture:

Relevant facts
Currently, in 2016, Central America is home to 44.6 million inhabitants, by 2050 it will be about 106 million (more than double), with an average per capita income that will triple by 2050. This translates into greater capacity to purchase among the inhabitants. Food production by 2050 should rise by 50 percent. This increase in production should take place on the same land that is currently used for agriculture.

Challenge
It is necessary to plan, to innovate and to generate new technologies, among others, that lead the region to produce and increase food production, limiting damage to natural resources and increasing resilience despite climate change and variability.

Definition of the plan
Climate-smart fishing and aquaculture is an approach to develop technical, political and investment conditions to achieve sustainable aquaculture and fishing development, food security and welfare generation, even under conditions of climate change and variability.

Components of the plan:
- ✓ creating and/or strengthening of capacities;
- ✓ promoting the development of fisheries and aquaculture with the ecosystem approach in the framework of the Code of Conduct for Responsible Fishing and the Code of Ethics;
- ✓ establishing a baseline on regional fishery and aquaculture production and climate change and variability;
- ✓ establishing mechanisms to improve conditions of water resources and renewable energies usage;
- ✓ organizing territories to optimize the use of resources;
- ✓ using the market;
- ✓ disseminating information; and
- ✓ ensuring sources of finance.

CONCLUSIONS AND FUTURE DIRECTIONS

The Regional Action Plan for Climate-smart Fisheries and Aquaculture is composed of eight actions. The activities to be carried out by each action are described below.

Action 1: Creating and/ or strengthening of capacities

In the region, the issues of climate variability and change are recent and there is a shortage of technical personnel who can deal with them.

In order to foster a climate-smart fishing and aquaculture plan, the integration of local and regional multidisciplinary working groups that receive information on climate elements is needed; especially on those elements with the greatest impact on fisheries and aquaculture activities, sources of information and, what is of major importance, how to interpret them and relate them to fishing and aquaculture. Members of working groups and other stakeholders are expected to be able to acquire skills to model scenarios of climate variability and change related to fisheries and aquaculture.

It is also important to include those fishermen and aquaculture farmers aware of the threats of climate variability and change so that they can contribute their experience and participate in the proposals related to adaptation and resilience measures.

It is suggested that fishermen involved should be organized so that the agreements reached, that relate to the anticipation of the climate change events, as well as the adaptation and resilience actions that are achieved, might be shared with their membership and disseminated to all members of the sector.

Action 2: Promoting the development of fisheries and aquaculture with the ecosystem approach in the framework of the Code of Conduct for Responsible Fishing, the Code of Ethics and the integration of biodiversity in fisheries

In Central America, OSPESCA and FAO have developed some efforts to apply the ecosystem approach, the most recent project being: Strengthening Interdisciplinary Research for Responsible Fishing in Central American Countries (FIINPESCA) — where aspects such as biological indicators of the shrimp and lobster fishery, macroeconomic indicators, value chains, employment, incorporation of women, climate factors and fisheries management aspects (governance) are analysed (FAO/OSPESCA/SUECIA, 2009).

In aquaculture, water use is crucial, quantitatively, qualitatively and also its distribution. Also, climate-related changes exacerbate pests. These and other factors that may become limiting and risky for aquaculture should be considered.

There are three crucial elements for climate-smart aquaculture:

a) improve productivity in a sustainable way;
b) increase adaptability and resilience to shocks; and
c) reduce greenhouse gas emissions.

In the SICA countries, fishermen and aqua-farmers have approved the Code of Ethics for Responsible Fishing and Aquaculture in the States of the Central American Isthmus (OSPESCA, 2011). The Code´s application is not binding in all Central American countries however.

The objective of the Code of Ethics is to serve as a framework for the process of harmonization of regulations and update of national legislation within the Central American Integration System in fishing and aquaculture issues. This code is valuable for the governance of the sector and the measures that can be taken in relation to climate change.

Action 3: Establishing a baseline on regional fishery and aquaculture production and variability and climate change

To find relationships among fishing, aquaculture and climate requires information. On climate, there are multiple sources. The meteorological services of each country in the region have historical records of more than 30 years. International climate services offer different types of information in daily, weekly, monthly and annual series. However, the weakness is found in fishing and aquaculture data, mainly in fisheries.

Relationships among fishing, aquaculture and climate cannot be found when one of the components of the equation does not have recent data. This is a weakness that must be overcome.

The countries of the region make great efforts to have records of the production of fishing and aquaculture; however, for different reasons that information is always out of date. In contrast, the information on climatological aspects is up to date. The ability to forecast based on historical information allows the generation of alerts.

The OSPESCA Information Collection Project in collaboration with Confederation of Artisanal Fishermen of Central America (CONFEPESCA) has fishermen who collect daily data in previously selected fishing ports: If both information (climatological and production) are available, we can establish relations (at the moment empirical) which explain some behaviors of the resources of interest for fishing. This practice, little by little, creates a sufficient base that allows acting in advance before the climate change phenomena occur, obtaining good levels of adaptation and increasing the resilience capacity.

Action 4: Establishing mechanisms to improve conditions of water resources and renewable energies usage

The contribution of fishing and aquaculture to the increase of greenhouse gas concentrations is minimal; however, this does not exempt them from the responsibility of implementing measures to reduce the emission of these gases.

The measures might include, for example: the use of more efficient engines, with a maintenance programme to ensure their optimal operation; the use of innovative technologies for water recirculation; the use of fishing gear and equipment that do not offer drag resistance, to reduce fuel consumption; the use of alternative sources of clean energy; the reduction of discards and waste.

Action 5: Organizing territories to optimize the use of resources

There are areas that because of their characteristics have conditions for certain uses; the management of territories, in order to make more efficient the use of the resources found in the area, is an option.

With this type of territorial management the bureaucratic processes of authorization, monitoring, organization of the producers, establishment of sanitary measures, willingness to use alternative energy, among others, are facilitated. It is also more efficient to implement adaptation and resilience measures, as well as to implement early warnings.

Action 6: Using the market

The market can make an important contribution to the sustainable management of resources under critical conditions, such as increasing the consumption of products captured or produced through the use of renewable energy.

Markets can reward those producers who are concerned about reducing greenhouse gas emissions, as well as those who produce through optimizing water use systems that do not contaminate the environment.

The creation of an authority or a seal that guarantees compliance with sustainability and quality aspects could be a stimulus for markets to better appreciate the region's fishery and aquaculture products.

The publication and promotion of successful cases can add value to regional efforts; the buyers could reward their suppliers, with their preference and promotion, as successful cases that generate a plus for their sales.

Action 7: Disseminating information

In general, marine and freshwater aquaculture biodiversity is affected first by the changes caused by climate variability, particularly resources of interest to fishing and aquaculture; the producers associated with the use of resources also realize the changes. These impacts may be negative such as the deepening or migration of dorado or common dolphinfish (*Coryphaena hippurus*) in the Eastern Pacific, or positive such as the acceleration of mollusk reproduction in the Republic of Peru, both an effect of El Niño.

Such events, some of which are very visible and some others not so much, sometimes go unnoticed in the fisheries and aquaculture sector or are attributed to other factors.

Climate-smart fishing and aquaculture should consider the processes of disseminating information about the climate and the relationship with the sector. The information must be timely and must be presented in an understandable way, especially the relevant aspects of the climate, fishing and aquaculture relationship prior, during and after the development of the phenomena.

OSPESCA is progressing regionally on this issue. The creation of specialized media such as the CLIMAPESCA weekly newsletter, which is regularly distributed on Monday of each week, aims to fill the information void; however, it is necessary to improve it and to make it more popular. Currently, OSPESCA is moving towards the establishment of an electronic medium and the development of mobile applications that will allow interacting with the sector in real time. This work is done in partnership with other SICA entities, and with the support of the United States Agency for International Development (USAID), the International Union for the Conservation of Nature (IUCN), and the Tropical Agricultural Research and Higher Education Center (CATIE).

However, this is not enough; OSPESCA considers it necessary to reach farmers and fishermen through meetings, exchanges of opinion, evaluation of verifiable cases, and to listen to their concerns and proposals. Intensifying communication is an effective way to accelerate adaptive and resilient processes.

OSPESCA, with the support of Centro Clima, the climate information system for the countries of the Central American Integration, has prepared for this year (2017) a training programme for technicians and producers in the management of new communication tools based on CLIMAPESCA, as well as a sustainability programme for the tools described above.

Action 8: Ensuring sources of finance

The Action Plan for Climate-Smart Fishing must have long-term financing activities, for its execution and continuity, which may consist of incorporating the regional requirements for adaptation of fisheries and aquaculture into the Green Fund of the United Nations or acting as a reference for research on the subject in the region.

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Climate change adaptation in coastal shrimp aquaculture: a case from northwestern Sri Lanka

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ABSTRACT

Unexpected temperature variations and rainfall patterns have direct, adverse impacts on shrimp farmers in northwestern Sri Lanka. Specifically, changing climatic conditions impact patterns of shrimp disease spread along an interconnected lagoon and make it difficult for shrimp farmers to predict and control the lagoon—the primary water source for coastal shrimp aquaculture. This paper examines how small-scale shrimp farmers adapt to the impacts of climate change by collectively managing shrimp disease. We studied three shrimp farming communities in northwestern Sri Lanka and analysed adaptation using a social-ecological resilience approach with a four-part framework: (1) living with uncertainty — shrimp farmers deal with the uncertain nature of the shrimp business by controlling (rather than trying to eliminate) disease; (2) nurturing diversity — farmers tend to diversify their income sources to include other activities and they also increase the risk of disease by dispersing pond waste water in space and time; (3) employing 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 (4) creating opportunities for self-organization — farmers have built on their experiences with producer cooperatives, known as *samithi*, to self-organize into a multi-level community-based management structure. Collaboration and collective action are central features of this adaptation mechanism. This small-scale shrimp aquaculture system is persistent, i.e. sustainable and resilient because it is continually adapting.

INTRODUCTION

The aim of this paper is to examine how small-scale shrimp farmers adapt to the impacts of climate change by collectively managing shrimp diseases. The paper argues that building resilience can be one viable option for climate change adaptation and specifically answers two questions: (1) How do small-scale shrimp farmers adapt to the impacts of climate change by collectively managing shrimp diseases? (2) What are the sources of resilience?

We studied three small-scale shrimp farming communities in the northwestern region of the Democratic Socialist Republic of Sri Lanka. All coastal aquaculture in the northwestern region produces black tiger shrimp (*Penaeus monodon*). The Democratic Socialist Republic of Sri Lanka is a small-scale shrimp producer in terms of quantity, but this case study provides unique insights into adaptation and resource management.

Large-scale shrimp farming survived in the country only from the late 1970s to the mid-1990s. However, small-scale shrimp farming has persisted since the early 1990s. It is important to know therefore if shrimp aquaculture in the hands of small-scale producers can be made more resilient and thus more adaptable to climate change.

Most literature about shrimp aquaculture concentrates on the wide range of adverse social and environmental implications (Belton, 2016; Benessaiah and Sengupta, 2014). The impacts of large-scale shrimp aquaculture are unpredictable and inequitable (Galappaththi and Berkes, 2014), depending on the level of vulnerability of social-ecological systems (Bush *et al.*, 2010). Few scientific studies illustrate how to engage in sustainable shrimp aquaculture (De Silva and Davy, 2010).

Recent literature on the country's shrimp aquaculture reflects diverse perspectives. For instance, Harkes *et al.* (2015) identified shrimp aquaculture as a vehicle for climate-compatible development, suggesting how the sector can support the mitigation of greenhouse gas emissions and adaptation to climate change impacts while stimulating rural development, aligning with the previous government's (Mahinda Chinthana) development plan. Bournazel *et al.*, (2015) described the impacts of shrimp farming, focusing on land use and carbon storage around Puttlam Lagoon. Galappaththi and Berkes (2013) examined the northwestern shrimp aquaculture using a social-ecological systems approach, focusing on the surviving small-scale shrimp farmers and how they deal creatively with uncertainties and complexities in natural resources management. Small-scale shrimp aquaculture operations have maintained close relationships with the environment on which, along with natural resources, they depend for their livelihoods and well-being. Interestingly, government statistics show incremental improvement in aquaculture shrimp production since 2005. Almost all national shrimp aquaculture production comes from tiger shrimp farming in the northwestern region (Figure 1).

FIGURE 1
Total aquaculture shrimp production (tonnes)

Source: NAQDA (2017).

This paper analyses adaptation to climate change among small-scale shrimp farmers in northwestern region of the Democratic Socialist Republic of Sri Lanka. A social-ecological resilience approach with a four-part framework is used. The approach emphasizes neither the ecosystem alone nor the social system alone but rather the interconnected social-ecological system as the unit of study (Berkes *et al.*, 2003). Resilience is "the ability of a system to absorb or rebound from disturbance without shifting to another fundamentally different system configuration" (Armitage *et al.*, 2007: 330). Social-ecological resilience is a key aspect related to the building of adaptive capacity (Berkes *et al.*, 2003). The framework we use identifies four ways to build social-ecological resilience to adapt to environment and climate change: (1) living with change and uncertainty; (2) nurturing diversity; (3) fostering learning; and (4) combining different kinds of knowledge (Folke *et al.*, 2003). Adaptation is the act of making something fit a new situation or use (Adger *et al.*, 2009). The literature highlights the importance of the cultural dimensions of climate adaptation (Adger *et al.*, 2013), and private sector engagement (Tompkins and Eakin, 2012).

METHODS

The study was undertaken using a qualitative case study approach (Hancock and Algozzine, 2015). Mixed data collection methods were used to capture the wide range of representative data on different local climate-adaptation and resilience-building efforts (Berg, 2016). First, participant observation was conducted in three shrimp farming communities in the northwestern region to obtain a contextual understanding of shrimp farming operations and climate adaptation. The data collection was carried out from 2012 to 2013; it involved spending time in shrimp farming communities and actively engaging in daily shrimp farming operations such as post-larvae stocking, water quality monitoring, shrimp harvesting, and attending producer cooperative meetings.

Second, semi-structured interview data were collected from 38 shrimp farmers using snowball sampling to obtain diverse and detailed qualitative data about collective action (Ostrom, 1990) undertaken with respect to climate adaptation, such as a zonal crop calendar system, the use of different kinds of knowledge for building climate resilience, and the role of producer cooperatives. Third, three focus group discussions were organized with shrimp farmers and government officers in each community to understand the overall shrimp aquaculture governance structure and to learn how information flows from the local to the national level for decision-making. Focus group meetings were used to clarify and validate other data collected though participant observation and interviews.

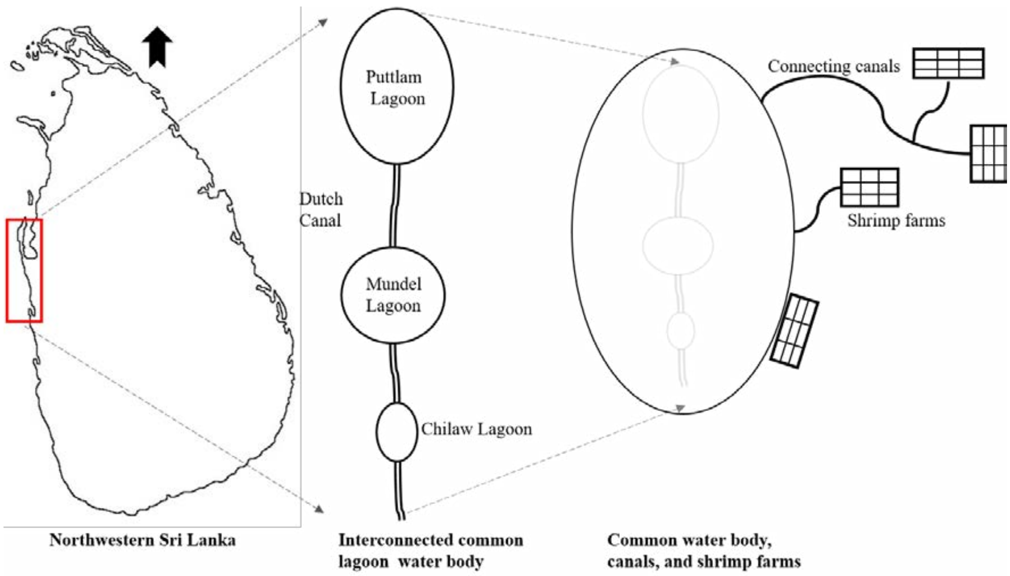
Fourth, seven key informant interviews were conducted with relevant government officers, feed suppliers, hatchery owners, members of shrimp processing companies, and other reputable and experienced people in the sector, including the shrimp farmers who introduced the present zonal crop calendar system. Finally, 28 unplanned on-the-spot interviews were conducted during national-level and zonal-level meetings. Analysis of the data began after the labeling and coding of each piece of subscribed data. Content analysis was supplemented with mind maps and management processes were used to create themes and bring meaning to the findings. This research was conducted in accordance with the Canadian ethical guidelines for research and the research protocols of the University of Manitoba, Canada.

The study area is in the coastal belt of the northwestern province of the country. Shrimp farming is the dominant industry in this area because of the specific soil characteristics and the brackish water required for black tiger shrimp aquaculture (Galappaththi and Berkes, 2015a). The brackish water is found in three lagoons—Chilaw, Mundel, and Puttlam. Coconut plantations and mangrove areas are among the most common types of vegetation found in the northwestern coastal belt. Income-generating activities related to shrimp aquaculture include shrimp broodstock collecting, hatcheries, shrimp farming, middlemen shrimp harvest collectors, shrimp processing and export companies, feed suppliers, and laboratory services (Galappaththi *et al.*, 2016).

In terms of the profile of shrimp farmers, most of them (42 percent) were between the ages of 40 and 50 years old. The youngest group consisted of three farmers (8 percent) under 30 years old. Shrimp aquaculture experience within a community ranged from 2 to 15 years, with a majority (66 percent) having more than 10 years of experience. The majority (37 percent) had some level of high school education, whereas 26 percent graduated from high school. Most (72 percent) shrimp farming operations were family-based, involving family labour and the wife, son, daughter, and other relatives, who contributed labour, kept the books, managed the farm, and engaged in producer cooperative activities. Almost all recorded shrimp farms were owner-operated. In terms of the scale of the operations, the size range of the pond area (pond size) varied from 0.2 hectares to 0.8 hectares. In 2012-2013, the majority (37 percent) of farmers operated two to five ponds. Some experienced shrimp farmers recalled that the large-scale shrimp operations in the 1990s were about 150 hectares in size (Galappaththi, 2013).

Climate change impacts northwestern shrimp aquaculture in the form of droughts, unusual monsoon patterns and floods, and unexpected temperature fluctuations (De Silva *et al.*, 2007). Climate impacts vary depending on the shrimp farming area. The southern part of the northwestern coastal region (Chilaw Lagoon) is characterized by relatively wet (raining and flooding) climatic conditions, with lagoon water salinity varying mostly by single digits. Unusual salinity drops in the Chilaw Lagoon system can increase the incidence of shrimp diseases. The northern part of the coastal belt is dominated by dry (drought) conditions, and water salinity in Puttlam Lagoon remains high (up to about 70 percent), creating unfavourable conditions for shrimp growth. Adequate rainfall between crop seasons helps flush out sediments from tanks that contain mud and debris, which could lead to poor water quality. Inadequate rain leaves shrimp farmers more susceptible to shrimp disease. Furthermore, unexpected extreme weather events such as flooding (e.g. the May 2016 floods) can damage elements of shrimp farming infrastructure, such as ponds and canals.

FIGURE 4
Sketch of the ponds and the canal/common water body where water is discharged/drawn



RESULTS

Shrimp aquaculture operations started in the late 1970s with four multi-national companies (Liver Brothers', Enris, Carson, and Andrew's) that initiated large-scale operations in an integrated fashion (Galappaththi and Berkes, 2014). Local people who worked in large companies learned shrimp farming techniques and later started small-sized and medium-sized shrimp farming upon the failure of the large companies in the face of challenges mainly related to shrimp disease (mainly white spot syndrome).

Shrimp disease is the primary adverse effect of the impacts of climate change on shrimp aquaculture in the northwestern region. The industry suffered a series of shrimp disease outbreaks (in 1989, 1996, and 1998) with significant damage to the sector. Presently, almost all northwestern shrimp farmers are small-scale farmers. These shrimp farmers together identified the key issue of the industry—shrimp disease spread by the interconnected lagoons (Figure 2). This body of water consists of mainly three lagoons and connects to the canal (called the Dutch Canal) running from the Colombo Kalani river mouth to the Puttalam Lagoon. Almost all the shrimp farmers rely on this interconnected lagoon for withdrawing and discharging used pond water. Shrimp farmers identified patterns of the spread of shrimp disease through the Dutch Canal, which varies with annual weather events and patterns. Once shrimp farms discharge disease-infected water into the common body of water, it starts spreading all over the water flow. The dynamics of the spread of disease depend on weather patterns such as monsoon rain.

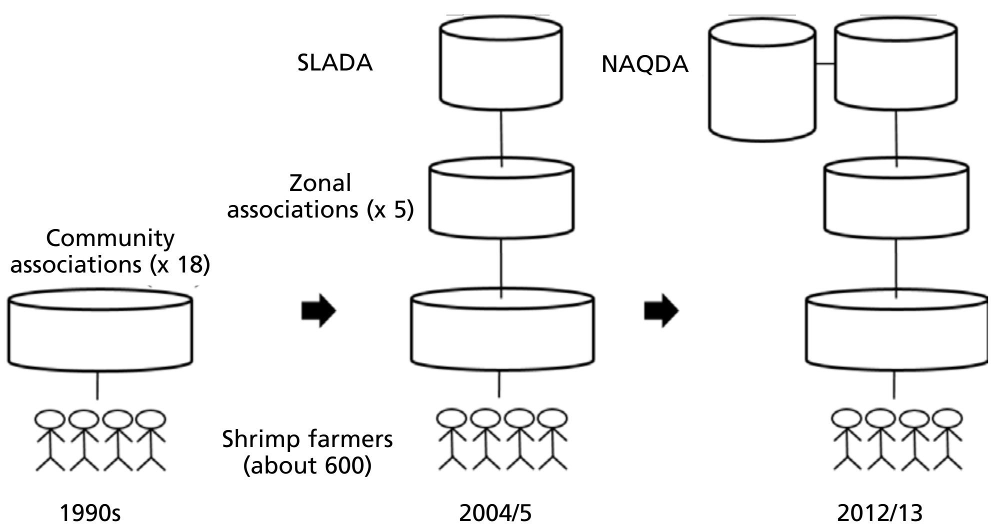
The key solution, thus, is to manage discharge and withdrawal dates from the common body of water. This serves to control (but not eradicate) shrimp disease. However, the solution requires collective action, action undertaken together by all shrimp producers connected to the lagoon to achieve a common (rather than individual) objective. Shrimp farmers achieved collective action through their community association (producer cooperative), collaborating with other producer cooperatives. This system is known as the "zonal crop calendar system" (ZCCS). ZCCS was introduced by shrimp farmers with the support of the National Aquaculture Development Authority of Sri Lanka (NAQDA) and private-sector shrimp farming stakeholders such as feed suppliers, hatcheries, processing companies, and consultancy servicers (all together called the Sri Lanka Aquaculture Development Association (SLADA) —the sector association for the shrimp industry).

How does ZCCS work? Shrimp farmers divide the northwestern shrimp farming area into five zones, with each zone divided into several sub-zones (equivalent to shrimp farming communities). Initially, these zones were created after a study of the spreading patterns of shrimp disease over the past years. Shrimp farmers, SLADA, and NAQDA collaboratively decided which zone (or sub-zone) can (or cannot) support farming during a particular crop season (three crops per year). This crop calendar is finalized after a series of meetings, which tend to involve many debates and arguments; individual and community-level power dynamics play a visible role in these debates. ZCCS became an annual process because of the ongoing but unpredictable impacts of climate change, such as unusual monsoon patterns and floods, and unexpected temperature fluctuations. As shrimp farmers are not farming in all three crop seasons, most farmers (85 percent) can diversify into other income-generating activities, such as fishing, vegetable farming, shrimp feed selling, and coconut farming. ZCCS is judged to be working well, both by farmers and government officials According to one NAQDA officer:

> *Before introduction of ZCCS, white spot [disease] spread aggressively in large areas and result[ed in] huge losses to many shrimp farms. But, now, with the implementation of ZCCS farmers are not getting such losses. We know [we still] have white spot disease in our lagoons and we are still getting diseases [in] certain parts of the lagoon, but we have minimize[d] the risk of losing [the] shrimp harvest because of [the] low occurrence of shrimp disease.*

ZCCS is managed by the multi-level institutional structure (Galappaththi and Berkes, 2014) that has evolved over time. Shrimp farmers have had community-level associations since the 1990s. Some of them were registered under the Sri Lankan cooperatives act and some were registered under relevant divisional secretariat officers. With the problems related to shrimp disease, farmers organized and formed the national-sector association SLADA. Development of ZCCS led to the creation of five zonal shrimp farmers' associations to represent multiple community associations. To strengthen the implementation of ZCCS, SLADA asked that the Ministry of Fisheries engage a government institute as a facilitator and monitor of the system. Since 2004-2005, SLADA and NAQDA have collaboratively worked for ZCCS implementation. Annual zonal crop calendar meetings start at the community level, eliciting shrimp farmers' feedback about previous crops and thoughts about coming crops. This feedback is forwarded to the SLADA-NAQDA decision-making body through zonal institutions (Galappaththi and Berkes, 2015b). All levels (from shrimp farmer community to the national level) are represented in the final meeting and decisions are made collaboratively.

FIGURE 5
Adapting institutions and structures



Multi-level adapting institutions drive the ZCCS. Presently, maintaining membership in the producer cooperatives is obligatory for carrying out shrimp farming in the northwestern area. This creates a mechanism for networking and access to the right information, such as good shrimp feed brands, shrimp market prices, selling experience with processing companies, and disease active areas. The producer cooperative helps community farmers work collectively and share their knowledge related to shrimp aquaculture. For example, during a shrimp harvesting event, cooperative members get together to help their fellow members. Some cooperatives provide compensation to farmers who have diseased ponds (depending on the average size of the shrimp at the harvest). The cooperative is the place where farmers share their farming techniques during monthly meetings. Moreover, cooperatives send their member farmers to government-sponsored technical workshops and to other relevant knowledge-gathering meetings in the region.

Some shrimp farmers have an understanding of the importance of lunar cycles and mangrove vegetation for the shrimp farming environment, and they use that knowledge to foster better shrimp farming techniques. For example, some farmers do not harvest on full-moon nights. Water pumping of the ponds is done only at a certain time of day, taking into account the tides and currents. Certain farmers in the region seem to be less vulnerable to shrimp disease. These shrimp farms are covered by dense mangrove vegetation. Field observations found that the inlet water of these farms is filtered through millions of mangrove roots. These farmers rely on the same raw material sources (post-larvae, feed), as do other farmers who continue to be highly vulnerable to shrimp diseases.

DISCUSSION

Sri Lankan coastal shrimp aquaculture shows the results of efforts to build resilience and adapt to the impacts of climate change. Collaboratively managing the ZCCS for disease control is the key to building resilience. The ZCCS seems to work because: 1) ZCCS is developed and introduced by the shrimp farmers themselves with the support of government institutions (Galappaththi and Berkes, 2015b); 2) the multi-level and bottom-up institutional structure of ZCCS facilitates the crop calendar development process (Galappaththi and Berkes, 2014); 3) shrimp farmers, the government, and the private sector are cooperatively involved in decision-making in ZCCS (Tompkins and Eakin, 2012), 4) ZCCS is an adaptive process evolving annually (Galappaththi and Berkes, 2015b); and 5) collective action and collaboration are the heart of the ZCCS mechanism (Galappaththi and Berkes, 2015a). We discuss the adaptation of Sri Lankan shrimp farmers using a social-ecological resilience approach with a four-part framework.

First, shrimp farmers learn to live with change and uncertainty by managing shrimp diseases (and their outcomes) rather than trying to eliminate the diseases (Berkes *et al.*, 2003). Large-scale companies left the aquaculture industry upon the outbreaks of shrimp disease because they could not survive in the midst of the changes and uncertainties created by the disease. However, small-scale shrimp farmers in the northwestern region collectively faced the challenges of the disease by adopting an annual zonal crop calendar based on the memory of past events, such as shrimp diseases and weather pattern changes (Folke *et al.*, 2003).

Second, shrimp farmers use diversification strategies for climate adaptation. They manage disease risk by controlling the release of used pond water in space and time (Galappaththi and Berkes, 2015b). Before the introduction of ZCCS, the lagoon water system was used by shrimp farmers throughout the year to withdraw and discharge pond water (Galappaththi and Berkes, 2014). At such times, shrimp disease can spread over the lagoon faster than at present and create large losses for most of the farmers connected to the lagoon via water (disease conditions can remain present for a long period of time). Because ZCCS limits boundaries in space and time, the spread of disease is restricted to smaller geographical areas, and losses for farmers are relatively smaller and more recoverable. By taking turns at using lagoon water, shrimp farmers spread the risk of disease. In addition, limited crops per year allow shrimp farmers to engage with other sources of income and not be limited to shrimp aquaculture.

Third, shrimp farmers use different kinds of knowledge (Table 1). Farmers combine their experiences with large-scale (failed) companies, their own experiences

TABLE 1
Types of knowledge adopted by shrimp farmers

Type of knowledge	Description
Shrimp production techniques	Current small-scale shrimp farmers learned shrimp farming techniques from pioneering multinational companies during the late 1970s and 1980s. This knowledge continues to evolve from generation to generation.
Marketing knowledge	Community associations provide required updated information related to shrimp marketing, selling prices and buyers, feed brands and prices.
Local environmental knowledge	This includes how to use mangroves to minimize shrimp disease risk, when water should be pumped into the ponds, and harvesting with consideration of the lunar cycle (to minimize the risk of shrimp disease).
Knowledge and practice with respect to collective action	Sri Lanka has a tradition of collective action. Shrimp farmers apply this knowledge to face their challenges, creating cooperatives, associations, and other groups to work efficiently.
Co-produced knowledge	By working together and sharing and learning from each other, and working together with SLADA and NAQDA, shrimp farmers combine and co-produce new knowledge.

as farmers, and government-sponsored technical workshops on shrimp production. Shrimp farmers' local knowledge about mangroves and lunar cycles indicates their close relationship to nature and natural resources (Galappaththi, 2013); they apply this knowledge to their day to day shrimp aquaculture operations, but the actual effectiveness of this knowledge has not been studied or explained. Furthermore, Sri Lankan shrimp farmers maintain local and traditional knowledge about collective action. The country has a history of collective action, especially in the fisher cooperatives in the coastal fisheries sector. Shrimp farmers' associations include informed members who have up to date marketing information. Community institutions play a significant role in helping shrimp farmers share and co-produce knowledge.

Fourth, Sri Lankan shrimp aquaculture cases show how to foster learning while living with the challenge of disease. Farmers have built on their experiences with producers' cooperatives to self-organize into a multi-level community-based management structure. This structure allows shrimp farmers to learn at multiple levels of governance (community, zonal, and national levels). The ZCCS is revised yearly. Every year, shrimp farmers learn from their ZCCS and bring those lessons to formulate the next year's crop calendar. Producers' cooperatives play a large role in bringing these lessons to the national level. The system uses feedback and operates on the basis of "learning by doing" (Folke *et al.*, 2003).

These four sources of resilience from small-scale farmers can be recognized as different but interrelated ways to adapt to the impacts of climate change in shrimp aquaculture. However, we are not arguing that the shrimp aquaculture governance in the Democratic Socialist Republic of Sri Lanka is perfect in terms of equitable distribution of benefits among farmers, as power imbalances inherent throughout the process can affect the resilience of social-ecological systems. However, the overall effectiveness of the ZCCS and the methods of resilience building in this aquaculture system are reflected in the sustainability and gradual increase in aquaculture shrimp production as shown in Figure 1 earlier.

How does climate change impact shrimp aquaculture governance in the northwestern region? ZCCS is the prime mechanism to build resilience for facing the challenge of shrimp disease. Crop calendar planning is based on the prevailing shrimp disease in the lagoon, whereas weather predictions rely on past weather experiences. From a social-ecological resilience perspective, unexpected and extreme weather increases the uncertainty and complexities of northwestern shrimp aquaculture social-ecological systems. Furthermore, shrimp farmers modify and adapt best management practices introduced by the NAQDA at the community level as appropriate for the local environment. Unexpected changes in climate limit the effectiveness of these "better management practices." However, shrimp farmers trying to manage the complexities and uncertainties created by climate change use an adaptive management (learning by doing) approach to implement ZCCS (Armitage *et al.*, 2007). Implementation of ZCCS is supported by the sources of resilience identified above using a four-part framework (Folke *et al.*, 2003).

CONCLUSIONS AND FUTURE DIRECTIONS

In conclusion, shrimp disease spreading along the lagoon is the key challenge for Sri Lankan coastal shrimp farmers. Shrimp farmers have self-organized with government support, implementing a calendar system to manage shrimp disease impacts. Climate change impacts, such as unexpected weather and extreme events, increase the complexities and uncertainties of shrimp disease control. Resilient small-scale shrimp aquaculture hinges on the collective action of individual owners through producers' cooperatives and collaborative multi-level management. Sources of resilience recognized in the Sri Lankan shrimp farming case include living with change and uncertainty, nurturing diversity, using different kinds of knowledge, and fostering learning, consistent with Folke *et al.*, (2003). Small-scale shrimp aquaculture persists (it is sustainable) because it is resilient and adaptive.

This paper shows that sources of resilience, collaboration among stakeholders, and collective action are the key features of adaptation. This study advances the knowledge necessary to address issues that have theoretical significance for resource management, and practical significance for sustainable aquaculture. The original research project produced publications regarding institutions for managing aquaculture commons (Galappaththi and Berkes, 2014), applications of commons theory to shrimp aquaculture (Galappaththi and Berkes, 2015a), co-management (Galappaththi and Berkes, 2015b), and information sharing through community cooperatives and its impact on shrimp supply chain management (Galappaththi *et al.*, 2016). The present study provides insights for sources of adaptive capacity to deal with climate change. Given current discussions about adaptation, climate change adaptation in Sri Lankan coastal shrimp aquaculture deserves further attention.

A better understanding of possible ways to adapt to climate change in shrimp aquaculture requires theoretical and practical attention to expand the knowledge base. Concepts of climate change adaptation and resilience require more attention to apply to small-scale aquaculture settings in better ways. Only a limited number of studies are available on resilience and climate adaptation in shrimp aquaculture. To understand climate change adaptations and sources of resilience, regional-level (South Asia, Southeast Asia) projects are needed to provide case studies for comparative analysis. Finally, a substantial part of the world's aquaculture production is coming from small-scale producers. Thus, it is important to discover how community-based institutions can carry out shrimp aquaculture as an alternative to large-scale commercial aquaculture. This is not to suggest that large-scale shrimp production operations could be completely replaced by community-based aquaculture. Rather, it is a potential approach to build climate-adaptable, resilient aquaculture systems in the future.

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Adaptation strategies of the aquaculture sector to the impacts of climate change[12]

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ABSTRACT

The need for adaptation of aquaculture practices is expected to increase as climate change impacts on the sector. Numerous options for aquaculture are reviewed and research areas identified that would improve adaptive capacity of the sector to climate change impacts. Suggestions for assessing and implementing potential adaptation measures are built around two pillars: (1) the sustainable livelihoods framework; and (2) an ecosystem approach to aquaculture (EAA). Risk assessment and management along the value chain, and feasibility assessments should support these pillars. The capacity of stakeholders to apply sustainable livelihoods analysis, risk assessments and management, feasibility assessments, and an ecosystem-based approach to aquaculture management should be strengthened.

INTRODUCTION

Farmed marine species have become the main source of fish for food in many nations. By 2021, aquaculture is expected to surpass capture fisheries in terms of tonnes produced. This share could reach 57 percent in 2025 (OECD-FAO, 2016). Aquaculture will need to continue to provide food, materials and services to a growing population in the face of uncertainties and risks posed by a changing climate. To do so it must adapt to the changes. Adaptation is a process that aims to develop resilience and capacity in vulnerable communities to enable them to prepare for and respond to potential shocks and trends with minimum costs and to take advantage of new opportunities responsibly and ethically (Daw *et al.*, 2009).

Adaptation to climate change can be a complex undertaking and poses many challenges, especially as the demands by various sectors on common resources often result in user conflicts. There is a greater level of human control over aquaculture (De Silva and Soto, 2009), which enables the sector to better manage risks. But the same degree of control makes it critical to have a properly planned and coordinated, well-governed and equitable adaptation strategy. This stresses the need for precise identification and characterization of the nature of hazards from climate change, predicting and assessing the risks that the hazards drive, and their impacts. The types of hazards spawned by climate change are physical, chemical and biological. Separately or in combination they pose biological, environmental, economic and social risks. The impacts or consequences, some positive, are contextual and depend on the vulnerability

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of the system. Although the final expression of risk impacts is social cost (or some gain), two critical gaps in understanding the dynamics of the risks remain: (i) understanding of cumulative impacts of multiple stressors on species, habitat and communities; and (ii) differentiating between risk impacts of anthropogenic sources and climate change hazards and describing their interactions (FAO, 2017).

SUMMARY RESULTS

Adaptation and risk mitigation are underpinned by common enabling factors: strong institutions and good governance, innovation and investments in environmentally sound technologies and infrastructure, sustainable livelihoods, and behavioural and lifestyle choices. Some of the most important factors shaping the adaptive capacity of farmers, households and communities are their access to and control over the natural, human, social, physical and financial assets and their ability to use them productively (FAO, 2017).

Aquaculture can be an adaptation option for other sectors: as an alternative for those whose livelihoods are disrupted; a contingency for those whose livelihood assets are suddenly diminished by a disaster; for livelihood and farming enterprise diversification; and as a productive use of land that has lost its capacity to support crops. In these cases, aquaculture can increase income, enhance food security and create jobs.

However, there remain important gaps in the science and technology foundation for adaptation. More studies are needed on climate change impacts on aquaculture crops and on post-production. There is a need to balance studies done on high value species in industrialized countries with more focus on tropical species and developing countries. Extending research on temperature and acidification to the analysis and understanding their social and economic consequences would inform adaptation at levels higher than the farm, i.e. household, cooperatives and community. Other gaps include the interactions of multiple impacts of climate change on production areas, and the cumulative impacts of multiple stressors on aquaculture systems.

CONCLUSIONS AND FUTURE DIRECTIONS

In order to select and implement effectively the strategic measures and technical options for adaptation, a number of capacity building measures are recommended:

1. promote ***livelihood analysis*** in aquaculture development planning and project formulation and train planners and development workers on the concept and process of the sustainable livelihoods approach. This ensures people are involved in the choice of adaptation measures and assures the choices are compatible with their livelihood objectives, strategies and assets. The analysis would identify which livelihood capitals need strengthening, how to enable better access to these capitals and increase the ability to manage them, and the role and capacities needed from institutions;
2. integrate into plans and projects the concept and practice of ***risk analysis***, and strengthen the capacities of organizations in risk analysis and management as the risk impacts along the value chain need to be assessed, communicated and well-managed;
3. adopt an ***ecosystem approach to aquaculture (EAA)*** for integrated and coordinated management of adaptation measures in the aquaculture sector. Such an approach avoids fragmented and isolated efforts. Training on the concept and application of ecosystem-based approaches should be given to disaster risk management personnel; and
4. check adaptation options, especially the major ones, using ***feasibility assessments*** supported by cost—benefit analysis.

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Key factors and concepts governing the ability of artisanal fisheries in the La Plata River basin to reduce their vulnerability and adapt to climate change

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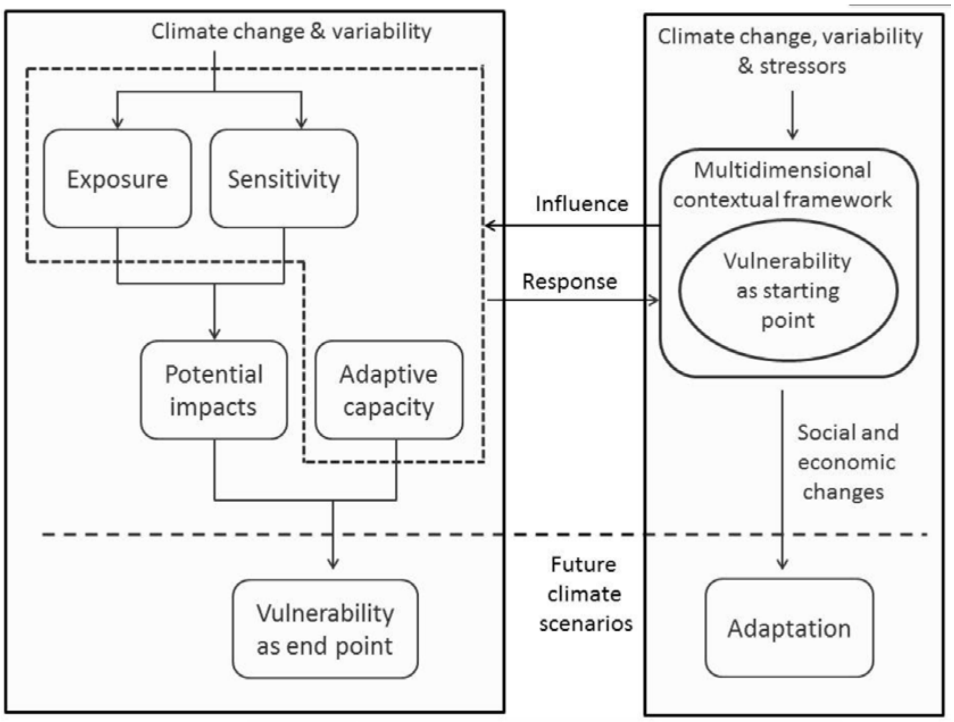
INTRODUCTION

Large-river fisheries, like other small-scale fisheries, play a critical role in providing food security, nutrition, employment, and poverty alleviation (Berkes *et al*., 2001; Béné *et al*., 2007). However, sustainably managing large-river fisheries in South America is challenging because of increasing fishing pressure, anthropogenic impacts (Barletta *et al*., 2010 and 2016), and climate change impacts. La Plata River basin, the second largest in South America and the fifth largest in the world, represents a case study that demonstrates the conceptual problems in improving small-scale fluvial fisheries adaptation and reducing vulnerability to climate change. In the La Plata River basin, the adaptation of riverine communities to climate change has been poorly considered by government agendas. Understanding the vulnerability of river fisheries to climate change is not simple but river fisheries nevertheless deserve attention because of their social importance. Predicting hydrological conditions will depend on the balance between several related factors, such as precipitation, temperature and land use patterns (Saurral *et al*., 2006). These effects could be exacerbated by several large dams and large reservoirs installed in the upper basin in Brazil (Agostinho *et al*., 2007) that have the capacity to reduce downstream main channel flows and floodplain area during low rainfall years. These factors add uncertainty about the real impacts of climate change on future basin conditions affecting fish and fisheries sustainability.

SUMMARY RESULTS: FRAMING CLIMATE CHANGE FOR LARGE RIVERS

Vulnerability and adaptation to climate change have been assessed using different approaches (e.g. Adger, 2006; Eakin and Luers, 2006; Fűsell and Klein, 2006; O´Brien *et al*., 2007; Brugère and De Young, 2015) but can be summarized in terms of two main perspectives (Okpara *et al*., 2016). The traditional framework or biophysical perspective outlined in the IPCC guidelines (IPCC, 2001 and 2007) is the dominant approach applied to assess vulnerability to climate change by most government agencies dealing with climate issues. This "end-point" method focuses on learning about the physical impacts of natural hazards and relates to the level of susceptibility that is observed after adaptive capacity is considered (Hopkins, 2014). Vulnerability is the difference between the adaptive capacity relative to potential impacts given by exposure and sensitivity in view of future environmental conditions projected by multi-decadal global climate models. Thus, adaptive capacity of a system affects the assessed vulnerability to climate change by modulating exposure and sensitivity and thus potential impacts (Figure 1).

FIGURE 1
Comparative frameworks of climate change vulnerability based on IPCC end-point approach (left box) and contextual starting point approach (right box)



Note: Inner dotted box indicates how exposure and sensitivity are affected by ongoing current vulnerability. Horizontal dotted line separates present and future climate conditions and vulnerability perception.
Source: Modified from O' Brien *et al.* (2007).

On the other hand, the "starting point" or "contextual" vulnerability framework focuses on past and present socio-economic conditions as the main pillars of vulnerability to cope or adapt to changing climate conditions (O´Brien *et al*., 2007). Vulnerability is understood as the present inability of a system to handle changing climate conditions and is considered an inherent characteristic of socio-ecological systems generated and shaped by multiple factors and processes (Kelly and Adger, 2000). This perspective is more centered on the social and economic well-being of society (Dessai and Humle, 2004), and emphasizes the current socio-economic determinants as drivers of vulnerability instead of focusing only on climatic hazards. Therefore, vulnerability can be reduced by modifying or improving the social background conditions in which climate change occurs so that individuals and groups can better adapt to changing climatic stressors (Fellman, 2013). Thus, both approaches stem from different framings of the climate change problem considering different temporal and spatial scales for adaptation, vulnerability drivers and policy recommendations.

Such different approaches could dictate dissimilar visions about how to cope with climate change but ultimately they will be context-specific. Inland fisheries are exposed to direct and indirect natural and human impacts that take place at different spatial and temporal scales across the basins. Although fishing communities have developed the capacity to cope with the natural hydrological variability exhibited by large floodplain rivers, fragile capitals may undermine the ability of fishers to reduce the exposure to extreme and extended unfavourable climate events and other stressors. In turn, the degree of sensitivity will be tied to economic, political, socio-cultural and institutional factors. In La Plata River basin, for example, fisheries adaptation to climate change is affected not only by climate hazards and expected future conditions but, more importantly, by visible barriers related to weak governance, poverty, inequity, poor health and education conditions, limited access to resources, weak assets, lack of livelihoods diversification, transboundary resource conflicts and fisheries management policies, and loss of ecological integrity because of rivers fragmentation (Baigún *et al*., 2016). The construction of a chain of dams in this basin could exacerbate the effects of water stress on poor fishing communities downstream and also upstream because of migratory species depletion, if fishers´ marginalization and poverty conditions are not first addressed to enhance adaptive processes. Similarly, access to technological measures, such as aquaculture development to mitigate unfavourable fisheries scenarios, could have low effectiveness if fishers lack basic services and education, or do not own their land. Thus, current contextual conditions appear to strongly influence the exposure and sensitivity to pervasive factors and limit the adaptive capacity to reduce vulnerability under the "end point" framework.

CONCLUSIONS AND FUTURE DIRECTIONS

Although river fishing communities systems have developed adaptive management strategies and have become resilient to dynamic environmental conditions usually exhibited by large floodplain rivers, a more holistic perspective is necessary to predict future vulnerability. This needs to be based on understanding the set of underlying key environmental, social, political, institutional and cultural factors that can exert a strong influence on fisheries adaptive capacity. Therefore, as climate change adaptation is rooted in a complex set of factors some authors have called to modify the traditional IPCC framework to a more comprehensive and integrative framework (Fellman, 2004; Eakin and Luers, 2006; Marshall *et al*., 2010; Cinner *et al*., 2013; Johnson and Welch, 2016; Johnson *et al*., 2016). These authors recognize that addressing future vulnerability conditions and approaches are context specific and need to incorporate the suite of factors that shape socio-ecological systems and enhance their resilience to adapt to future socio-economic and environmental changes under various climatic scenarios.

However, successful climate change adaptation and vulnerability assessment in large river fisheries needs also to be linked and supported by a shift in management approach. Whereas the capacity of conventional management systems to adapt to climate change impacts have been considered low (Badjeck *et al.*, 2009), the application of an ecosystem-based approach to fisheries (EAF) (De Young *et al.*, 2008) encourages more participatory policies, and better governance mechanisms. The EAF approach also strengthens the concept that fluvial fisheries represent valuable ecosystem services that help reduce poverty and marginalization and provide livelihoods instead of being considered only as commodities (Baigún *et al.*, 2013). This framework also has the ability to improve adaptive capacity by encouraging innovative fisheries management alternatives that benefit the most vulnerable fisheries sectors. In river fisheries, as in other socio-ecological systems, adaptive capacity may be heterogeneous according to location, gender, health and social status (Adger *et al.*, 2007). Thus, a potential advantage of the contextual approach is supported by the strong involvement of communities and stakeholders in identifying climate change stresses, impacts and adaptation strategies (Fellman, 2013), all actions that align with EAF principles. This combined vision would be better suited to enhance the resilience of fishing communities, support their livelihoods and maintain key ecosystem services in large floodplain rivers.

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

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INTRODUCTION

In the People's Republic of Bangladesh, fisheries and aquaculture play an important role in food supply, food security, income generation and export earnings. According to Allison *et al.* (2009), the country ranks 12th among countries that are most vulnerable to climate change impacts on fisheries. Chapainawabganj is one of the most vulnerable districts of northwest Bangladesh to climate change impacts, particularly increasing drought, on fisheries and aquaculture (Islam *et al.* this volume). *Kole* fish culture is a non-traditional and recent intervention that offers a climate change adaptation opportunity, especially to support livelihoods for fishers of northwest Bangladesh. *Kole* are small lakes or large ponds that are found in vast areas of the riverbed when the flow of the Padma River is significantly reduced each dry season, but anthropogenic causes also play a part. These *kole,* hereafter referred to as river ponds or, more simply, ponds, are not flooded for five or six months until the wet season begins, and offer trapped water that can be used for aquaculture. In recent years, unemployed fishers and youths near these river ponds have started culturing fish in large ponds in Chapainawabganj District. River pond fish culture started in 2010 in an unorganized manner by local fishers in the dry season when fishing options became limited. Thereafter, increasing numbers of fishers became involved in river pond fish culture as a part-time income generating activity. A preliminary investigation was carried out to assess the feasibility of this type of fish culture as a climate change adaptation initiated by fishers and to identify challenges and future opportunities.

METHODS

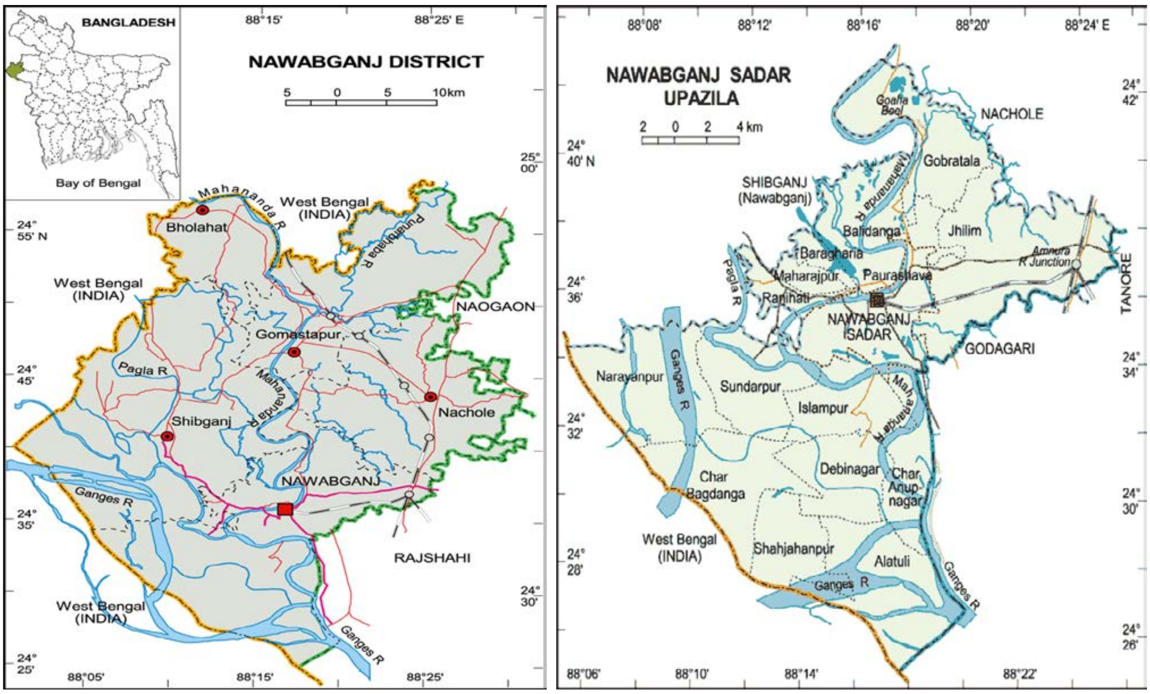
Surveys were conducted at three selected ponds in the Padma River of Sadar upazila (sub-district) in Chapainawabganj District. The first survey was done during January to July 2012, and repeated in January to July 2015 to re-examine practices and harvests. The surveys were done using a structured questionnaire. Selected local groups kept all records of the fish culture operations to inform the study. Each group consisted of 5 to 20 members. Personal interviews and focus group discussions were conducted in each pond area with voluntary members participating. Information gathered during the surveys included: pond inputs, stocking, post-stocking management, harvesting and marketing, labour, expenditure and income, and identified risks. Focus group discussions recorded the future potential, challenges and sustainability of river pond fish culture, conflicts of interest among stakeholders, and validation of data obtained from the surveys. A total of six focus group discussion sessions were held with 5 to 14 members of each group present. No females participated in either the surveys or focus group discussions, as women are not directly engaged in river pond fish culture, but will be specifically included in future surveys. Targeted interviews were also conducted with two field staff from the local fisheries office as key informants to validate the data gathered. Wild fish specimens were collected and brought to the local office of the Department of Fisheries for identification.

SUMMARY RESULTS

The ownership of river ponds lies with the Ministry of Land and is controlled by the local Sub-district Executive Officer. Sub-district fisheries officers facilitate temporary permission from the Sub-District Executive Officer for fisher groups near ponds to stock fingerlings and farm fish in the pond. River pond fish culture is normally undertaken by a group of 5 to 40 local fishers residing near the pond.

Physical features of river ponds: Usually ponds begin to appear in November to December each year (Figure 1), and initially they have a large area (e.g. 15 ha) and are deep (> 4 m). Gradually the ponds become smaller and shallower as conditions become drier. The initial area of the biggest pond surveyed was 15.0 ha, which gradually shrank to 7.4 ha. The smallest pond was 3.5 ha, which finally became 2.5 ha.

FIGURE 1
Map showing the study area



The boundaries and names shown and the designations used on this map do not imply the expression of any opinion whatsoever on the part of FAO concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers and boundaries. Dashed lines on maps represent approximate border lines for which there may not yet be full agreement

Fish production: Stocking of river ponds usually begins in early January and ends in February. In 2012, fingerling stocking density was 768±266 fingerlings/ha or 320±154 kg/ha. In 2015, stocking density had increased to 3 534±1 730 fingerlings/ha or 737±460 kg/ha. In most cases, species selection in stocking was done on an ad hoc basis considering the natural food available and preferred by different fish species. Feeding was also irregular and on an ad hoc basis. Fish harvesting and marketing was usually done in June to July, and takes two or three weeks to complete. To reduce the risk of fish escaping because of unexpected early monsoon and inundation, partial harvesting from May is a common practice. In 2012, the average fish production was 767±447 kg/ha including 42±31 kg wild fish and in 2015, the average fish production recorded was 2235±970 kg/ha including 82±15 kg wild fish. This production level was found to be within the average range of fish production from pond aquaculture, which is 4.3 MT/ha (DoF, 2015). A total of 49 wild fish species, including two prawn species, were recorded in this study.

Socio-economic and environmental aspects: In the dry season, about 50 percent of aquaculture river ponds in the Chapainawabganj District suffer from water scarcity, reduced water depth and about 10 percent of ponds become completely dry (personal observation). Ponds provide an alternative farming option during dry periods, and can also be used for raising carp fingerlings early in the fry-rearing season when most of the nursery ponds lack the quantity of water required. It is estimated that about 100 to 125 ponds with a total water area of about 2 000 ha appear each year in the Padma River basin in northwest of the country. These waterbodies present significant potential for additional fish farming and livelihoods, with current annual production of 1 500 to 4 000 MT using traditional culture practices that can be increased to 6 000 to 8 000 MT worth USD 15–20 million if improved technology is adopted. About 2 500–3 000 people can be engaged in river pond fish culture, representing 75 percent to 90 percent of fishers whose livelihoods become vulnerable during dry periods.

FIGURE 2
A large pond in the Padma river bed in Sadar upazila of Chapainawabganj district, Bangladesh

CONCLUSIONS AND FUTURE DIRECTIONS

The contribution from inland fisheries to the country's total fish production is gradually declining as a result of climate change impacts on rainfall and water supply, which is affecting food security and livelihoods. The river ponds offer a new opportunity for seasonal fish culture to support fishers' livelihoods during dry periods. River drying and limited fishing scope in the dry season is now a regular phenomenon that has prompted fishers to initiate fish farming in river ponds as an alternative livelihood option and has future potential as a climate change adaptation.

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The use of water lettuce (*Pistia stratiotes*) for lowering water temperature of freshwater ponds with the black-chin tilapia (*Sarotherodon melanotheron)*

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ABSTRACT
The effects of the water lettuce (*Pistia stratiotes*) as a floating plant to reduce water temperature of freshwater ponds and the growth of the black-chin tilapia (*Sarotherodon melanotheron*) were determined. Two densities of the plant contained by floating PVC pipes were tested (12 percent and 24 percent of pond water surface). The results showed that the mean water temperature (max-min/day) of the pond with 24 percent shading of the plant was lower by 3.2° C compared to that of the control pond (without shading), whereas that of the pond with 12 percent shading was reduced by only 1.5° C. The fish in the pond with 24 percent shading grew at 0.59 g/day compared to -0.12 g/day for fish in the pond with 12 percent shading after 32 culture days. This indicates that the lower water temperature in the pond with 24 percent plant cover favoured the growth of fish despite the lower levels of pH and dissolved oxygen and higher water transparency compared to the control pond. Further studies are recommended to determine the cost-effectiveness of the use of the plant as well as its other benefits for growing fish in aquaculture ponds as a coping strategy for climate change.

INTRODUCTION
Aquaculture, the farming of aquatic plants and animals, is vulnerable to the adverse impacts of changing climate. In the Republic of Philippines, brackish aquaculture ponds and seaweed culture in open coastal waters sustained the biggest losses because of the El Niño event of 1997-1998 that caused high surface temperatures and drought (PCAMRD, 1999). One of the coping strategies for reducing water temperature of aquaculture ponds is the use of artificial shading material, such as fine-mesh nylon netting. The prohibitive cost of such material, however, limits its use by small-scale farmers.

The water lettuce (*Pistia stratiotes*), a floating aquatic weed that is common in freshwater lakes and rivers of tropical countries such as the Republic of Philippines, was reported by Attionu (1976) to reduce water temperature by lessening sunlight penetration in open freshwater systems. According to Akinbile and Suffian (2012), the roots of the plant absorb ammonia, nitrates, metals and phosphates, and provide oxygen. Moreover, they also stated that the plant shades the ponds from light and prevents overheating of the pond water.

This study was conducted in April-May 2016 at the height of the El Niño episode in Bay, Laguna, the Republic of Philippines and determined the effects of (*P. stratiotes*) shading on lowering the water temperature of freshwater ponds and on the growth of the black-chin tilapia (*Sarotherodon melanotheron*).

METHODS

Two shading densities of *P. stratiotes* were tested (12 percent and 24 percent of pond water surface) within each of two 200 m^2 ponds (mean depth of 0.75 m) supplied by a freshwater irrigation source. The ponds were fertilized with vermicompost (organic fertilizer) at 1 ton/ha.

P. stratiotes was contained at the pond surface by floating frames made up of 5 cm diameter polyvinylchloride (PVC) pipes. Three floating frames for the plant with a total area of 28 m^2 were used in one pond and six floating frames with a total area of 56 m^2 in a second pond. In each pond, 120 male *S. melanotheron* with 100 g mean weight were stocked. A 200 m^2 pond without the plant and fish was used as the control.

Water temperature readings were taken in the ponds with a Taylor Maximum/ Minimum Thermometer. Water quality parameters for pH (Tetratest), transparency (Secchi disk) and dissolved oxygen (YSI metre) were measured. The mean weights of the fish were measured after 32 days of culture to determine their growth rate.

SUMMARY RESULTS

The results (Table 1) showed that the mean of the max-min water temperature readings for the pond with six frames of the plant was 3.2^o C lower than that of the control pond, whereas the mean temperature for the pond with three frames was only 1.5^o C lower than the control. These results indicated that the six frames of the plant were more effective in lowering pond water temperature than the three frames. The dissolved oxygen and pH levels were lower and the transparency of the water was higher in the pond with six frames compared to those in the control pond.

TABLE 1

Mean temperature (max-min) and water quality parameters for dissolved oxygen, transparency (water clarity) and pH for the test and control ponds

Pond (percent shade)	Mean temperature (° C)	Water quality parameters c		
		O_2 (ppm)	Transparency (cm)	pH
0	33.8[a]	2.18	10	8.5
12	32.3[a]	ND	ND	ND
24	30.6[b]	1.38	14	8.0

Notes: a=three readings; b=two readings; c=determined at 6:00 am; ND=No data.

The growth of the fish in the pond with 24 percent shading was faster than that of fish in the pond with 12 percent shade that actually lost weight (Table 2). The tolerable water temperature range for pond culture of tilapias is 28–32^o C. The results showed that the lower water temperature in the pond with 24 percent shade was more favourable for fish growth. This and other possible benefits of the plant should be studied further.

TABLE 2

Growth of S. melanotheron in the ponds with 12 percent and 24 percent shading after 32 days of culture

Pond (percent shade)	Mean fish weight at harvest (g)	Growth rate of fish (g/day)
12	96	-0.12
24	119	0.59

CONCLUSIONS AND FUTURE DIRECTIONS

The water lettuce (*P. stratiotes)* was effective in lowering pond water temperature by 3.2° C, which contributed to faster growth of *S. melanotheron*. The growth of fish in the pond with 12 percent shading where water temperature was lowered by 1.5° C was negative. Further studies are recommended to determine the cost-effectiveness of the use of the plant and its other benefits in aquaculture ponds for growing fish as an adaptation to climate change-induced pond temperature increases.

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

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INTRODUCTION

It seems unclear whether fishing communities adjust in response to actual or expected climatic change in a particularly different way than they adapt to other types of variability and hazards. However, addressing climate risks, enhancing adaptive capacity and reducing vulnerability are currently important aims in development plans for the fisheries and aquaculture sector may not be often covered effectively by governmental agencies. Here, we report on an ongoing evaluation of the adaptation *continuum* (from impacts-focused to vulnerability-focused) as part of the local actions in Brazil derived from the "*Global understanding and learning for local solutions: reducing the vulnerability of marine-dependent communities*" (GULLS) project, funded by the Belmont Forum and which plans to provide adaptation options in five countries of the southern hemisphere considered hotspots of ocean warming (Cochrane *et al.*, 2014; Hobday *et al.*, 2016). The aim of this paper is to share key local views on the construction of adaptation plans in fishing communities (and industries) in Brazil, applicable also to a regional level.

The way that cultures adapt and react to environmental and climate change differs significantly around the globe and adaptation-driven innovation is developing in several different ways in distinct communities and societies. It is, therefore, particularly important to develop context-specific adaptation plans rather than generalized or global approaches.

The concept of "adaptation" applies to both natural and social sciences, referring in both cases to three key processes: flexibility, acclimatization and learning. The way each culture develops those three processes may also differ as innovation arises from diversity and exchange. In this sense, adaptation can be seen as a process, action or outcome of a system to better cope with, manage or adjust to changing conditions, stresses, hazards, risks and opportunities, and to enhance the fitness and survival of individuals (natural sciences) or a society (social sciences) at the local level. We argue that the responses to climate change exposure in fishing communities, being characterized as <u>coping</u> or <u>adapting</u> (Box 1), deserve context-specific adaptation plans rather than "all-fits-one" general approaches. However, outcomes from central places (*sensu* Gasalla and Tutui, 2002), such as science-based forecasting and assessments may not be disregarded and should contribute as guidance on the perspectives of further change.

BOX 1

Different characteristics of coping and adapting in fishing communities

Coping x Adapting

Coping

- Short-term and immediate
- Oriented towards survival
- Not continuous
- Motivated by crisis, reactive
- Often degrades resource base
- Prompted by a lack of alternatives

Adaptation

- Oriented towards longer term livelihoods security
- A continuous process
- Results are sustained
- Uses resources efficiency and sustainability
- Involves planning
- Combines old and new strategies and knowledge
- Focused on finding alternatives

Based on: Smit and Wandel (2006); Bennett *et al.* (2014); Bennett *et al.* (2016).

METHODS

In GULLS - Brazilian section, climate change impacts have been assessed through different sources and innovative approaches, including bottom-up surveys within fishing communities (Martins and Gasalla, 2018a), the application of the "ethno-oceanographic framework" (Gasalla and Diegues, 2011; Martins and Gasalla, 2018b), vulnerability analyses (Aswani *et al.* 2018; Martins and Gasalla, 2018b), the downscaling of global/regional ocean models (Popova *et al.*, 2016) and some stock assessment modelling, education and policy mapping (e.g. Hobday *et al.*, 2016).

Below we describe a strategy in which these science-based outcomes are incorporated into participatory methods to identify adaptation options (Figure 1). The idea is to combine local knowledge with scientific data, in a process of builds on people's understanding about climate risks and adaptation strategies, and by providing dialogue and knowledge exchange within communities of practice.

The adaptation design process includes 1) the analysis of current exposure and impacts of climate change; 2) a model-based analysis of future climate scenarios; 3) understanding of individuals, households, and communities vulnerability, as well as the engagement of multiple stakeholders; and, 4) the effective sharing of knowledge and lessons learned.

FIGURE 1

Proposed framework to empowering climate change adaptation-driven innovation in fishing communities through science-based support

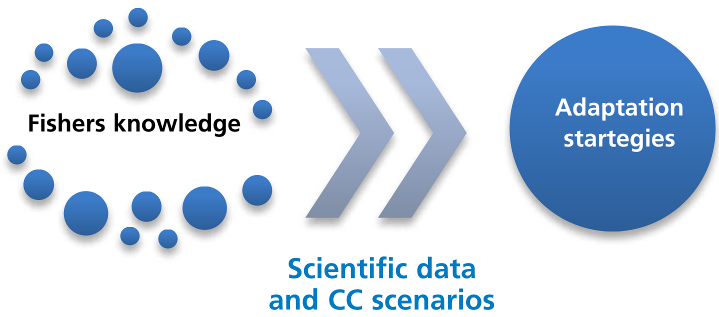
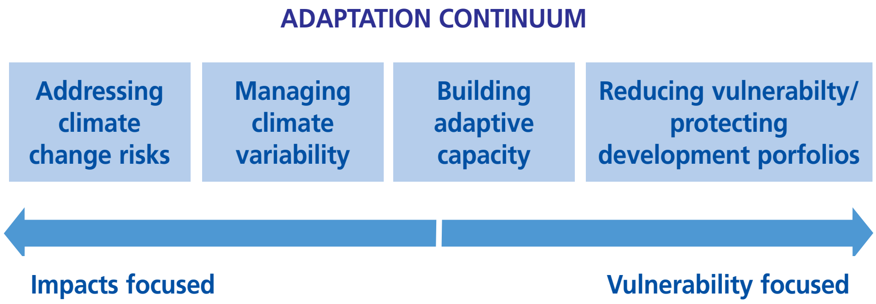


FIGURE 2
The adaptation continuum, from impacts to vulnerability



Community, household, and individual adaptation to climate change is being facilitated by the extent to which local people are 'experiencing climate change', are 'knowledgeable about climate change', and are able to change their behavior to 'actively manage risks' (Bennett *et al.*, 2014). Our methodological approach follows the adaptation *continuum* (Figure 2), and the following steps (in Box 2) are applied into the co-production of an adaptation plan to climate change in fishing communities and industries. The scientific counterpart included in the stepwise method above is based in a set of working groups in which the GULLS research has being organized (Figure 3).

BOX 2
Stepwise planning for the co-production of an adaptation plan for climate change in fishing communities

STEP 1
Sharing outcomes with fishing communities on:

- Fisher's perception studies
- Vulnerability analysis
- Ecological risk assessment
- Ocean models
- Stock assessment
- Policy mapping

STEP 2
Discuss adaptation options based on:

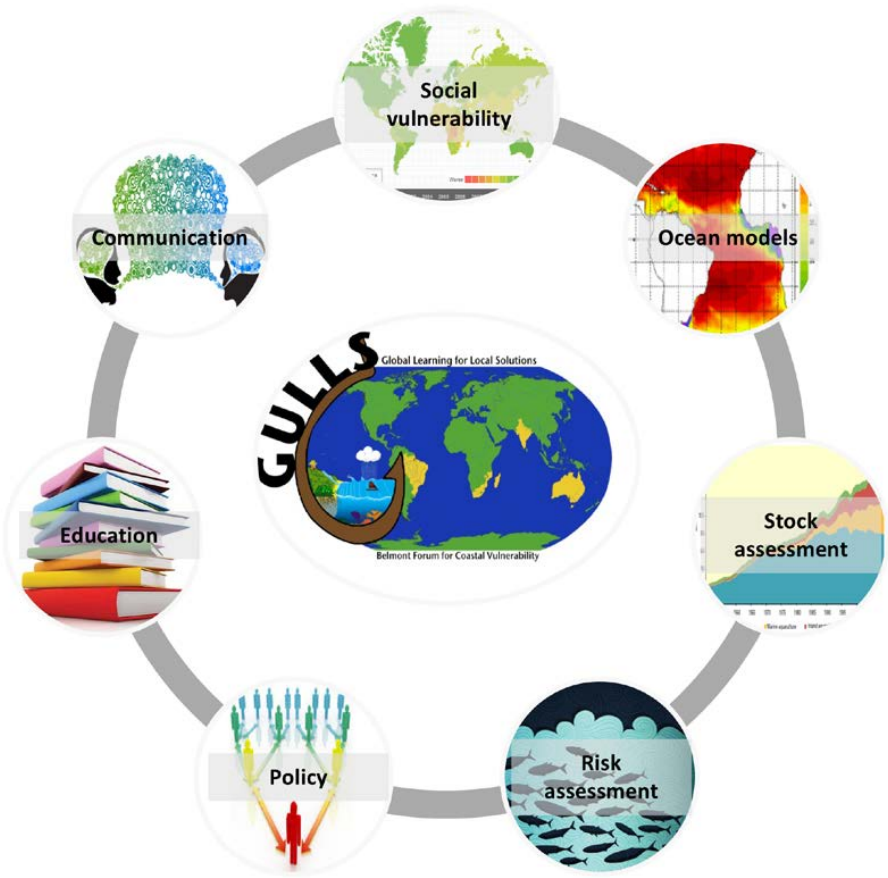
- Fisher's perception, solutions and attitudes
- Vulnerabilities found
- Ecological risk found
- Ocean models projections and forecasting
- Stock assessment projections
- Policy mapping analysis

STEP 3

- Focal groups with local fishers, stakeholders, research and decision makers to present climate-related research outputs and draw adaptation options and strategies to climate change scenarios.
- Present the impacts of climate change identified and build the adaptation strategies in a participatory process.
- Share positive and negative experiences among the communities, regions or countries.

FIGURE 3

The set of interacting analyses and actions produced in the GULLS project in Brazil, aiming different understanding on climate change impacts, vulnerabilities, policies and education needs



Source: Adapted from Cochrane *et al.* (2014) and Hobday *et al.* (2016).

SUMMARY RESULTS

Coastal fishing communities have shown their own perspectives, which allow to build on both extremes of the adaptation *continuum*. Martins and Gasalla (2018a) shows an application of the ethno-oceanographic approach to climate change in Brazilian fishing communities, which highlights main perceptions found and eventual alternative scientific confirmations and hypotheses. The study of stakeholders' perceptions seems to empower fishing communities in a way that their perspectives are taken into account and linked to the science produced; finding a place where their innovations may be enhanced, validated, stimulated and contextualized. On the other hand, the outcomes of a series of scientific working groups currently running specific science-oriented analyses (Figure 3) with local and international teams is being presented to selected fishing communities where participatory approaches will allow the co-production of local adaptation plans and strategies to current climate change challenges.

Climate change impacts have been explored in different ways (Aswani *et al.*, 2018; Gasalla *et al.,* 2018; Martins and Gasalla, 2018a,b; Popova *et al.*, 2016) and should be taken into account in this process, especially in the small-scale sector (Gasalla and Castro, 2016). The co-production of an adaptation plan following Box 2 seems to be a promising strategy at the country (and regional) level.

CONCLUSIONS AND FUTURE DIRECTIONS

Regional adaption plans may be co-produced between science and local users and innovation-based solutions found at the community level should be emphasized. Respecting the numerous geographical, economic and cultural peculiarities of the heterogeneous coastline area of Brazil is key if aiming to moderate harm or exploiting beneficial opportunities to the sector.

Participatory methods provide opportunities to link community knowledge to available scientific information on climate change and oceans. Our method and results tend to provide a solid foundation for the discussion of practical strategies exploring innovation and will facilitate both policy formulation and community-based adaptation to climate change in Brazilian fishing communities.

Current actions are helping the sector to better understand the implications of climate change on their livelihoods, as well as to support researchers refining local data and model downscaling. GULLS-Brazil should trigger climate change adaptation-driven innovation and self-empowerment and this local understanding and learning I also key to global solutions.

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Theme 3

Linking fisheries and aquaculture adaptation to broader processes

Building socio-ecological resilience to climate change for fisheries through local skill and indigenous knowledge

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ABSTRACT
Indigenous communities of northeast India remain isolated from the mainland and live in a distinct cultural setting with their environment. Because of their high degree of exposure to and connections with the environment, they have rich traditional knowledge about predicting and adapting to climate change. We accessed and illustrated the traditional knowledge on fish and fisheries from the region through a participatory rural appraisal (PRA) approach. Our study revealed that ecological and climatic circumstances are maintained through the traditional system of governance and local self-government. Local skills, tools, techniques, wisdom, beliefs and customs of the Indigenous people act as a buffer during disasters and successfully build resilience to climate hazards. Most of this knowledge was transferred over successive generations and has become a part of living, cultural and religious sustenance. Adaptation strategies at the community level for fisheries help to reduce vulnerabilities to extreme weather, such as drought, floods, and unpredictable rainfall patterns. Adaptation to climate change in fisheries is delivered through strategies at fine-scale spatial and grassroots levels. Mainstreaming climate change adaptation efforts can only be achieved through extensive assessment, research, recognition, and promotion of local skills, culture, Indigenous knowledge and community-based fisheries.

INTRODUCTION
To investigate the key areas of climate change, the research community needs to improve its understanding of the complex interaction between humans and their ecosystems, especially including climate features (Moss *et al.*, 2010). Perceptions of climate change, risks, responses, and adaptation depend not only on external legitimacy but also on the inner cognitive feelings and emotional processes of the observers. For a better understanding of climate change, scientific research needs to be ground-truthed by integrating its results with traditional knowledge systems (Usher, 2000; Riedlinger and Berkes, 2001). Consequently, decision-makers increasingly recognize the intuitive thinking processes of Indigenous people as key aspects of climate change knowledge. Indigenous people's proximity to nature and their total dependence on local resources gives them better insight into changes on the ground and the strategies they use to protect themselves and adapt to any changes are important elements of traditional knowledge. This knowledge can be integrated into resource management systems and assist in broader climate change adaptation strategies.

Scientific study, research and policy formulation efforts have been made in responding and adapting to climate change. Although scientific communities undertake their research at broad spatial scales, and often over decades, the hazards of climate change are expressed quickly at the local level. Although IPCC has assessed a wide range of technical, economic and institutional elements, an effective and appropriate framework for the subsistence economy and traditional tenure systems has not yet been developed (Klein and Nicholls, 1999). The local and traditional knowledge base can be used to help refine assessments of the adaptive capacity of climate change in fisheries. This will require an intensive assessment of information from marginal people still living in Indigenous cultures that coexist with aquatic environments. Their approaches in responding and adapting to climate and climate change need to be evaluated. How is their society able to link with the local ecosystem and how do they respond to changes? In addition, scientific views need to be framed and interpreted at local scales. In many parts of the Republic of India, Indigenous knowledge of climate can be traced to relatively inaccessible areas where communities typically have been settled for a long time.

The status of knowledge, however, is influenced by modern changes that may erode and disrupt the spontaneous viable linkages of people and nature. Communities of the eastern Himalayas, particularly northeast India, remain isolated from the mainland of the Republic of India (Verma, 1995) and thus they live in a distinct cultural setting within a complex sphere of interacting with the environment. In considering climate change adaptation options, knowledge of local assessments, conservation practices, and traditional resource-use systems and techniques in such areas can improve adaptation strategies. The majority of the people are small-scale artisanal fishers and they practice community-based fisheries resources management. These communities may possess a rich knowledge of the variables used in perceiving and predicting climate. Therefore, the present study was undertaken to assess the indigenous knowledge of aquatic resources utilization and to link it with socio-ecological resilience to climate change. The present paper aims to characterize the available indigenous tools, techniques, and wisdom for sustainable fisheries in the context of climatic hazards. The study proposed to establish the pathway in which indigenous knowledge systems simultaneously achieve climate change adaptation and offset climate impacts.

METHODS

The study was conducted in northeast India in an area situated at 21° 57’ N – 29° 30’ N and 89°46’ E – 97° 30’ E. The region hosts more than 130 tribal communities (Census of India, 2011) and the populations in 6 699 villages comprise 100 percent tribal peoples (Government of India, Ministry of Tribal Affairs, 2013). Preliminary screening and identification of the communities/ethnic groups were made based on livelihoods and the value they placed on traditional aquatic resources. Potential “target ethnic groups” were chosen as the key informants for the assessment of traditional knowledge systems. A total of 78 districts were selected and grouped into 20 sub-zones. Two to four villages from each sub-zone (a total of 53 villages) were chosen for investigation. A total of 371 community members were selected as respondents on the basis of simple random sampling. However, questionnaires and discussions with fishers, farmers, traditional healers, village headmen, the local priest and other elder indigenous community members were also part of the study. We accessed local skills, tools, techniques, wisdom, customs, and beliefs on fish and fisheries and coupled this with climate response and adaptive approaches. Participatory rural appraisal (PRA) tools were applied by holding dialogues and conversations with the respondents in the form of semi-structured interviews. Data from the interviews were categorized and examined to gain an understanding of perceptions on climate change and climatic hazards, and to depict the adaptive mechanisms for short-term as well as long-term climate variability.

SUMMARY RESULTS

The northeast region of the Republic of India is inhabited by a fairly homogenous set of ethnic groups surviving as mutually exclusive traditional societies. Most ethnic groups, including tribal communities, exhibit a similar pattern in terms of their subsistence, culture, economic and ecological appraisals. Cultivators remain poor, and their livelihoods still depend on natural resources. The majority of the poor people rely on dwindling aquatic resources and operate primitive methods of agriculture. In this study, 92 percent of the respondents possessed unique traditional knowledge with particular reference to the aquatic environment. It included novel folk technologies, tools, techniques, wisdom, rituals, beliefs and other institutional arrangements (Table 1). The respondents reported their perceptions of climate change and the strategies used to adapt to climate variations, which were predominantly based on ensuring their continued use of aquatic resources. The researchers classified the elements of traditional knowledge systems reported into three categories: perception; prediction; and adaptation to or coping with climate variability.

1. Perception of climate change and climatic hazards

In the assessment and exploration of the perceptions of indigenous people, 87 percent of the respondents agreed that climate was changing and stated that they had experienced climatic hazards. The prominent indicators identified during the survey in the context of climate change for fisheries were:

I. increased intensity, frequency and severity of extreme weather;
II. erratic rainfall pattern or unreliable monsoon;
III. more floods, higher intensity of monsoon winds;
IV. larger storms causing structural damage to ponds, and loss of fisheries stocks;
V. decreased endemic or local fish species;
VI. extreme drought, reduced water retention period and reduced fish yield;
VII. increased spread of vector-borne diseases;
VIII. reduced water quality, appearance of fish diseases and parasites;
IX. changes in species composition and fishing efforts affected by changes in biogeography of species;
X. declining catch from the wild and lower stock abundance leading to decreased revenue;
XI. changed post-harvest and processing costs and technology because of longer cloudy and rainy periods;
XII. impact on marketing and transportation because of frequent floods and hot dry periods;
XIII. impact on socio-economic conditions and pressure on livelihoods; and
XIV. effects on small-scale fisher folks including fish processors and ancillary workers.

2. Prediction or forecasts of weather and climatic variability

Surprisingly, 57 percent of respondents stated that they were competent in weather and climate forecasting or prediction. They perceived that sudden changes in the behaviour or appearance of insects, plants or animals were linked to irregular extreme weather. For example, if a large group of Reticulitermes insects, a group of termites, comes out of the soil during the monsoon season, this predicts that the rain will stop for a few days. Similar predications were scientifically proven for the potato aphid (*Macrosiphum euphorbiae*) that reduced their sexual behaviour in response to the drop in atmospheric pressure that precedes rain (Owens, 2013). People also predict rain by observing the unusual behaviour of the Jungle Owlet (*Glaucidium* sp.). This owlet chirps and beats its wings on the ground a few hours before rain. If frogs (*Rana* sp.)

TABLE 1
Important feature of adaptation responses, tools, techniques, mechanisms or strategies possessed by indigenous people of northeast India

Adaptive responses, mechanism or strategies	Features (Examples in Figure 1)	Illustrations
Co-operative management	Collective wild fishing methods Co-operative pond construction and management For example, Ngami-Marup of Meitei community	Established fishers' co-operatives to help in construction and management of ponds. People in the co-operatives also help and support each other during community festivals as well as in the face of climatic hazards.
Self-governing institutions	Communities have well prepared governance and rules for fishing formed under the leadership of community head or village chief For example, autonomous district council, village chieftainship, headmen	Regulated fishing in local waterbodies under the leadership of village headman. Banned fishing for some seasons at a fixed time. This can allow for breeding and help fish abundance recover after excessive fishing or disasters.
Community-based fisheries	Division of labour inside the community Each member actively participates in fishing and management of resources Collectively generated wisdom or tactics were transformed into cultural heritage, which passes from one generation to another	Helped in building better relations in the community and supported local economies. Collective action plays an important role in livelihoods, environmental stewardship, economic stability, social improvements and food security for the villagers in extreme weather or in the event of environmental hazards.
Diversification or alternative resources	Non-conventional aquatic vegetation with aquaculture long standing For example, planting Nymphaea pubescences, N. nufera, N. stellata, Trapa natans, Euryale ferox, Alternanthera, Enhydra fluctuans, Jussiaea repens, Marsilea minuta, Alternanthera philoxeroides and Ludwigia claveliana, etc. in ponds dikes which provided wild edible vegetables & traditional medicine Preference for mollusk, crustacean and aquatic insects as alternative foods as part of cultural heritage and traditional medicine	Traditional aquaculture systems act to reduce significant losses during natural disasters and also help in sustainable development. This tradition helped them adapt to extreme weather events.
Custom & tradition	Preference and valuing of indigenous over exotic fishes regardless of sizes and because of custom and tradition. For example, compulsory feeding of *Acanthopthalmichthys* to newly wedded couples in the Meitei community on the first night of marriage to strengthen their bond Establishing temples near waterbodies, leading to improved breeding grounds because no fishing then is practiced there and devotees also offer food for merit making. Popularization of traditionally processed or cured fish For example, fermented, pastes, smoked, salted, dried, etc. products of long standing; also traditional fish products used as supplementary traditional dietary elements or traditional medicines	Higher values and preference accorded to indigenous fishes, and exotic species may even be snubbed. This environmental stewardship could reduce the risk of exotic species is escaping during floods or storm surges. Conservation of wild fisheries resources by protecting brooders that sustained and fed people during low productive periods. Traditionally processed fish are not only an important part of the regular diet, but also a crucial source of food during calamities or in off- seasons. A part of adaptive strategies particularly during drought.
Culture & beliefs	Utilization of fishes in cultural ceremonies and religious beliefs was widely practiced by various communities For example, *Ushil*: Release of catfish sp. in nearby waterbodies when a person is sick, believed to cure ailments or be a good omen. *Ngamu thaba*: Release of a pair of *Channa* spp. (Ngamus) in nearby waterbodies before starting a marriage to bring prosperity and long life to young couples *Ipan thaba:* Offering 7 dried fishes to God on the 7th day after childbirth to ensure the good health of the child	Propagation of catfishes in the surrounding waterbodies may have controlled mosquito larvae, making this an adaptation strategy to reduce diseases related to climate change impacts. Incorporation of processed fish in custom and religion can encourage fish processors to produce more and thus enhance food availability as an adaptive strategy.

TABLE 1 (CONTINUED)

Adaptive responses, mechanism or strategies	Features (Examples in Figure 1)	Illustrations
Tools & techniques	Traditional fishermen have very good ideas and innovations for making and selecting fishing gears and crafts	Changes of climate/weather may transform the biogeography of animals and plants, which may affect fishing grounds and effort. Diversification of traditional tools and fishing gears for enhancing and adapting fishing effort in various waterbodies or grounds caused by climate variability, i.e. areas flooded, underwater, with high water flow in streams or rivers, swamps, bogs, muddy waters, etc.
	For example, 24 varieties of traps, 9 enmeshing gears, 7 impaling and hooking instruments, 5 fishing gears/craft accessories have been recorded in the present study. In addition, extracts of more than 23 plant species were used as anaesthetics in fishing	
	For example, fixing of split bamboo can rid fish of parasites when they rub their bodies against the bamboo pieces. For control of tadpoles, application of straw ash is being used by numerous tribal peoples	Climate change may increase infection and transmission of parasites in fish. Indigenous technique may control the parasite with little effort.
	For example, water turbidity was controlled by spreading banana leaves. Planting water hyacinth (*Eichornia* sp.) helped to check pollution, regulate temperature as well as control plankton blooms	Increased rainfall, storm water, high suspended solid and nutrient levels, soil erosion because of climatic variations may increase turbidity and pollution. That can be checked by indigenous techniques of fisheries management.
	For example, paddy rice with fish farming was practiced by numerous tribes; especially popular among the Atapani and Adi tribes	Change in climate may cause algal blooms and spread of aquatic weeds in paddy fields. Fish may feed on and control algae, weeds and insects etc. and their excreta can fertilize rice fields.
	For example, preparation of dike systems of fish farming or fish-with-paddy farming	Helps in minimal loss of fish stocks caused by uneven flooding.
	Specialized and diversified post-harvest tools and technologies	Adapted by increasing capacity and duration of storage for uses in dry seasons/disaster periods.

croak from waterbodies in the evening for an extended time, this is said to signify that rain is approaching. Abnormal spider spinning, such as producing shorter and thicker webs, also predicts rain. The early flowering and larger bud size of the night-flowering jasmine (*Nyctanthes arbor-tristis*) are said to predict heavy rain for the year. Construction of nests by the crow *Corvus splendens* on the top branches of the fig tree *Ficus rumphii* signifies an expected flood.

3. Adaptation to and coping with climate change

In the survey, diverse forms of indigenous knowledge including tools, techniques, traditions, customs, beliefs and traditional co-operative management practices were recalled that are directly or indirectly associated with adapting to climate change. Most of the local skills and indigenous technical knowledge were delicate and highly sensitive to the changing behavior of aquatic ecosystems. They strengthened ecosystem–societal links by producing resource-friendly traditional management systems or techniques. Almost all the fishing gears and crafts were made of bamboo by using specialized techniques. Sometimes the limitations of resource extraction intensity were balanced by establishing local autonomous systems to maintain the needs for subsistence. About 90 percent of the knowledge or techniques available appeared to be directly or indirectly related to resilience to climate change, but this requires scientific validation. Seventy-one percent of respondents confirmed their involvement in community-based fisheries. Their adaptation and coping mechanisms can be classified into: co-operative strategies; traditions and customs; culture and beliefs; wisdom; tools and techniques.

FIGURE 1
Varied forms of traditional tools and techniques related to fish and fisheries assessed from northeast India

CONCLUSIONS AND FUTURE DIRECTIONS

Humans and their environment are intimately related in many Indigenous cultures. An intricate web of interchange comprising expropriation and manipulation characterizes the connections and flow of resources. Such interactions are multifaceted and have arisen spontaneously, rather than by planned and/or explicit paths. Regardless of economic, ethnic or political positions, people settled near forests and centres of crop origin have a common interest in maintaining their ecological resources. Such areas tend to be isolated physically, politically and economically from policy and development planners (Lipton, 1979). Animism and other autochthonous cultures surviving in indigenous communities of northeast India can provide knowledge on how human and non-human entities interact within the environment. These systems create close linkages between natural processes and community practices. The linkages value the true legacy of coexistence between biological resources and human heritage. In these systems, resource control and a one-dimensional flow of benefits are rare.

If the resource users are in close proximity and have a critical dependence on healthy and functioning natural resources, an intuitive or ecological basis of resource system management has been shown to evolve spontaneously (Ellen, 1981). Indigenous or aboriginal people settled in isolated remote locations often maintain such systemic knowledge. Social anthropologists consider the northeast region of India a cultural hotspot because of the existence of diverse ethnic groups and sub-groups or tribes and sub-tribes. More than 200 ethnic groups live there and many of them are still forest dwellers following animistic beliefs. The Indigenous people of the region possess great knowledge of plants, animals, and natural phenomena. They are intricately associated with the environment in which they live. Thus they possess a rich knowledge of social level "intuitive" thought. Many of the communities have a physical and spiritual relationship with the environment and secure their livelihoods on the basis of a functional knowledge of it. They have had a long time for informal experimentation based on their understanding and intuitions of the resources and their availability. The indicators that enable the people to make predictions are based on the development of plants and the behavior of animals in their local environments, and these predictions have been gradually incorporated into traditional ceremonies and religious faiths. Usually, traditional people recognized such manifestations of environmental dynamics in terms of a myriad of opportunities and limitations for the survival of the community. The majority of the tribal populations of northeast India live in the forests, and their livelihoods depend on the aquatic resources. Their economy is of primitive character and the society is predominantly agrarian. Sometimes, they live on small islands permanently in the middle of lakes. As an example, dwellers on the island of Loktak Lake, Manipur (1 100 households) settled either permanently or temporarily on the Phumdis (heterogeneous mass of vegetation and organic matter) long ago and made small huts to live in.

They are not only keen observers of the change in the aquatic environment but also vigorously predict and adapt to the changes. They manage the ecosystems based on cultural and religious beliefs. Lai Haraoba (merit making ceremonies associated with Meitei deities) in Meitei communities and Law Kyntang (sacred forest) of the Khasi tribes are two examples of the autochthonous cultures that have coexisted with resource exploitation for a long time. Lai Haraoba is the indigenous ritual performed every year by Meitei communities, for the strength, prosperity and health of the village. Local priests invoke (Ekoukhatpa) the spirit of the Forest god from nearby waterbodies and ask the oracles about the village's fate and predict disasters for the upcoming year.

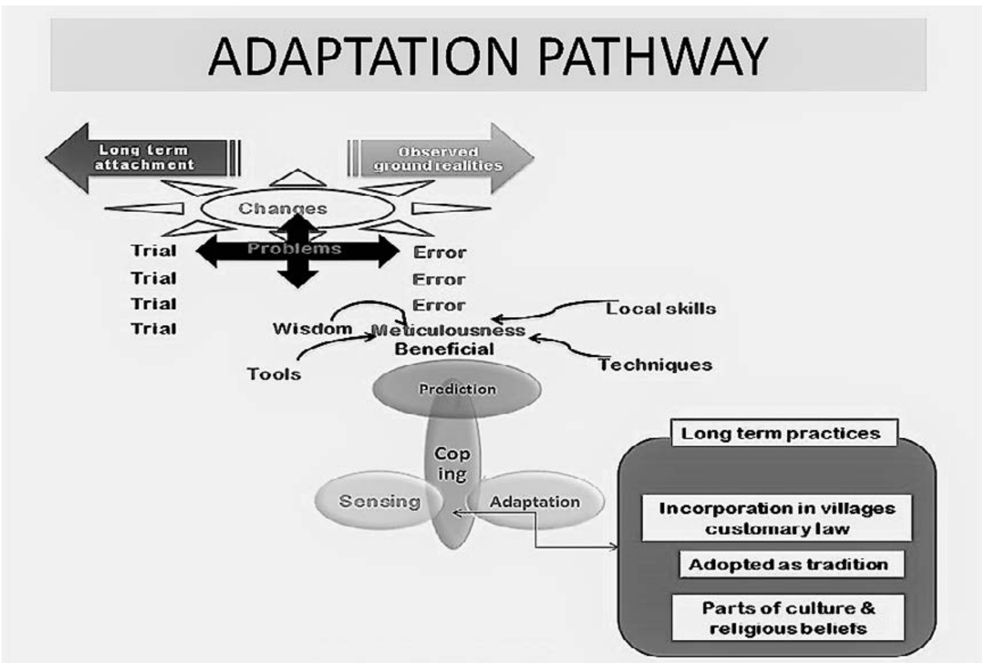
The indigenous fisherfolk have adapted traditional tools for food security and income generation. The fishers are mostly small-scale artisanal fishers and they use community-based fisheries approaches. These tools and techniques have also facilitated women to participate in fisheries related activities (Inaotombi and Mahanta, 2016) that are essential to ensure a socio-ecological balance. The innovations for fish and fisheries have been created and held by the indigenous people over successive generations. Such wisdom helps in building adaptive or coping mechanisms that the people are executing to cope with short-term climatic variability. Indigenous knowledge and local skills are used as key elements for survival, sustainable yields and have increased the potential range of adaptation options to climate hazards for fisheries. These tools and techniques (including gears and crafts) enable people to tackle the risks of climate change. Local skills and tools act as buffers during disasters and successfully build-in climatic resilience. Scientific and formal research needs to recognize and incorporate these local tools and techniques.

Determinants of adaptive capacity within communities co-evolved with changes in the physical environment (Dolan and Walker, 2016). The forest and other environmental entities are closely associated with and valued by the community as a whole. Because of high social cohesiveness, indigenous people of northeast India develop local control systems through group action with respect to sanctions and facilities governing resource utilization. Organized communities are highly engaged in decision-making about resource use and may improve adaptation attitudes towards climatic variables. Thus, recognition of community-based fisheries management can help in bringing positive socio-ecological linkages through strengthening traditional institutional mechanisms. Therefore, it is important to ground-truth research at the community level and include the knowledge systems of indigenous peoples.

Societal adaptation to the environment evolves by rationing resources, diversifying usage and needs, or transforming resources to meet the demand (Berkes, 1989; Devis, 1993). For example, Katal or Jeng is the transformation of a waterbody by erecting or planting patches of weeds as fish habitat. Transforming natural resources on the basis of meeting human demands needs to be appropriate and based on the attributes of the available natural resources (Jochim, 2013; Gadgil and Berkes, 1991). The responses of traditional societies of northeast India depend upon the characteristics of the resources as well as the socio-economic obligations of the villagers. When the changes concern local scarcities, the mechanisms for revitalizing the resource system involves collective protection and regulated use. Indigenous people settling in isolated areas are privileged to have political independence. Limiting the pressure of demand on resources and the extraction intensity in keeping with subsistence needs was achieved by establishing local autonomy systems. From adult suffrage or clans, representatives of village councils or headmen of autocracies were elected to safeguard customs and ways of life. Control and management of various waterbodies including rivers, ponds and lakes was achieved through the traditional systems of governance and local self-government. Logically, the indigenous people developed their political systems through social evolution. This traditional autonomy in the management of indigenous people's affairs was recognized and protected under the sixth schedule of the Constitution of India (article 244 (2) & Article 275(1)).

The rules of resource management are usually seasonally specific and they evolved efficiently as a result of the different perceptions and values of the decision-makers and resource users. These rules were incorporated into customary law or became part of the culture and belief system of the indigenous people (Figure 2). Adopted norms and practices are greatly influenced by the circumstances and features of biophysical resources (Jochim, 2013). Traditional fishing guidelines also evolved as rules and regulations for the community and the individual's behaviour vis-à-vis nature. They became a custom of the community when the majority of the members adopted the practices. Such customary laws maintained and stabilized the social order when transmitted from one generation to another (Singh, 1993). They were also integrated into religious beliefs and rituals (Figure 2). Such laws are usually created by numerous unwritten usages, and thus much data are still unavailable. There is a concern for the

FIGURE 2
Pathway of climate change adaptation strategies through indigenous knowledge system



permanent loss or fossilization of such traditional knowledge from the region. This precious knowledge and the traditional techniques need to be documented, protected and promoted for future uses.

FUTURE DIRECTIONS

Formally, indigenous knowledge has been gradually recognized as a form of rational and reliable information and has acquired equal status with scientific knowledge (UNEP, 1998). Local skills and indigenous knowledge are not only pragmatic and sensible but are also cost-effective and sustainable. It is therefore of utmost importance to involve Indigenous people and communities in decision-making, planning and management. Their knowledge could aid in building a strong foundation for effective research design and implementation of climate change adaptations. Adaptation to climatic hazards can be interpreted through strategies available from the fine-scale spatial and grassroots techniques evolved by indigenous people. The focus should be shifted to local-level capacities that deal with institutional frameworks that govern decisions at different scales. The bottom-up approach needs to be established by re-orientating the whole process of project planning, design and implementation. In various parts of the world, there is concern for the permanent loss or fossilization of such valuable knowledge. Current scientific knowledge should allow such knowledge to be tendered and adopted for technical solutions that fit within adaptation strategies rather than to deny this potential content and the systems within which it has evolved. Mainstreaming of climate change adaptation efforts can only be achieved by extensive assessment and research with emphasis on conservation of indigenous knowledge.

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Co-managing risk: disaster relief in agricultural and fishing communities in Central Philippines

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ABSTRACT
Natural hazards have become a way of life in the Republic of the Philippines. The well-being of socially-disadvantaged agricultural and coastal communities depends on how relief budgets for floods and other disasters are managed. The paper presents a case in the Central Philippines to examine actual disaster spending of households, legislation for disasters, and the role of non-government organizations (NGOs) in disaster relief. The Central Philippines is a disaster-vulnerable region known for its diverse marine ecosystems and its strong fisheries industry but its disaster funds are either misdirected or limited. The paper focuses on an exploratory analysis of disaster expenditure and legislation for effective disaster planning. Using 192 geographically selected households from one agricultural town and one coastal town in Central Philippines, findings revealed that although strong disaster legislation may lead to minimum flood damage, the level of spending does not determine flood impacts. It is postulated that the implementation of legislation, including monitoring and support from NGOs or other civil organizations, is essential in reducing local disaster vulnerability. This is especially true in coastal communities in the town of Oton where strong collaboration with NGOs is prevalent. NGOs in the case study area, as front-line institutions for disaster response, have *strong* involvement in community-based disaster management, which includes planning and capacity building, advocacy, and influencing legislation for disaster prevention.

INTRODUCTION
Disasters are disruptions of a community at any scale brought about by hazardous events interacting with conditions of exposure, sensitivity, and adaptive capacity, which lead to human, material, economic, and environmental losses (UNISDR, 2007). Flooding is a natural occurrence where bodies of water such as rivers overflow to land areas that are not usually submerged (Jah *et al.*, 2012) and is one of the most common disasters in the Republic of the Philippines. Traditionally, floods are triggered by the interaction between hydrological and meteorological factors (altitude, precipitation, and snowmelt) (De Moel and Aerts, 2011). As such, flood damage models often use hydrological data (e.g. rainfall volume) to predict flood characteristics (e.g. speed and velocity) (see Pistrika and Jonkman, 2010; Jongman *et al.*, 2012). However, social and economic factors, such as poverty and gender, also influence disaster vulnerability (Wisner *et al.*, 2004), as well as deforestation and non-compliance with infrastructure regulations (Bankoff and Hilhorst, 2009). Therefore, in recent years, there has been increasing interest in understanding the social science of floods.

Disaster risk reduction and management (DRRM) involves mitigation, prevention, preparedness, rehabilitation, and response. In the Republic of the Philippines, poor households are highly dependent on their natural resources (e.g. coasts and rivers) and they often (illegally) settle near these assets to have easy access to food or livelihood opportunities. Aside from the economic and social pressures, disasters adversely affect day-to-day activities, for example, catching fish, weaving nets, washing clothes, and attending school. Therefore, the well-being of socially disadvantaged households along coasts/rivers and farms partly depends on how well they adapt to risks and mitigate disaster impacts.

Recent evidence shows that flood-mitigation strategies have been mismanaged (Wisner *et al*., 2004). About 1 106 municipalities (out of 1 500) and 80 cities (out of 117) have Disaster Coordinating Councils (DCCs) that are non-functional. Most towns focus on limited areas of disaster management, such as preparedness and response (Benson, 2009). In addition, multisectoral collaboration remains a challenge because actors — government, NGOs, the media and other stakeholders — perceive, prepare, manage, and record disasters in different ways. For example, the state and state agencies view disasters from a different perspective than that of those who are directly affected. Moreover, operations of NGOs that include civil society organizations are dependent on their organizations' ideologies (Bankoff and Hilhorst, 2009). The responses of media to disasters relate to the public awareness and humanitarian dimensions. As a result, there are differences in the preparation, management, and perceptions of disasters, and consequently the levels of disaster impacts.

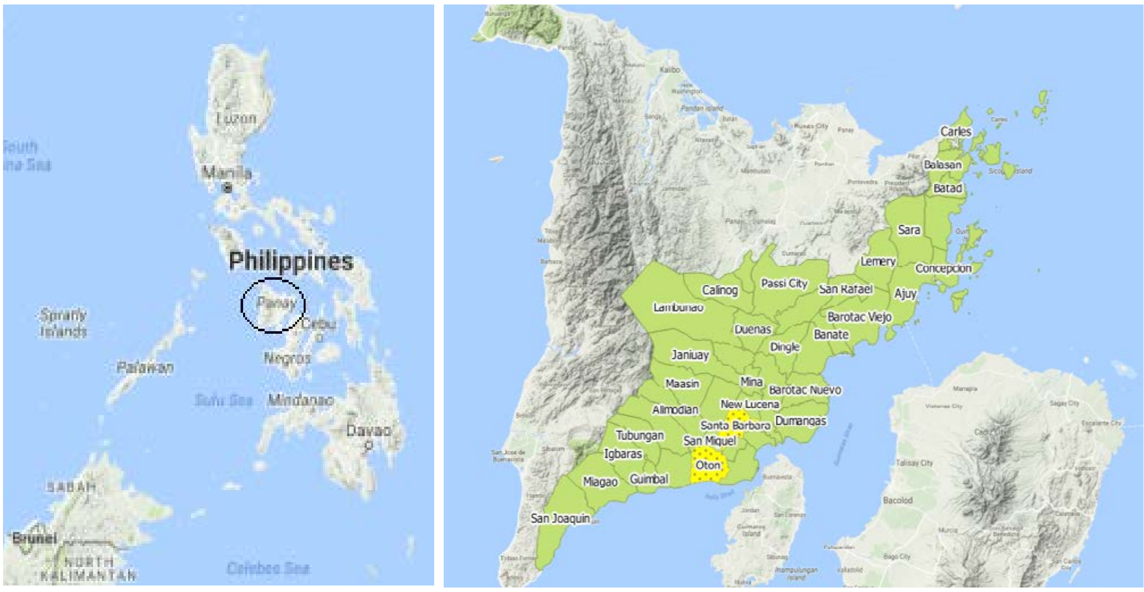
This paper highlights three important concepts affecting successful DRRM, namely (valuing) flood impacts, disaster legislation, and disaster spending. Legislation/regulation is essential in: (1) providing a legal framework for various disaster activities; (2) institutionalizing the functions of many (participating) institutions; and (3) safeguarding funds for disaster support programmes. More importantly, the paper examines NGOs as DRRM agents and emphasizes their roles in disaster mitigation and preparedness (Benson, 2009; Islam and Walkerden, 2015). Hence, understanding these three areas and NGOs may improve the well-being of fishers and farmers as disaster vulnerable groups.

METHODS

The Republic of the Philippines, an archipelagic economy in Southeast Asia, is an interesting case study area because disasters are common in the country and farming and fishing are important yet exposed activities (Bankoff, 2015). An average of 20 typhoons with associated flooding affect the country each year (ADRC, n.d), and this is projected to increase; the Intergovernmental Panel on Climate Change (IPCC) project more frequent and/or stronger typhoons in the future (IPCC, 2014). Households in agricultural sectors also have low income and poor access to infrastructure support that weakens their disaster resiliency. Hence, fishers and farmers experience the greatest impacts and welfare losses from disasters, for example, personal injuries, inundation of their houses, and damage to fishing boats and gears.

In order to draw comparisons between the disaster experiences of coastal and agricultural residences, we chose a coastal town (Oton) and an agricultural town (Santa Barbara) in the Province of Iloilo, in Central Philippines (Figure 1). These areas present experiences of disaster-vulnerable and less-developed communities, and their actions to minimize disaster impacts. Mitigation and other disaster programmes are usually limited, low priority (Benson, 2009), inadequate, and/or unavailable (Iloilo City Government, 2012) in these towns. The towns were also selected because of household heterogeneity in terms of livelihoods and flood experience and because household-level flood damage data are available.

FIGURE 1
Case study areas: Oton and Santa Barbara of Iloilo Province in Central Philippines



The boundaries and names shown and the designations used on this map do not imply the expression of any opinion whatsoever on the part of FAO concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers and boundaries. Dashed lines on maps represent approximate border lines for which there may not yet be full agreement

Oton is a town in southern Iloilo and comprises 37 barangays (or villages) (8 644 ha), with six of these being coastal. In 2012, the town had a population of 17 315 and fishing is a major industry. However, declines in fish catches and a longstanding problem with municipal water boundaries and therefore water supply are two of the main threats in the municipality.

Santa Barbara, located 16 km north of Iloilo City (capital of Western Visayas Region), has 60 barangays (13 196 ha) with 55 472 residents (DILG, 2010). Agriculture is the main industry, however the town has rapidly industrialized in the last five years. Future development plans include an eco-adventure park and recreational adventure tourism, which may adversely impact agricultural lands through rapid conversion of (rice) farms to various industrial uses.

According to the Economic Commission for Latin America and the Caribbean (ECLAC), disaster impacts are classified into three categories: (1) direct damages to assets; (2) indirect losses refer to damages incurred after the disaster and extend throughout the rehabilitation and reconstruction period; and (3) losses from impeding macro-economic variables such as overall prices.

Information about monetary flood damages and losses (property/personal damages, loss of employment opportunities, and additional damages) were collected using household surveys conducted in July and August 2013 in Oton and Santa Barbara. Barangays were geographically selected in order to gather and compare information from households that are near bodies of water (e.g. rivers, creeks and ocean). Six barangays were selected per town and 16 residents per barangay were interviewed — with a total sample of 192.[13] Secondary sources were also used to gather information about disaster legislation and expenditure. Documents used include the Disaster Risk Reduction and Management – Climate Change Action Plan 2012–2016, Executive Orders (EO), Memorandum of Agreements (MOA), and Local Disaster Risk Reduction and Management Fund (LDRRMF).[14]

[13] For survey details, see Fernandez (2016).

[14] In the Philippines, the Republic Act (RA) No. 10121, also known as the Philippine Disaster Risk Reduction and Management Plan (DRRM) Act of 2010, provides a mandate to strengthen disaster risk reduction and management of the Philippines.

After encoding and documentation, the researchers evaluated flood monetary damages, disaster legislation support, and disaster expenditure as per the indicators of successful DRRM and their equivalent ratings outlined in Table 1.

TABLE 1
DRRM indicators used to assess and rate households surveyed in Oton and Santa Barbara, Central Philippines

Indicator	Rating		
	Low	Moderate	High
Flood monetary damages	< PHP 1 501 per household per year*	PHP 1 501 to PHP 2 500 per household per year	> PHP 2 501 per household per year
Disaster legislation support	No guidelines and/or legislation before 2010 and available guidelines and/or legislation after 2010	Available guidelines and/ or legislation before 2010 and available guidelines and/or legislation after 2010	Available guidelines and/ or legislation before 2010, available guidelines and/or legislation after 2010, and revised/updated guidelines and/or legislation after 2010
Disaster spending	< PHP 301 per household per year	PHP 301 to PHP 600 per household per year	> PHP 601 per household per year

* USD = PHP 45 in 2015.

RESULTS AND DISCUSSION

Flood monetary damages

Respondents were asked to identify the losses they experienced from flood incidents in the last five years. Results showed that the majority of damages were to property and other personal effects, followed by damages because of lost employment opportunities. These damages may include the cost of repairs to fishing boats and gear as well as foregone income from an inability to fish during typhoons. Other losses included additional costs for medical treatment and purchase of clean/safe drinking water (e.g. distilled /purified water from water stations).

The coastal municipality of Oton has a moderate rating for flood damages (PHP 1 903), whereas the agricultural town of Santa Barbara has high flood damage rating (PHP 3 915). This may be attributed to the differences of property values and income levels between coastal and agricultural areas (Cervantes, 2012; NEDA, 2016). Thus, households in Santa Barbara have experienced higher flood impacts compared to households in Oton.

However, low (flood) damages do not mean that floods do not affect households. Analysis of flood frequency and annual flood damages across income deciles, showed that average annual flooding incidents dropped with annual income whereas the mean annual flood damage decreases with annual income (Figure 2). These patterns suggest that floods affect the wealthy households less compared to the poor households.

Disaster legislation support

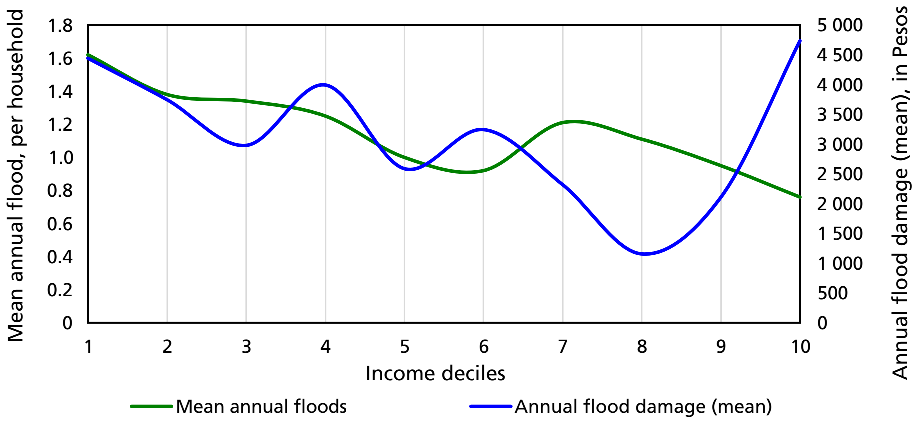
Disaster legislation in the Republic of the Philippines is multi-level but interdependent. Local-level disaster legislation should be congruent with the national disaster policies in order to strengthen and build disaster-resilient communities and institutionalize procedures and measures for reducing disaster risks.

Disaster-related legislation was analyzed and categorized according to the level of disaster-related legislative support (high, moderate or low). Findings showed that both municipalities have high or "strong" legislation support ratings. This means that both municipalities enacted and updated their disaster-related legislation and/or guidelines before the implementation of the national Republic Act (RA) 10121 (a list of all legislation and regulations in both municipalities is in Annex A).

The municipalities institutionalized their visions of "disaster resilient communities" by strengthening "economic, social, infrastructure, institution and environment sectors" and developing Disaster Risk Reduction and Management – Climate Change Action (DRRM – CCA) Plans. They also conducted risk assessment and Hazard Vulnerability Capacity Assessment (HVCA) to determine disaster benchmarks and to identify disaster-vulnerable groups (including fishers, farmers, women, children, and people with disabilities).

However, in spite of these initiatives, fishers and farmers are left out in the context of actual disaster assistance/support. The "environmental" policies in DRRM-CCA plans focused on activities relating to business and other economic enterprises, with no mention of how disaster-vulnerable groups benefit from these initiatives. For instance, Santa Barbara has the Ecological Solid Waste Management Program called "No Segregation, No Collection Policy" that requires, for example, piggery owners to have septic tanks. Meanwhile in Oton, plans focus on (liquid/solid) waste segregation and disposal and on economic enterprises and zoning regulations. These examples show the inadequacy of specific plans for vulnerable groups, which may include the creation of social enterprises that diversify livelihood options for farmers/fishers and strengthen their financial and social capitals. Moreover, plans should also embrace gender mainstreaming of activities and social inclusion approaches that strengthen community disaster resilience (Chakrabarti and Enarson, 2009).

FIGURE 2
Annual number of floods and annual flood damages by household income deciles



Source: Fernandez (2016).

Disaster spending

The primary aim of national and local disaster legislation relating to response is for government to return "normalcy" to communities in the shortest possible time. The success of disaster policy therefore, requires local government officials to understand how much should be spent in order to accurately allocate budget for such events.

Disaster budgets are sourced in many ways: (1) General Appropriations Act (GAA) through existing budgets of the national line and government agencies; (2) National Disaster Risk Reduction and Management Fund (NDRRMF); (3) Local Disaster Risk Reduction and Management Fund (LDRRMF); (4) Priority Development Assistance Fund (PDAF); (5) donor funds; (6) adaptation and risk financing; and (7) Disaster Management Assistance Fund (DMAF). Resources are also available from the following: (1) community-based good practices for replication and scaling up; (2) indigenous practices on DRRM; (3) public-private-partnerships; and (4) DRR and CCA networks of key stakeholders. As mandated in Section 21 of RA 10121 of 2010, the Local Disaster Risk Reduction and Management Fund (LDRRMF) should be at least five percent of the estimated revenue from regular sources. This fund will support disaster risk reduction and management activities.

This study found that disaster preventive and preparedness activities consume the bulk of LDRRM funding. In Santa Barbara, approximately PHP 7 M was allocated in 2013 for the improvement of structural facilities (e.g. construction and maintenance of roads, evacuation centres, drainage, and waterways); PHP 500 000 for climate-resistant crops or seeds for farmers; and PHP 100 000 for organic farming. In the same year, the local government of Oton spent an estimated PHP 3 M on seminars/trainings of rescue team members/volunteers and procurement and installation of early warning devices. No specific funds were allocated to other vulnerable groups (e.g. fishers) in either municipality.

Annual disaster spending of municipalities was assessed and classified according to three ratings (Table 1). Findings indicate that Santa Barbara incurred a "high" rating (PHP 604) whereas Oton incurred a "low" rating (PHP 189).

Interestingly, both towns have strong legislative ratings; however, each town incurred different levels of flood damages and disaster spending. In the case of Santa Barbara, the municipality experienced a high level of flood damage despite high expenditure on disaster mitigation activities and high (strong) legislative support. In contrast, the municipality of Oton experienced a moderate level of flood damages with lower disaster spending and high legislative support. These results suggest that the municipality of Oton may be using its funds more appropriately and perhaps, more systematically, compared to the municipality of Santa Barbara. This can be attributed to the low disaster spending in Oton, yet households experienced only moderate flood impacts. In contrast, Santa Barbara allocated a lower budget to activities that would safeguard the socially disadvantaged households.

Non-government organizations and civil society organizations

The differences between the two municipalities can be attributed to the influence of "third parties" such as NGOs, including civil society organizations. These institutions provide assistance at various levels of disaster management (e.g. preparedness, rehabilitation) and (potentially) improve social welfare (Luna, 2001; Gaillard and Cadag, 2009). Collaboration between the government and NGOs could strengthen monitoring and evaluations, avoid programme or activity duplication, and reduce corruption in relief works. On the other hand, strong involvement of NGOs in the community facilitates advocacy, planning, and capacity building as well as "influencing the jurisprudence of disaster prevention." Moreover, relief and other commitments before, during and after disasters should be clear and transparent in order to reduce relief dependency (Islam and Walkerden, 2015).

In Santa Barbara, the Kabayan Action Group — Santa Barbara (KAG-SB) Chapter — acts as ancillary manpower in emergency response and peacekeeping. Similarly, the local government of Oton collaborates with volunteers through the Oton Search and Rescue Team (OSART) that is responsible for emergency response and communication between 37 barangays and the Municipal Disaster Risk Reduction Management (MDRRM) council. It also cooperates with the Bantay-Dagat (Sea Patrol), a community-based volunteer organization, during rescue operations. There are also smaller NGOs, such as the Panay Centre for Disaster Response Inc., Creative Community Foundation, and Process Foundation Panay Inc. that are involved in relief efforts during and after disasters.

CONCLUSIONS AND FUTURE DIRECTIONS

The disaster experience of agricultural and fishing towns in Central Philippines may be understood in the context of flood damage, disaster legislation support, and disaster expenditure. This exploratory and qualitative study showed that floods mostly affected poor communities. Poor households tend to live in close proximity to their natural resources (e.g. upland or coast) and depend heavily on these resources for livelihood income. Poorer households are more impacted as they have inadequate resources and lack social support. Flooding affects households in low-lying areas, regardless of their social status. However, strong disaster-related legislation and high disaster spending of local government unit translate to low flood damages. Although, findings showed that despite having strong disaster-related legislation and high disaster spending, floods can still adversely impact households.

Local Disaster Risk Reduction and Management (LDRRM) plans were found to be one-dimensional in both municipalities, despite having "strong" legislative support. This is evident through their lack of depth and focus on the well-being of vulnerable groups before, during, and after disasters. In most cases, there is no comprehensive and holistic disaster planning, with sectoral roles and responsibilities unclear, limited, and/or absent. Hence, floods affect resource-dependent households in both inland and coastal areas.

Moreover, a thorough analysis of the results suggests that plans should include specific programmes/projects focusing on disaster vulnerable groups (e.g. poor, women, fishing households). In Oton, "vulnerable groups", which include fishers, farmers, senior citizens, and persons with disabilities, were mentioned in LDRRM plans; however, the disaster agenda and budget allocation were relatively less focused on fishers and almost non-existent for other groups. Since these groups have unique needs and challenges, planners should recognize heterogeneity in developing their LDRRM plans. Local planners and policymakers should also incorporate a local economic development agenda within LDRRM plans, so that mitigation and other disaster activities are sustainable and synergistic (Wisner *et al*., 2004; Benson, 2009).

Natural disasters are often politicized and as a result, the allocation of funds can be inequitable and poorly planned. The findings of this study suggest that large disaster funds do not necessarily produce the intended results, such as reduced flood impacts, and would be more effective if local governments properly allocated and managed the funds. These results are further supported by the fact that nearly half of all local disaster risk reduction and management funds remain unused or poorly allocated in municipal disaster-related activities.

The results also underline the importance of NGOs in successful disaster risk reduction management. NGO involvement appears to mediate flood impacts through the strengthening of disaster monitoring and/or minimizing corruption (Bankoff and Hilhorst, 2009). Thus, coordination between stakeholders should be encouraged or strengthened in order to promote resilient communities, regardless of their different perspectives on disaster management.

Further research is needed to investigate and quantify the relationship between NGOs and their contribution to low flood impacts. This would include: an in-depth analysis of LDRRM plans of both municipalities and of the key NGOs working in the area; exploration of actions specific to community-based mitigation for disaster vulnerable groups; and examination of the features of successful interventions and implementation for fishers, farmers and other vulnerable groups (such as the disabled). Information on their (private/community) mitigation activities and their experiences with NGOs and other institutions may be particularly useful.

Flooding as an issue is not divisive and should be treated as a common problem between stakeholders. Thus, holistic, well-coordinated, and updated disaster legislation should be developed in order to effectively minimize flood impacts. This paper presents preliminary evidence of some discrepancies between local disaster spending and distribution of funds but to better understand disaster spending, annual budget allocations and line item categories need to be studied in detail. This includes studies relating to local budget allocations, especially in areas with weak and non-standardized financial management systems.

Given these findings, new policies should focus on site-specific, market-driven, and collaborative disaster risk reduction management plans for Oton and Santa Barbara. A comprehensive understanding of the nature of flood damages, legislative support, disaster spending, and NGO collaboration can support vulnerable groups and ultimately help in the overall success of local disaster risk reduction management in municipalities.

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ANNEX A

LIST OF LEGISLATION AND REGULATIONS IN STUDY MUNICIPALITIES

Oton has the following disaster legislation/regulations:

- Ordinance No. 260, Series of 2014 — An ordinance creating the Municipal Risk Reduction and Management Office (MDRRMO) of the municipality.
- Executive Order No. 05, Series of 2013 — An order reorganizing and reinforcing the Municipal Disaster Risk Reduction and Management Office (MDRRMO)/ Committee of the Municipality of Oton and re-designating the Deputized Coordinator.
- Resolution No. 96, Series of 2012 — A resolution adopting the Municipal Disaster Risk Reduction and Management Manual.
- Executive Order No. 12, Series of 2012 — An order reorganizing and reinforcing the Municipal Disaster Risk Reduction and Management Council (MDRRMC) by organizing the Municipal Disaster Risk Reduction Management Office/ Committee of the municipality.
- Executive Order No. 07, Series of 2012 — Enhancing Emergency Response Capability of the Municipal Disaster Risk Reduction and Management Council (MDRRMC) by re-organizing the Oton Search and Rescue Team (OSART).

Santa Barbara has the following disaster legislation/regulations:

- Resolution No. 57, Series of 2014 — A resolution approving the proposed Local Disaster Risk Reduction and Management (LDRRM) Plan of the municipality.
- Executive Order No. 32, Series of 2014 — An order designating the volunteer desk management officer in the municipality.
- Executive Order No. 24, Series of 2014 — An order further strengthening the Local Disaster Risk Reduction and Management Council (LDRRMC) of the municipality.
- Executive Order No. 22, Series of 2013 – An order establishing the volunteer and citizenship desk and designation of a focal person.
- Executive Order No. 4, Series of 2013 — An order institutionalizing the coordination mechanism among the disaster response units.
- Executive Order No. 14, Series of 2012 — An order organizing/strengthening of the Municipal Council for the Protection of Children (MCPC) incorporating the early childhood care and development coordinating committees.
- Executive Order No. 13, Series of 2012 — An order strengthening the Local Disaster Risk Reduction and Management Council (LDRRMC) of the municipality.
- Executive Order No. 13, Series of 2011 — An order re-organizing and institutionalizing the municipality emergency response unit to be referred as ‘ALERTO Santa Barbara’.

Embracing the value chain framework for post-disaster livelihood interventions: the milkfish industry in an area in Leyte, Philippines affected by *Haiyan* typhoon

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ABSTRACT

Typhoon *Haiyan* destroyed fish-pens and cages in Barangay Santa Cruz in the municipality of Tanauan, Leyte province, in the Republic of the Philippines in 2013. Where there was once a highly productive milkfish industry, fishers and households had to struggle to survive through the economic shocks and dislocation brought by the sudden-onset disaster. The impacts on women fishers extended beyond the problems of milkfish production and sales. At home, it was the women who had to meet the challenges of cash shortages and feeding the family when income from fishing ceased. The economic opportunity for rehabilitating milkfish production was pursued with the assistance of the Japan International Cooperation Agency (JICA) and government agencies, such as the Department of Trade and Industry and the Bureau of Fisheries and Aquatic Resources. The rehabilitation attempted to build better structures and employed a "value chain" framework to guide the design of post-disaster interventions. This paper reviews the processes and gains derived from the improved and upgraded milkfish value chain to rehabilitate and build resilience of coastal communities to extreme weather events. It briefly describes the industry and the opportunities and constraints faced by the four major value chain players: (1) input suppliers of fingerlings, fries, feeds, and equipment; (2) milkfish producers who grow, harvest and sell fresh milkfish; (3) processors of soft-bone milkfish/*bangus*; and (4) traders, shops and other retail outlets. A major concern of input suppliers was the high cost of transporting fingerlings from other parts of the country and the increased mortality rates when the fingerlings are not locally sourced. Feed was also expensive. The presence of technical and financial support from both government and non-government agencies was crucial during the transition and establishment of the business. The fishpen operators were ideal partners for the initiative since they showed interest in the livelihood by attending meetings, cooperating within the organization, and participating in planning sessions. The constraints, on the other hand, were the low survival rates of fries, the oversupply of milkfish from areas not affected by *Haiyan*, and weather conditions, particularly the high incidence of typhoons that continue to impact on operations. Foreseen problems include accessing loans for larger operations and/or how to expand the enterprise when JICA and other disaster relief support end and is withdrawn from Barangay Santa Cruz.

INTRODUCTION

Much has been said about the damage caused by super-typhoon *Haiyan* when it made landfall on 8 November 2013 in the central Philippines, particularly in the Eastern Visayas region where the municipality of Tanauan is located. With wind speeds of more than 300 km/hour and storm surges of over 4 m, *Haiyan* brought unprecedented damage that affected 16 million people, displaced 4.1 million people, destroyed 1.1 million houses, and caused more than 6 300 deaths (USAID, 2014).

The coastal fishing sector was worst affected, with 86 percent (or 15 913) of fishers who were registered under the Municipal Fisheries Registration System (NEDA, 2014) in Leyte province being adversely affected by *Haiyan*. Fishing boats and equipment were either lost or damaged beyond repair, and new capital was needed to re-start fishing activities. Women involved in the milkfish industry were affected, specifically in relation to loss of income from selling fish and from other post-harvest activities.

This paper examines the experiences of the women milkfish processors, one of the most vulnerable groups affected, in the small village of Barangay Santa Cruz, and how they were able to rebuild their livelihoods with the assistance of government and other organizations, such as JICA. The paper describes the upgrading of the milkfish (*bangus*) sector, specifically the soft-bone *bangus* industry, with the use of the value chain (VC) approach, as initiated by the regional office of the Department of Trade and Industry (DTI).

METHODS

The data utilized is from a number of participatory community initiatives, such as the Milkfish Industry Cluster Value Chain Upgrading workshop conducted in June 2015 by JICA and the DTI, the Yolanda Knowledge Sharing Forums (Livelihood Cluster Session) spearheaded by the Asian Development Bank (ADB) held in October 2015, and the Study on the Promotion and Marketing of High Value Aquaculture Products initiated by USAID from June to July 2015. The data were supplemented by key informant interviews with officers and members of the Santa Cruz Women Fisherfolk Association in order to document the perspectives of female fish processors.

Pre-Haiyan scenario

The Eastern Visayas region had been experiencing worsening poverty even before *Haiyan*, with poverty rates increasing from 41.5 percent to 45.2 percent from 2006 to 2012 (Oxfam, 2014). Poverty incidence among women was similarly rising from 33.7 percent to 37.4 percent for the same period. Fishing communities registered a poverty rate of 29 percent in 2006, with a significant increase to 45.7 percent in 2009 (Oxfam, 2014). Similarly, the 2011 Annual Poverty Indicator Survey showed that among poor families, one in four (or 24.7 percent) suffered hunger, the highest hunger incidence among the country's sixteen geographic regions (PSA, 2013).

Direct impacts of *Haiyan* on fisheries

The destruction caused by *Haiyan* worsened the socio-economic situation of households already under pressure. Poverty rates increased to 55 percent in 2014, making the region the poorest in the country (Gabieta, 2015). Fishery production dropped by 14 percent, from 161 581 tonnes harvest in 2013 to 137 518 tonnes a year after *Haiyan*. It may be noted, however, that during the previous five years, fishery production was already on a consistent downtrend (BFAR, 2015). More than 500 fish cages were destroyed by *Haiyan*, resulting in a drop in aquaculture production from 34 501 tonnes in 2013 to 30 791 tonnes in 2014. Commercial and municipal fishery production dropped by 28 percent and 10 percent, respectively (BFAR, 2015).

POST-HAIYAN RECOVERY ROADMAP

Less than two weeks after *Haiyan*'s landfall, the National Economic and Development Authority (NEDA) crafted the Reconstruction Assistance on Yolanda (RAY) — Build Back Better, to serve as a basis for government interventions. This was followed in October 2014 by a more detailed plan and roadmap called the Comprehensive Rehabilitation and Recovery Plan (CRRP) that was signed by the Philippine president. It consisted of eight volumes that outlined specific programmes, projects and activities with a total funding requirement for its implementation of PHP 167.86 billion (USD 4 billion). The budget breakdown was: social services (15.7 percent), livelihoods (18.2 percent), infrastructure (20.9 percent), and resettlement (45.1 percent). Specific to the fishing sector, the CRRP included the provision and repair of fishing boats *(bancas)*, and a total of 30 186 *bancas* and 13 909 marine engines were consequently reportedly distributed (NEDA, 2014).

For the province of Leyte (excluding Tacloban City), an estimated livelihood investment requirement of PHP 14.57 million (USD 290 000) was determined — the highest among all *Haiyan*-affected areas — which reflected the fact that the area was the worst-affected by *Haiyan*. The amount for Leyte province totalled PHP 39.569 million (USD 780 000) once the investment requirements for resettlement, social services, and infrastructure services were included (NEDA, 2014).

Post-disaster needs assessment

The Bureau of Fisheries and Aquatic Resources (BFAR) identified several programmes for the recovery and reconstruction phase of the fisheries sector in a needs assessment conducted in 2015 (BFAR, 2015). These included the following: rehabilitate fish sanctuaries and fish cage operations in mariculture areas, reinstate environment-friendly mud crab culture livelihoods, and provide basic start-up materials and structures for milkfish, tilapia, oyster and seaweed farming.

Moreover, BFAR supported the repair of boats and provided new ones through its AHON (Rise) project, a collaborative effort between national and local governments, NGOs, and the private sector. Two years after *Haiyan*, BFAR had distributed materials for the repair of fishing boats to 21 420 fishing families. It has also distributed 1 087 fibreglass boats *(Bangkang Pinoy)* with 5.5 HP engines to Leyte province (NEDA, 2016).

Other support and assistance to the municipal fisheries sector included fishing gear distribution and the provision of marine fish cages. Registered fishers and fisheries associations were provided with fishing boats and engines, post-harvest equipment such as chest freezers and fish dryers, capacity building and other technical, product development and marketing assistance, and credit and insurance facilitation for the fisheries sector (NEDA, 2014).

Assistance to Barangay Santa Cruz fishing households

Barangay Santa Cruz was provided with basic start-up materials and structure for milkfish culture in cages, including fingerlings for fish cage operations as well as the rehabilitation of community-based multispecies hatcheries and stock enhancement activities.

In collaboration with the local government unit of Tanauan, donors such as JICA provided technical and financial assistance to Barangay Santa Cruz. JICA also partnered with BFAR in the implementation of quick impact projects from 2015 to 2016 to assist recovery and rehabilitation in Barangay Santa Cruz, including installation of approximately 50 fish pens in the village. The short-term goal was to help restore economic activities and raise the income of households, and the long-term goal was to export milkfish as a specialty product of Tanauan to Japan.

The project is a joint undertaking of the Santa Cruz Fishpen Operators Association, and Santa Cruz Women's Fisherfolk Association with the assistance of BFAR, Leyte

Provincial government, Tanauan municipal government, and Higashi-Matsushima City of Miyagi Prefecture of Japan.

WOMEN FISHERS REBUILDING LIVELIHOODS

In Barangay Santa Cruz there are two industry associations — the Santa Cruz Fishpen Operators Association, which has only men as members, and the Women's Fisherfolk Association. The former raises and produces milkfish, whereas the latter processes the milkfish into soft-bone *bangus* and brings the product to the market. The two associations are dependent on each other, with the Santa Cruz Fishpen Operators Association providing the input product for the Women's Fisherfolk Association's enterprise.

Soft-bone *bangus* is an original recipe of the women in Santa Cruz. The product is prepared in a pressure cooker, hence the bones become very soft. The women claim that they have a secret recipe that combines ingredients mixed into the *bangus* to make it a palatable product. The soft-bone *bangus* is packed in air-tight and vacuum-sealed bags, labelled and then sold in the market and at selected retail outlets.

The President of the Women's Fisherfolk Association represents the group in sectoral meetings that are called by government agencies such as the BFAR and DTI. She also does the marketing to retail stores, aiming to sell a regular volume of processed soft-bone *bangus*. At the village level, she ensures that any new information she learns is shared with other members of the association.

Start-up scenario

Five months after *Haiyan* (*i.e.*, July 2014, the Santa Cruz Fisherfolk Association officially started its business of processing soft-bone *bangus*. It produced 700 kg per year, processing two to three boxes of fresh *bangus* per week with 30 kg per box. All inputs were sourced from outside Tanauan and the market was limited to the municipality, which bought 85 percent of the soft-bone *bangus* produced. Members of the Women's Fisherfolk Association received a ten peso (USD 0.21) incentive for every pack of processed milkfish sold. Women who participated in processing were provided free meals and drinks as labour compensation during the period the business was not making money. Others were volunteers in the temporary processing facility. Dividends were distributed at the end of the year.

The equipment for the start-up was provided by JICA and women initially started working with two pressure cookers of 40 litres capacity each, a refrigerator and a vacuum sealer. The business initially did not have a License to Operate from the Food and Drug Administration, but the required papers were being prepared. The start-up business commenced even before women's village houses were fixed and the rescue and relief phase of the humanitarian work was still ongoing.

Transition state

In December 2015 (18 months after *Haiyan*), the JICA-assisted livelihood programme for the survivors of *Haiyan* entered its transition phase. The processing facility was improved, and the equipment doubled (four pressure cookers, two refrigerators, two vacuum sealers, and two deep freezers), and production increased by about 600 percent. The Women's Fisherfolk Association no longer got their milkfish supply from outside Tanauan but from the Santa Cruz Fishpen Operators Association, which was simultaneously assisted by JICA and the government to recommence their fishpen operations. The latter sold fresh milkfish at PHP 110.00 (USD 2.35) per kg.

The softbone *bangus* product was sold for cash or credit, as well as on consignment every 15 days to three contracted outlets in the nearby city. The product, wrapped in banana-leaf, was packed in printed vacuum bags with a packet of pineapple-pickle sauce, another product of the Women's Fisherfolk Association. It has a registered product name and labelling and the Association has commenced the application for trademark and patent, together with the processing of a License to Operate with the assistance of the Department of Science and Technology (DOST).

With the increase in sales, the Women's Fisherfolk Association was able to pay management incentives to three of their officers, and processing incentives to seven women-processors each day. At the end of 2016, dividends taken from a portion of the net profits were shared to all the Association members.

RESULTS AND DISCUSSION

The Women Fisherfolk Association has been integral in improving the livelihood options and income of women in Barangay Santa Cruz after Typhoon *Haiyan* as well as recommencing the milkfish pen operations of the Santa Cruz Fishpen Operators Association. The future target is to process soft-bone *bangus* five days a week with an input of 30 kg of milkfish per day. The Santa Cruz Fishpen Operators Association will be invited to become co-investors in the processing business, an important arrangement to ensure a regular supply of fresh milkfish for the processors.

Part of the business plan is for cash, credit and consignment sales to continue with the aim of expanding into a larger market, including seeking more contracted outlets and possible export to a partner in Japan once production volumes are large enough. It is envisioned that the management and processing incentives can be increased to standard market rates, and to benefit more female workers. Moreover, the Association is aiming for at least 50 percent of the net annual profit to be available for distribution as dividends. Finally, the License to Operate, the Certificate of Product Registration from the Food and Drug Administration, and the trademark and patent for soft-bone *bangus* will be finalized.

UPGRADING THE MILKFISH INDUSTRY CLUSTER VALUE CHAIN

The Women's Fisherfolk Association believes that the reason for the quick transition of their small-scale soft-bone *bangus* business from "nothing" to "something profitable" may be attributed to three factors: (1) the use of the value chain approach in developing and promoting the milkfish industry cluster; (2) the support and collaboration of JICA with the local government unit, government agencies, and other value chain actors/players within the umbrella programme of recovery, reconstruction and rehabilitation after *Haiyan*; and (3) the women's willingness to build the business by starting with nominal pay or as volunteers.

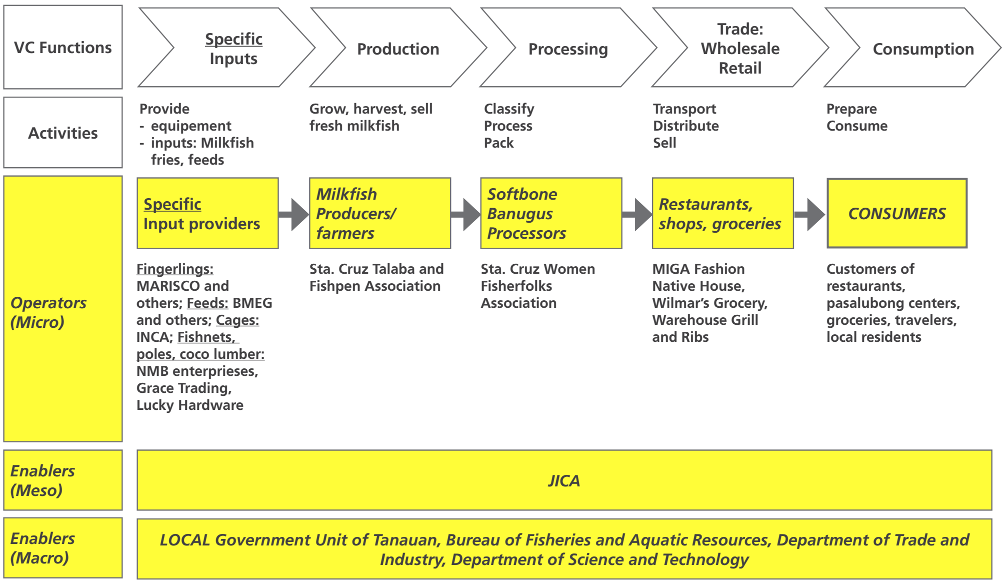
The value chain approach has shown the stakeholders the importance of bringing all the actors together for consultation, validation, planning, and establishing the business enterprise. Workshops were conducted to determine the status of the milkfish industry, particularly soft-bone *bangus* and the strengths and weaknesses of the value chain, as well as to develop a plan of action and interventions.

Although the approach described here seems simple, it requires significant coordination, cooperation, and communication across all sectors. That is, from the supplier of inputs, to the fish farmers, milkfish growers, soft-bone *bangus* processors, and sellers, traders and retailers. The sequence of related business activities (known as VC functions) were identified together with the corresponding set of enterprises (known as VC operators/actors) to link and coordinate each in order to produce soft-bone *bangus* (Figure 1). The value chain players realized the synergies and gains from coordinating with each other and strengthening their value chain.

The VC players/operators

All of the 62 fishpens in Barangay Santa Cruz were lost or damaged by *Haiyan*. JICA helped rehabilitate 42 fishpens, with each operator receiving one fishpen of 1 000 m^2, each with 18 000 fingerlings, and production and harvests were scheduled so that everyone was able to sell their product.

FIGURE 1
The soft-bone bangus value chain map: Santa Cruz Women's Fisherfolk Association



Source: JICA Workshop Report, June 2015.

Other inputs were sourced from various enterprises, some of which were in areas not affected by *Haiyan*. With more production, the fishpen operators needed additional buyers of fresh milkfish. The women soft-bone *bangus* processors were the answer. However, the latter were new in the industry and the product was new in the market, hence, a lot of marketing effort was needed.

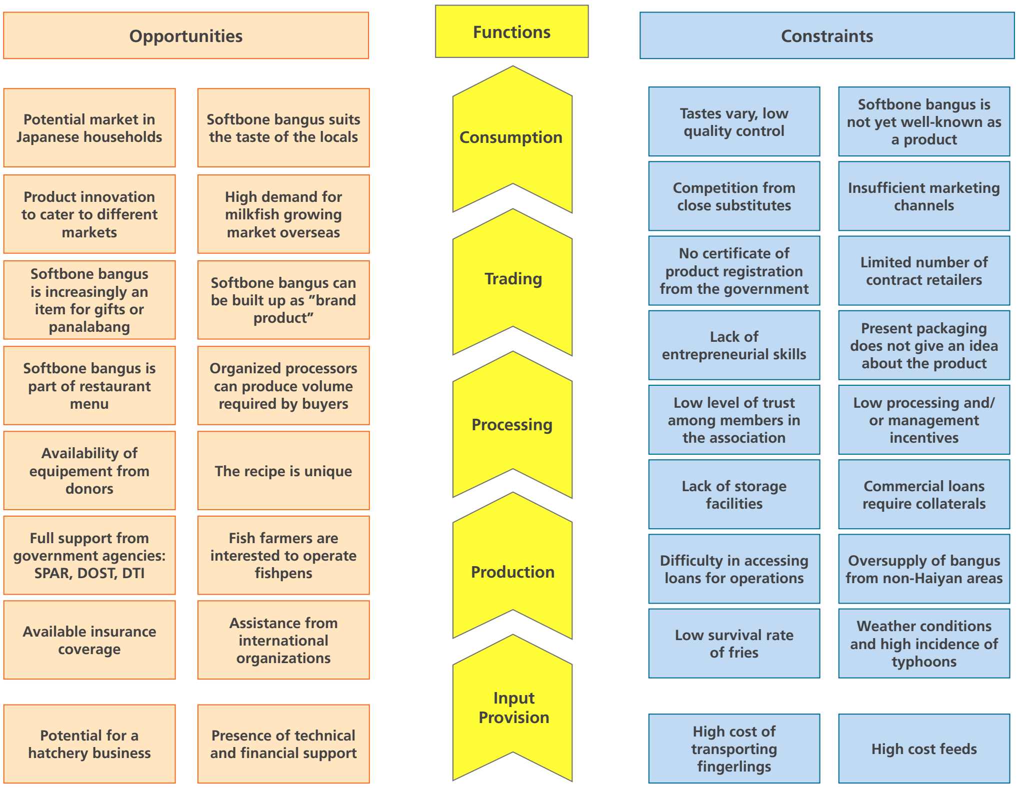
Opportunities and constraints

A major concern of input suppliers is the high cost of transporting fingerlings from other parts of the country and the higher mortality rates if the fingerlings are not locally sourced. Feed is also expensive, making input provision relatively costly. The presence of technical and financial support from both government and non-government agencies was crucial during the transition and establishment of the business. Sourcing more inputs locally, including plans for establishing a hatchery, are key actions to secure supply and reduce costs (Figure 2).

For the production phase of the value chain, support from BFAR, DTI, and DOST and JICA was critical in providing start-up capital and the technical assistance for fish pen operations to recommence after *Haiyan*. The fish pen operators were ideal partners for the initiative since they showed interest in the livelihood by attending meetings, cooperating within the organization, and participating in planning sessions. The constraints, however, are the low survival rates of fries, the oversupply of milkfish from areas not affected by *Haiyan*, and weather conditions, particularly the high incidence of typhoons that are expected to continue to impact on operations. The operators also foresee challenges in accessing loans for larger operations or to expand in the future when JICA and other disaster relief support is withdrawn from Barangay Santa Cruz.

Women dominate the processing phase of soft-bone *bangus* and have developed a niche product in the market. The recipe is unique and demand is growing, including by restaurants. The women's processors' association was given equipment and start-up capital with support from government agencies. There are wider community benefits in supporting the women processors in that they are able to produce large volumes for markets outside the municipality. On the other hand, there are constraints which

FIGURE 2
Opportunities and Constraints of the Santa Cruz Soft-bone Bangus Value Chain



Source: JICA Workshop Report, June 2015.

include: lack of storage facilities, low level of trust among members in the association as a result of unclear division of labour and tasking in the processing facility, poor management and processing incentives given to women processors, and a lack of entrepreneurial skills. Although the association is able to operate fully at present, there is concern about its long-term sustainability once JICA exits.

Next in the value chain is trading. Since the soft-bone *bangus* is a new product, it has yet to secure a certificate of product registration and other licenses from relevant government bodies. There are similar and substitute products in the market, and limited contract retailers at present. Marketing is limited to the domestic sector and current marketing channels are insufficient to compete effectively. There is, however, significant market potential for soft-bone *bangus* locally and in Japan, facilitated by JICA, which is willing to import the product from the Philippines in the future. Soft-bone *bangus* can be built as a "brand product" for Tanauan since there is no other municipality in the Philippines that produces the same product. More product innovation and product concepts may also emerge over time increasing the market potential of *bangus*, for example, promoting it as a "gift item" (*pasalubong*). The long-term goal is for soft-bone *bangus* to be associated with Santa Cruz, Tanauan and for it to become the municipality's post-*Haiyan* icon.

There remains a lot of marketing and product work to fully realize the potential of softbone *bangus*, including: better packaging and labelling, more advertising and promotion, and improvements in the shelf life of the product. There is also a need to improve product quality (e.g. taste, colour), and upgrade the processing facility (handling and packaging) to adhere to international standards. At the local level, the product is marketable and enjoys the curiosity of households who want to taste something new.

Value chain upgrading strategies

An industry vision was defined in a workshop attended by all participants (men and women) in the value chain. The industry vision was to provide interventions and strategies that will have the widest reach, the biggest impact and are achievable to deliver short-term value chain benefits. Each VC function has to be strengthened to ensure a sustainable industry. There may be sufficient producers (fish farmers) but if marketing is weak, then the former will not maximize economies of scale. Similarly, even if marketing is excellent, but the processors are not producing quality soft-bone *bangus,* then the traders will not succeed.

For the VC function on input provision, the players plan to develop local hatcheries for fingerling production in order to supply fish farmers with cheaper inputs and for the latter to experience less fingerling/fry mortality. This should be coupled with initiatives to improve the skills of the manpower that will operate the hatcheries.

For the VC function on production, the fishpen operators are looking into strategies that will improve access to finance, and human resource development. Activities geared towards investment promotion will have to be conducted. Advocacy and lobbying for the inclusion of fish pen operations for insurance coverage will be helpful since the municipality is geographically prone to typhoons.

Improved financing schemes to answer the sustainability of soft-bone *bangus* processing in a post-JICA scenario is also important. Initiatives to improve the quality of the product must be given priority. Regular production in order to meet larger market demands will have to be worked out. Moreover, the entrepreneurial skills of the women processors need enhancement.

The next VC function is marketing. Access to markets through selling missions, joining product fares, and obtaining the requirements of various buyers are identified as strategies. So, too, are effective promotions, labelling, packaging and market penetration. Using social media to improve marketing channels is recommended. A good database will have to be maintained for the purposes of planning, coordination, and monitoring.

THE CRUCIAL ROLES OF THE VALUE CHAIN ENABLERS

The value chain enablers both at the meso-level (i.e., private partners and organizations/ associations) and at the macro-level (i.e., government agencies and local government units) have significant roles to play in areas such as, but not limited to: (a) human resource development through coaching, values orientation, and the conduct of organizational and entrepreneurial training events; (b) information dissemination through networking using market information databases; (c) conduct of updated market research on soft-bone b*angus;* (d) wider insurance coverage to fishers' enterprises in the value chain; (e) policy creation and enforcement through ordinances and other regulatory requirements; (f) access to finance, particularly loans without collateral; and (g) investment promotion, and market matching.

The BFAR is the lead agency supporting the women processors of soft-bone *bangus*. It released a set of policies and incentives relevant to the industry after *Haiyan*. Examples include the provision of inputs through the construction of fish cages and fish traps for fish culture, and provision of the corresponding initial batch of milkfish fingerlings. Quarterly monitoring on fish production is important as a basis in the determination of the carrying capacity of the area. Likewise, post-harvest facilities need to be provided to fisherfolk associations who must have wider access to financial assistance, marketing/handling, and other forms of services. For the processors, they have to embrace business/entrepreneurial practices that promote food safety and the global competitiveness of the products.

These policies and incentives are geared towards ensuring good quality fishery products. The sustainability of the fishery programmes — from the input provision to the trading/selling of processed milkfish — is built into the mechanism of the creation of the Executive Management Council, which is chaired by the local chief executive, particularly, the municipal/city mayor.

CONCLUSIONS AND FUTURE DIRECTIONS

A disaster-resilient milkfish industry cluster is a target to achieve. This will have to be worked out by all the operators and enablers of the value chain, from input provision to production, to processing, and to marketing.

From the perspective of the women processors of soft-bone *bangus,* they need to be assured of continuous production and sale of the product. As defined by the value chain framework, this means that the fish pen operators must have continuous production which will only happen if they have a continuous supply of inputs from the various providers of fingerling, feeds and other inputs. Having submersible cages that can withstand typhoons and extreme events is also a good practice (introduced after *Hiayan*) that should be continued.

Moreover, continuous production must be complemented with the presence of traders who will increasingly gain larger and wider markets for soft-bone *bangus,* which will be demanded by retailers, restaurants, shops/malls, and households either as ready-to-eat food, or gift/tokens (*pasalubong*), or as for resale.

In order to strengthen the value chain for the industry cluster, the VC governance needs improvement. Most of the time, players act individually. This will not lead to economies of scale or the sustainability of the industry. VC governance necessitates the identification of lead enterprises/lead actors who will ensure that industry standards are followed, and industry practices are continually being upgraded. This means that if the traders' group want quality soft-bone *bangus,* then they should reject the processors' output which is considered poor quality, then the processors will reject the fish farmers' output which is of poor quality, and the fish farmers will make sure they only get the best from the input suppliers. In contrast, if the trader receives everything that the processors give them regardless of quality, then there will be a domino effect of poor quality input coming from backward linkages and poor quality outputs going to forward linkages.

Value chain governance needs to be geared towards value chain resilience to extreme events and climate change. Enabling mechanisms must be institutionalized, such as the inclusion of the industry roadmap in the municipality's Annual Investment Plan and the Comprehensive Development Plan.

Finally, knowing how success will be measured in quantifiable terms must be clear to everyone involved. For a value chain to be upgraded and strengthened, good gender-responsive value chain governance and the use of gender-sensitive value chain monitoring tools are necessary. For post-disaster interventions, the case of the Santa Cruz soft-bone *bangus* small-scale industry has shown that this livelihood will be meaningful if all the value chain functions are given equal importance and attention by responders to disasters.

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How smallholder aquaculture communities can survive and prosper by genetically adapting their broodstock to climate change

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INTRODUCTION

Smallholder aquaculture is sustainable indefinitely in the face of climate change only, we propose, if smallholders can develop genetic strains adapted to their — increasingly unpredictable — local environments. We further suggest that this is more likely to happen if aquaculture smallholders participate in genetic exchange networks, variously called "community-based breeding programs" (CBBP) (Mueller *et al*., 2015), "participatory plant breeding" (Ceccarelli *et al.,* 2010) or "on-farm dynamic management" (Thomas *et al.,* 2015), that allow concurrent rapid adaptation to local climate change threats and opportunities in a range of environments. CBBP enable the dynamic change that characterizes terrestrial crop "landrace" systems — open, decentralized genetic systems that are constantly evolving (Bellon *et al.*, 2015; Hellin *et al*., 2014; Loeuille *et al*., 2013; Poudel and Sthapit, 2015; Sthapit, Padulosi and Mal, 2010; Thomas *et al.*, 2015) — while avoiding inbreeding and genetic erosion (Doyle, 2016). Developing aquaculture CBBP networks will have challenges; however the basic social frameworks for CBBP already exist in many places (Bellon *et al*., 2015; Frison, 2016; Pautasso *et al.*, 2013; Szuster, 2006). Technical help from local and regional government organizations and institutions, as well as non-government organizations, will be required (Mueller *et al*., 2015; Sthapit, Padulosi and Mal, 2010). A recent review and analysis of CBBP in Latin America, Africa and Asia highlights this high dependence of CBBP on external organizational, technical and financial support (Hellin *et al*., 2014; Mueller *et al*., 2015).

HOW SUCCESSFUL SMALLHOLDER GENETIC ADAPTATION WORKS

Since domestication of animals began more than 15 000 years ago, people have adapted to new environments by genetically modifying the animals they depend upon. At present, with increasing environmental variability, having a diversity of combinations of genes and traits that are constantly selected in response to changing conditions and growing knowledge should allow aquaculture to adapt better to climate change (Doyle, 2014), as is the case in other commodities.

Networked breeders and farmers exert on-farm selection pressures that change from location to location and over time in the face of climate change stressors and emerging pathogens (Hellin *et al*., 2014; Loeuille *et al*., 2013). The key aspect of CPPB is that, whereas local strains are continuously developed for cultivation, the networked, global meta-population continues to evolve indefinitely as a sustainable source of continuously better-adapted genetic material for industrial aquaculture as well as smallholders (Ceccarelli *et al*., 2010). A networking approach allows efforts to be directed at enhancing diverse local adaptive capacities as a complement to a small number of worldwide (generally industrial) adaptations (Hellin *et al*., 2014).

Coping with an increasing rate of climate change in smallholder aquaculture may, as in terrestrial plant and animal production, require the development of new social networks of a modern type (Bellon *et al*., 2015; Frison, 2016; Pautasso *et al*., 2013). It is unlikely that this can be solely a bottom-up process, as evidenced for example in Thailand (Szuster, 2006). According to Sthapit, Padulosi and Mal (2010):

[farmers'] ability to cope with impacts of climate change will be strengthened if the research and development institutions can [strengthen] social seed networks and policy supports that promote farmer-to-farmer [germplasm] exchange systems.

At least 59 different types of interventions for supporting on-farm conservation have been identified (Bellon and Vanetten, 2014). Research and development agencies will play a crucial role in technical and organizational aspects of guiding germplasm exchanges within aquaculture networks that are adapting to climate change (Bellon and Vanetten, 2014; Carroll *et al.*, 2014, Hellin *et al*., 2014; Mueller *et al*., 2015; Pautasso *et al*., 2013; Sthapit, Padulosi and Mal, 2010). Furthermore, modern, high-tech crop varieties are often grown together with local landraces in agricultural communities experiencing a range of climates (Bellon *et al*., 2015, Pautasso *et al.*, 2013).

The high fecundity of shrimp can lead to rapid inbreeding and enhanced susceptibility to disease (Bellon *et al*. 2015; Doyle, 2016), as well as a reduced capacity to evolve, which results from loss of genetic diversity in small broodstocks. Unfortunately, although genetic exchange is widespread among smallhold aquaculture farmers, it is largely undocumented and not informed by genetics (Szuster, 2006). As noted by Poudel, Sthapit and Shrethsa (2015):

> *Strengthening the collective actions of [CBBP] communities in variety access, selection and seed production activities will ensure the flow of quality seeds in the community. This process will strengthen farmer's capacity to cope with climate change in traditional production systems.*

Adding germplasm exchange functions to existing or new aquaculture networks, and to supporting organizations and institutions, will present both technical and social challenges, as described for other sectors. The most obvious challenge is to implement procedures for exchanging germplasm that do not also cause the spread of disease. Existing national and international disease-control policies (essentially, broodstock isolation) inhibit the formation of CBBP germplasm exchange networks that would constitute an evolutionary basis for sustainable, diverse, long-term, adaptive resistance to pathogens (Doyle, 2014). The heart of the technical/policy dilemma is a feedback system (Doyle, 2014) within which, while pathogens are evolving in response to climate change, broodstock isolation reduces the genetic and evolutionary capacity to resist new and increasing disease threats. The feedback loop is completed when a decrease in aquaculture production caused by disease results, in accordance with isolation policies, with increased genetic erosion and inbreeding (Doyle, 2014 and 2016).

CONCLUSION AND FUTURE DIRECTIONS

The uncertainty surrounding the specific impacts of climate-change is reflected in growing interest in *adaptive capacity* as an alternative focus of policy efforts, rather than *specific adaptations,* e.g. adaptations to controlled industrial environments that are isolated from environmental and pathogenic stressors associated with climate change (Hellin *et al.,* 2014; Sthapit , Padulosi and Mal, 2010). The fact that CBBP systems can be economically self-sustaining, while remaining dependent on technical and other support from advanced technical institutions and organizations, in relevant cultural milieus and levels of technological maturity is demonstrated by the success of terrestrial crop and livestock farmer associations in the Republic of India, the Kingdom of Thailand, the Kingdom of Denmark, the Republic of France, the Americas and elsewhere.

Technical developments that facilitate CBBP networking will also enable national and multinational agencies to monitor and manage aquaculture networks as large meta-populations, which, collectively, preserve the genetic diversity of domesticated stocks indefinitely as a global, common genetic resource. The need for an aquaculture system redesign that both creatively *uses* and *conserves or increases* genetic diversity is especially acute in the Asia-Pacific region and other regions where smallholders are currently responsible for an estimated 70 percent of total shrimp production (Doyle, 2016). Although we emphasize that successful CBBP need to receive help from institutions and extension staff (Mueller *et al.,* 2015), the power in decision-making will remain with farmers as their local climates change. Smallholder farmers will have social ownership of the CPPB evolutionary and germplasm exchange programmes (Mueller *et al.*, 2015).

SUMMARY OF ESSENTIAL STEPS

1. recognize the value of community-level, science-driven adaptation of smallholder aquaculture to deal with the local effects of climate change;
2. organize the necessary administrative and policy support for modern germplasm exchange networks; and
3. develop new technical understanding and procedures for implementing local broodstock selection and safe, biosecure regional and global germplasm exchange.

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Capacity building of stakeholders to integrate fisheries and aquaculture in emergency response and preparedness: a case study from India

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INTRODUCTION

Viewing fisheries and aquaculture through a food security lens ensures that the sector meets food, nutrition and livelihood needs. The sector generates small-scale livelihoods, employment, wealth, national and international trade, entrepreneurship and contributes to farming of other food production systems. Fishing communities also play an important role in safeguarding local cultures, indigenous technical knowledge and maintaining social and cultural identity and values. Fish is a source of food across classes and geographic regions including rural and urban, poor, middle class and upper class with many poor people being highly dependent on fish for food and income. Fisheries provide livelihoods for over 200 million people and 90 percent of these people are in developing countries. They also provide a safety net income source for those experiencing temporary or seasonal hunger or unemployment. However, people who depend on fisheries and aquaculture for their livelihoods are increasingly vulnerable to natural and human hazards, which are occurring more frequently and projected to increase in intensity under climate change, affecting developing countries disproportionately.

In this context, there is a need for workshops to build stakeholders' capacity to plan for and respond to emergencies in the fisheries and aquaculture sector. The aim of these workshops should be to raise awareness of stakeholders about the vulnerability of the sector, the current frameworks for response, the need to be better prepared, and to enhance the quality and accountability of stakeholders in preparedness and response to emergencies affecting the fisheries and aquaculture sector.

This paper draws on best practices and experiences in responding to natural hazards that have affected communities working in fisheries and aquaculture, and overviews the workshops conducted to build capacity in stakeholders to integrate fisheries and aquaculture in emergency response and preparedness based on existing capacities and expected needs as per the guidelines of FAO (Brown and Poulain, 2013; Cattermoul *et al.*, 2014).

METHODS

Workshops were designed to build upon Fisheries and Aquaculture Emergency Response Guidance by Cattermoul *et al.*, (2014) and Guidelines for the Fisheries and

Aquaculture Sector on Damage and Needs Assessments in Emergencies by Brown and Poulain (2013) published by FAO. These documents are guidelines available to support those responding to an emergency involving the fisheries and aquaculture sector, and are designed to improve the quality and accountability of preparedness and response to emergencies affecting the fishery and aquaculture sector.

With this background, workshops were conducted in the states of Maharashtra, West Bengal (WB) and Assam in the Republic of India. The aim of the first workshop was to raise awareness of stakeholders about the vulnerability of the sector, the current frameworks for response and the need to be better prepared through appropriate training. The aim of the subsequent two workshops was to enhance the quality and accountability of stakeholders in preparedness and responding to emergencies affecting the fisheries and aquaculture sector. Core content areas that were addressed in these workshops were:

- importance of the fisheries and aquaculture sector;
- disasters affecting the sector;
- role of government and non-government organizations (NGOs) involved in emergency response;
- context of humanitarian action;
- mechanisms for disaster response; and
- standards underpinning humanitarian actions and fisheries and aquaculture interventions so as to improve participants' understanding and their capacity to respond to emergencies and plan for fisheries and aquaculture.

Assessing loss and damage in fisheries is a key requirement in many disaster situations so the expected outputs of the workshops were to help build the necessary capacity to improve the quality of the assessments undertaken.

A total of 87 participants (Workshop I: 30, Workshop II: 24 and Workshop III: 33) attended these workshops. A questionnaire with simple Yes/No answer choices was administered to 30 participants (before and after the workshops) with the objective of testing participants' knowledge on issues related to core content areas of the workshops. Five issues selected from the contents of the workshop were: (1) the importance of the fisheries and aquaculture sector; (2) disasters affecting the sector; (3) standards underpinning humanitarian actions; (4) fisheries and aquaculture interventions to assess loss and damage in disaster situations; and (5) how to improve the quality of the assessments which are undertaken. Before and after workshop scores were analysed to determine if there was improvement in understanding for these categories after each workshop.

SUMMARY RESULTS

The first workshop conducted in Mumbai on 18 December 2015 was attended by 30 diverse stakeholders. There was representation from central government, from state government, from district level, from NGOs, and from fishery cooperatives, academicians, researchers and youth.

The second workshop was organized from 25 to 27 February 2016 in the Sundarbans region, at ICAR-Central Institute of Brackish Water Aquaculture (CIBA), Kakdwip, WB. The 24 workshop participants were from nine organizations representing five NGOs. Participants were also from a few universities and from the state government.

The third workshop was organized at the Fisheries Research Centre, Assam Agriculture University, Jorhat from 10 to 12 March 2016. The third workshop was attended by 33 participants representing NGOs, a local fisheries college, ICAR-Central Inland Fisheries Research Institute (CIFRI); a number of progressive fish farmers, and staff from the department of fisheries in two areas.

In the northeast region, recurrent flooding causes vast damage to both capture and culture fishery resources almost every year, and often make rural people homeless.

Another impending threat to fishery resources is the scarcity of water. Taking these issues into consideration, locale-specific case studies were developed for the workshop.

It was found that for "importance of fisheries and aquaculture sector" and "disasters affecting the sector", not much improvement in the participants' scores was obtained. Participants reported that they were aware of the sector's importance to the livelihoods of people and also the general types of natural disasters that affect the sector. However, with reference to "standards underpinning humanitarian actions", "fisheries and aquaculture interventions assessing loss and damage in disaster situations" and "improving the quality of the assessments undertaken", improvement in the scores was obtained. These results plus feedback from participants, demonstrate that workshops were able to build some necessary capacity of stakeholders in enhancing the quality and accountability of stakeholders in preparedness and response to emergencies affecting fisheries and aquaculture sector.

CONCLUSIONS AND FUTURE DIRECTIONS

Reflecting on the experience of the three-day fisheries and emergencies course, it was observed that the participatory approach of the training and learning through case studies and group exercises was successful in building knowledge. Suggestions by participants about the content and process to improve the training experience included the addition of case studies for specific types of natural disasters, and translation of reading materials into local languages.

To take this forward, this knowledge and capacity needs to be incorporated into academic curricula of fisheries courses to teach best-practices to the next generation who will be at the forefront of assisting vulnerable communities affected by disasters in their countries and regions. Youth in turn can strengthen the support provided to vulnerable fishing and aquaculture communities as they build resilience to natural disasters. It is expected that appropriately informed and trained people can undertake better needs assessments and planned responses, and can also advocate for the importance and needs of the sector leading to improved fisheries management.

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

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Introduction

Climate change is affecting the livelihoods of fishers in the Sundarbans, a unique Biosphere Reserve and World Heritage Site. Mangroves of the Sundarbans represent rich and unique ecosystems that are distributed over two countries — the Republic of India and the Republic of Bangladesh. The Indian Sundarbans occupies 4 267 km^2 of the total area of 14 300 km^2 that encompasses 19 adjacent blocks in West Bengal (Department of Sundarban Affairs, 2016). The ecosystems of the Sundarbans are a nursery ground for nearly 90 percent of aquatic species on the east coast, and coastal fisheries in eastern India depend upon the Sundarbans (Chandra and Sagar, 2003). The area is home to more than 4 million people and consists of 104 islands, with 54 inhabited (Department of Sundarban Affairs, 2016; Government of India, 2011). Nath (2016) reported that climate change has resulted in the submergence of Supari Bhanga and Lohachara islands of the Sundarbans, and the primary concern is future sea-level rise that is expected to further increase island submergence (Seggel and De Young, 2016). Homeless inhabitants of these islands have migrated to Sagar Island as environmental refugees. Being internationally recognized, the Sundarbans is a focal point for many non-government organization (NGO) projects. Different funding agencies have supported livelihood interventions in the Sundarbans, including for fisheries affected by climate change.

The Department of Fisheries, Department of Sundarban Affairs, Government of West Bengal, and the Indian Council of Agricultural Research all work on climate change and livelihood interventions in the Sundarbans. Although governmental organizations (GOs) and NGOs are involved in a range of fisheries development activities, few studies have investigated the role of NGOs in supporting climate change adaptation. This study addressed this need by analysing the various interventions and programmes undertaken by NGOs on livelihood development under a changing climate in the Sundarbans region.

METHODS

The project collected information from officials, key informants of NGOs, using focus group discussions (FGD) and also from secondary sources such as annual reports and official records, and identified approximately 111 NGOs working on agri-allied activities for livelihood development in the study area. Of these, seven NGOs had been intensively working on fishers' livelihood and climate change interventions in the Sundarbans region. Thus, these seven NGOs were selected for this study (Table 1). The officials of these seven NGOs were surveyed using a structured interview schedule. They provided information on interventions related to capacity development programmes on disaster management in fisheries and aquaculture, techniques of climate resilient aquaculture, fishery inputs and supports for mitigating the adverse effects of climate change, and aquaculture restoration practices. The parameters were: working area (i.e. the blocks they cover); interventions; funding agencies; number of beneficiaries from the project; and the training programmes provided. In addition, information was collected on the detailed activities for climate change adaptation undertaken by each NGO.

Preliminary studies showed that NGOs are involved in interventions such as

TABLE 1
NGOs working on livelihood interventions and issues of climate change in the Sundarbans

	Non-Governmental Organization	Working Areas/Blocks
1	Tagore Society for Rural Development (TSRD)	Sagar, Rangabelia, Basanti, Gosaba, Hingalgunj
2	Socio-Economic & Ecological Development (SEED)	Sagar, Patharpratima, Gosaba
3	Sabuj Sangha	Sagar, Patharpratima, Raidighi
4	Paribesh Unnayan Parishad (PUPA)	Sagar
5	Vivekananda Institute of Biotechnology (VIBT)	Sagar
6	Sundarban Dream	Gosaba
7	Nature Environment and Wildlife Society (NEWS)	Patharpratima, Gosaba, Kultali, Basanti

inputs distribution, infrastructure development, capacity building, and climate change initiatives for the fishing communities in the Sundarbans. Content analysis was performed by using conceptual and relational analysis (Ghosh and Sharma, 2014) to study the details of interventions for mitigating climate change issues and funding status in a more comprehensive manner. For this, secondary data were collected from the offices of NGOs and through FGD for the last three years, i.e. 2012-13 to 2014-15, as the World Bank Funded Integrated Coastal Zone Management Programme (ICZMP) was operational during this period. Descriptive statistics were applied to analyse the information.

SUMMARY RESULTS

The present study revealed that among different livelihood interventions available, NGOs gave priority to environmental awareness campaigns, environmental awareness mapping, biodiversity/climate awareness programmes and observation of special environmental days/weeks. These initiatives were mainly funded by the World Bank under the ICZMP, and other sponsors included the Ministry of Environment and Forests, Government of India, the West Bengal Biodiversity Board, Government of West Bengal and the Institute of Environment Studies and Wetland Management, West Bengal. Approximately USD 630 000 (INR 42.20 M) was invested in climate change issues out of a total expenditure of USD 4.16 million by NGOs in the Sundarbans region for the 2014-15 financial year. The primary impacts of climate change in the Sundarbans are: sea-level rise; island inundation; increasing salinity in water and soil resulting in adverse effect on mangrove forests; changes to fishing patterns; and an erratic monsoon which is detrimental to fishing communities. The interventions of NGOs on issues of climate changes do not appear to be coordinated or consistent, and are presented in Table 2.

CONCLUSIONS AND FUTURE DIRECTIONS

The seven NGOs working in the area of fisheries and climate change in the Sundarbans undertake project activities and training programmes related to different capacity

TABLE 2
Interventions of NGOs on issues of climate change

Non-Governmental Organization	Interventions	Funding Agencies	Investment USD (Indian Rupee)	Achievements (2012-13 to 2014-15)
Tagore Society for Rural Development (TSRD)	Training programmes on disaster management, restoring environmental and ecological balance	World Bank, ICZMP	USD 10 396 (INR 692 075)	About 10 000 participants were trained
Socio-Economic & Ecological Development (SEED)	Climate adaptive agriculture and aquaculture	World Bank, ICZMP	USD 9 764 (INR 650 000)	145 fish farmers benefitted by developing a better livelihood plan, including training
Sabuj Sangha	Promoting resilience in coastal areas Training and awareness sessions on crop intensity and diversity Knowledge management and research on conservation and preservation of coastal ecosystem Development of model organic garden and training centre, organic farming venture, establishment of gene/seed banks	Ministry of Environment and Forest, Govt. of India Dept. of Environment, Govt. of West Bengal World Bank West Bengal Biodiversity Board, Govt. of West Bengal Institute of Environment Studies and Wetland Management, Salt Lake, West Bengal National Institute of Oceanography, Goa, India	USD 15 895 (INR 1 058 171)	30 000 people were reached with awareness raising, skill development and livelihood support 246 self-help group leaders were provided with inputs to cope with the impacts of climate change
Paribesh Unnayan Parishad (PUPA)	Biodiversity conservation and restoration Training programmes and awareness raising campaigns on integrated fish and salt tolerant rice farming	United Nations Development Programme (UNDP)/ Small Grant Project (SGP)	USD 30 042 (INR 2 000 000)	About 6 000 people benefited
Vivekananda Institute of Biotechnology (VIBT)	Development of a network of village-level human resources for identification of critical gap in crops cultivation Use of domestic and municipal waste and usage of cow-dung for biogas production	European Union (EU) and Dept. of Science & Tech., Govt. of India	USD 166 524 (INR 11 086 000)	250 beneficiaries were supplied with biogas plants
Sundarban Dream	Training programmes on environmental protection and climate change impacts	Department of Fisheries, Govt. of West Bengal, Marine Products Exports Development Authority (MPEDA) and Central Institute of Fisheries Education (CIFE) – Kolkata Centre	Donation	About 1 000 training participants benefitted
Nature Environment and Wildlife Society (NEWS)	Assessing the impacts of climate change in the Sundarbans Development of cyclone shelter in the Sundarbans Community approach for reducing greenhouse gas emissions	Danone Fund for Nature, Paris	USD 402 677 (EUR 361 000)	Mangroves were afforested and restored in 5 596.69 hectare 75 081 tonnes of greenhouse gas (CO_2) emission was reduced

Source: FGD with NGO officials and official records.

development programmes on disaster management in fisheries and aquaculture, techniques of climate resilient aquaculture, fishery inputs and supports for mitigating the adverse effects of climate change and restoring aquaculture practices. However, the study has revealed that there is no comprehensive plan of activities or strategy to coordinate climate change activities by NGOs. Currently, NGOs focus on working areas as needs arise rather than having a strategic plan of action with clear benefits for the livelihood of fishers. This is a major gap that needs to be addressed.

RECOMMENDATIONS

In general, a greater focus is needed by NGOs in raising awareness in fishing communities about how to develop climate resilient fisheries, and to provide adaptation solutions, particularly on the remote islands of the Sundarbans. Such activities will require better coordination with government and participation of NGOs in relevant capacity building programmes at a national level. Other specific recommendations include:

Policy issues

Details of socio-economic and livelihood profiles of fishers, and needs assessment results, should inform a targeted programme of climate change adaptation and policy formulation. Such information can also facilitate effective partnerships between government — Department of Fisheries, Sundarban Development Board, Indian Council of Agricultural Research — private organizations and NGOs. In addition, greater awareness and compliance should be encouraged with all stakeholders to follow environmental protection laws and regulations.

Technology and infrastructure development

NGOs need greater knowledge and capacity in implementing the latest technologies for climate change adaptation, such as online management systems, human resource development and analytical modules, communication and e-extension technologies to reach more beneficiaries.

Financial

As NGOs operate under resource limited circumstances (e.g. labour, skills and funds), greater effort should focus on obtaining funds from national and international donor agencies. Improved financial support should be accorded to ensure record keeping and documentation at the end of projects and accountability to ensure project funding targets key needs and has been invested responsibly.

Reports suggest that climate change is resulting in sea-level rise, disappearing islands, increasing salinity in the water and soil resulting in adverse effect on the health of mangrove forests, soil, change in fishing patterns, erratic monsoon which is detrimental to the fishing communities. This study showed that NGOs gave priority to environmental awareness campaigns, environmental awareness mapping, biodiversity/climate awareness programmes and observation of special environmental days/weeks. There is a need for greater project coordination, and for NGOs to make fishing communities more aware of climate resilient fisheries and to provide adaptive solutions to climate change for fishing communities.

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Insurance for aquaculture and fishery adaptation to climate change: experiences from China and Viet Nam

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ABSTRACT

The broad concept of insurance as a risk management tool and a climate change adaptation strategy in aquaculture and fishery has been widely accepted by governments and their fisheries sectors. This prompted the trial of schemes designed to insure a large pool of farmers and fishers on the one hand and to be a viable business for insurers on the other. Examples from the People's Republic of China and the Socialist Republic of Viet Nam illustrate the attempts to achieve these two linked outcomes. Generally, small-scale and medium-scale farmers' and fishers' access to insurance cover is still limited and there is a need for well-designed insurance products that suit the circumstances and needs of such farmers and fishers. Innovative insurance programmes can promote good farm management practices. Public-private partnership models such as mutual insurance can be feasible in providing insurance services to groups of small farmers, but government subsidies are needed initially.

INTRODUCTION

Insurance of aquaculture and fishery assets has been against hazards associated with a variety of phenomena: physical (flood, drought, storms, cyclones, abnormal temperatures, etc.); biological (diseases, pests, harmful algal blooms); chemical (acidification, salinization of freshwater, oil spills, chemical leaks, contaminated run-offs); and geological (landslides, mudslides, tsunami). Except for oil spills, chemical leaks, run-offs and tsunami, and damage to fishing assets from fire on board fishing vessels, engine failure or running aground, almost all of these hazards are driven by, associated with, or exacerbated by climatic variability. These have exacerbated market risks.

Awareness of the opportunities and benefits offered by insurance as a financial tool for risk management has been raised among governments and aquaculture industries: farmers can recover their businesses faster after a disaster; insurance combined with other tools such as credit can encourage investments in farm improvement, better management and new technology, which increase the resilience of farmers to the impacts of climatic and economic disasters; and insurance enables farmers to participate actively in risk management. As a public investment in a partnership among government, commercial insurers, farmer groups and value chain actors, it lightens government's costly burden of disaster relief, recovery and rehabilitation efforts, all of which comprise an adaptation strategy.

METHODS

Having been accepted by policymakers as a climate change adaptation strategy, insurance initiatives moved to the practical issues of: (a) making aquaculture insurance a viable and sustainable business; and (b) farmers being able to participate continuously in insurance programmes. The national programmes that are described below are pilot schemes aimed at achieving these two outcomes. The information is derived from a review of the People's Republic of China's capture fishery and pilot aquaculture insurance programmes (FAO, 2017) and a review of the Socialist Republic of Viet Nam's pilot agriculture insurance programme that covers rice, livestock and aquaculture (FAO, 2016). The China review is informed by case reports of mutual, commercial, "mutual + commercial" and "cooperative plus commercial" arrangements. The Viet Nam review focused on the aquaculture component.

SUMMARY RESULTS

Improvement of risk management capabilities

Awareness raising of insurance for risk management. Fishers and fish farmers used to consider insurance only for loss of life, accident injury and catastrophe, not as a risk management measure. China Fishery Mutual Insurance (CFMI) association has realized the importance of insurance awareness and, among other promotional efforts, publishes a magazine and releases successful stories to the mass media and social media. The fishery extension stations are promoting insurance to fishers and fish farmers and conduct visits to successful insurance cases.

Innovative insurance schemes. Weather-index based insurance (i.e. wind speed and temperature) in the People's Republic of China for seaweeds, mitten crab, and bivalves provides indications of technical and economic efficiency of administration, reduction of fraud, and proper compensation. The scheme shows its suitability for risks that are the direct impacts of climate variability.

Risk sharing tool instead of disaster relief fund. The Government of the Socialist Republic of Viet Nam sought to apply insurance as a strategy to lighten the financial burden of government from costly post-disaster assistance. The pilot programme insured rice, livestock and aquaculture production against storm, flood, drought, cold, frost, tsunami and other perils. It also provided cover against named pests and diseases.

Farmer resilience. A "cooperative + commercial" model provided incentives for the members of the cooperative to reduce losses from disease with better management practices. If the total amount of indemnity paid divided by the amount of premium collected did not exceed 60 percent, the insurer returned part of the premium to the cooperative, which was then distributed among its members for the purchase of water quality improvement compounds and other inputs. This illustrates the use of insurance as an incentive for investing in improved technology and better practices, which improves the farmer's capacity to adapt to risks.

Sustainability of the insurance programmes

Institutional support. The common features of the programmes in the People's Republic of China and Socialist Republic of Viet Nam are strong government support, a clear policy, and a state subsidy of premiums. China's central and local governments subsidize 40 to 80 percent of the premium depending on the local government's financial resources. Viet Nam subsidized premiums according to the level of participants' household income: 100 percent to poor, 80 percent (revised to 90 percent) to almost poor and 60 percent to non-poor households, and 20 percent to organizations or cooperatives. The common effect of subsidies is that it attracted wider participation. China's subsidized programmes have been viable. Viet Nam's aquaculture pilots suffered losses, although crop and livestock insurance was profitable.

Institutional infrastructure. China has a mature commercial and mutual insurance infrastructure. CFMI has a national outreach through near-autonomous offices in major fishing and fish-farming provinces. The capacity of reinsurers in risk sharing remains a challenge for the development of aquaculture insurance.

Technical capacity. China's commercial insurers, aside from having well trained field operatives, rely on the expertise of fishery and aquaculture cooperatives in risk identification and assessment. In contrast, in Viet Nam insurance companies did not coordinate with social organizations — farmers' associations, women's associations, cooperatives, and farmer unions — to develop insurance products that could have better met the needs of the clients.

CONCLUSIONS

Insurance spreads the cost of insuring climate change-induced risks from aquaculture farmers to insurers and insurers to reinsurers. Generally, small-scale and medium-scale farmers' and fishers' access to insurance cover is still limited. The reviews suggest the need for well-designed insurance products that suit the circumstances and needs of farmers and fishers. Innovative insurance programmes can promote good farm management practices, and can be seen as a risk mitigation approach. Public-private partnership models such as mutual insurance can be feasible in providing insurance services to groups of small farmers. Importantly, government subsidies are needed, especially during the pilot stage.

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Theme 4

Communicating climate change and potential impacts

Communicating climate change that leads to action: from awareness to behaviour change

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ABSTRACT

Communicating the impacts and necessary responses to climate change is a fundamental building block to informing policy, changing behaviour and reducing vulnerability. The complex and long-term nature of climate change presents particular challenges for communicating strategies that ultimately are designed to lead to action to address climate change and change behaviour to reduce vulnerability. Understanding the motivations of individuals and their social networks is also critical to how any change in attitudes and behaviour will ultimately lead to an increase in social resilience. Communication strategies for ocean acidification (OA) and social marketing to help restore small-scale fisheries provide some best practices for communicating climate change and well tested approaches for eliciting behavioural change.

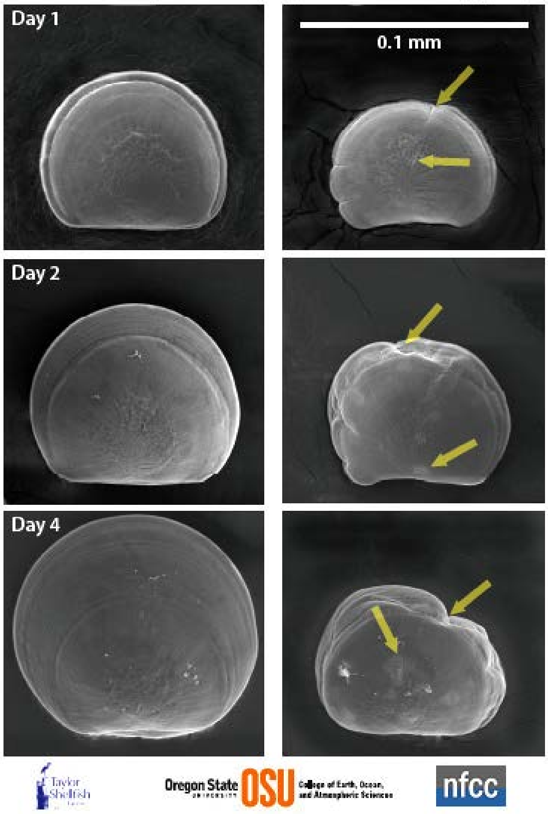
INTRODUCTION

We live in an era that some call the behavioural revolution, which began with the work of psychologists Daniel Kahneman and Amos Tversky in the 1970s and has since inspired new fields of research, such as behavioural economics (Thaler, 2015). There has been a great unfolding of new insights about how people are motivated to make decisions, along with novel communication techniques and modern technology for sharing information. Gone are the days of *homo economicus* — a purely rational and self-interested utility-maximizer (Bowles and Gintis, 1993). It is now known that many human decisions are, on the surface, irrational but predictably so (Ariely, 2008); that human behaviour is more akin to that of ants and honeybees than it is to that of lions and tigers and bears (Wilson, 2012); and that, perhaps most radical of all, human beings are much better at cooperating than they are at competing (Bowles and Gintis, 2011).

Perhaps no other contemporary global challenge than climate change has more to gain from appreciating this deeper understanding of human behaviour and the communication techniques that influence it. Recent campaigns by two organizations provide relevant examples from which we can learn about the opportunity to leverage novel human behavioural insights for addressing climate change.

The National Fisheries Conservation Center in the United States started its Global Ocean Health (GOH) programme in 2007 to communicate the threat of OA and help stakeholders adapt to, remediate, and mitigate its effects; as well as other climate impacts on the ocean. Field surveys and modeling confirm that the chemical processes driving the uptake of anthropogenic CO_2 (Sabine *et al.*, 2007) have lowered seawater pH by 0.1 since 1750, a 30 percent increase in acidity (Feely *et al.*, 2004). This process of OA is further exacerbated in the Pacific northwest of the United States of America by the upwelling of carbon-rich waters within the coastal zone, creating "OA hotspots" (Feely *et al.*, 2008). In the late 2000s, the combination of coastal upwelling and anthropogenic CO_2 uptake caused mass mortality of oyster larvae (Figure 1), triggering an "oyster seed crisis" for shellfish growers in Oregon and Washington states. The loss of hatchery-produced seed as well as wild oysters triggered extensive economic impacts (Washington Blue Ribbon Panel on Ocean Acidification, 2012).

FIGURE 1
Three examples of damage to oyster larvae over time from ocean water acidity and low available carbonate, compared with healthy larvae on the left



Source: Oregon State University.

The GOH programme raised funds at the start of the crisis to outfit hatcheries with monitoring and buffering equipment, and programme staff served on the world's first Blue Ribbon Panel on Ocean Acidification. Since then, GOH work has been largely focused on stakeholder engagement: outreach to those whose livelihoods or way of life is threatened by OA and other consequences of a high-carbon ocean. In 2011, GOH brought commercial fishermen before the United States Senate to testify about the effects of OA, prompting bipartisan support for increased funding. OA is one of the fastest-growing fields in oceanography and new research is released daily. These studies show that all marine calcifying organisms, including oysters, clam, shrimp, lobster, and crabs rely on calcium carbonate availability and are at risk. OA also has negative behavioural and recruitment effects on some fish species. A small sea snail, the pteropod, may be a key biological indicator of OA and an important warning about food web consequences (see Figure 2). More than half of the pteropods collected from nearshore waters from central California to the Canadian border are found to have severe shell damage caused by OA (Bednarsek *et al.*, 2014). The marine food web impacts of impaired pteropods are as yet unknown, but could have widespread effects on pink salmon and other key fish species. GOH's work with shellfish growers, coastal communities, and North American Indian tribes has clarified several key lessons regarding communication of climate change, particularly that of OA, with its emphasis on marine chemistry.

FIGURE 2
Pteropod dissolving over 45 days in acidified conditions

In another example of climate change communication, experiences from *Rare*, a global conservation organization working to promote the adoption of sustainable small-scale fishing and farming behaviours in Latin America, Asia and Africa, provide insights on the use of behavioural sciences to improve natural resource management in ways that can deliver benefits for climate change adaptation. Specifically, behavioural approaches can build social resilience, help communities adapt to climate change, and make the link between community engagement and national policy. Such adaptation and resilience building, done in collaboration with local democratic governance, has generated demonstrable evidence of changes at the sub-national and national levels.

Lessons from ocean acidification

Communicating to people that they have a stake in the health of the ocean and a reason to care about climate change impacts is key to reaching across boundaries and breaking through their natural resistance to bad news. In a survey of Oregon shellfish growers, more than 80 percent indicated that OA will have consequences today, which is more than four times that of the general public's perception of the threat (Mabardy *et al.*, 2015). This demonstrates clearly that when people are conscious of a direct threat to their livelihood, understanding and acceptance of climate change impacts greatly increases.

Research into scientific communication continuously reports that speaking to people in their own language, telling them a story of a person or people they can relate to, is significantly more effective than relating scientific concepts in scientific terms. For GOH, this has been proven repeatedly at workshops and presentations for northwest Indian tribes, coastal communities who rely on fisheries and reef ecosystems for tourism, and most significantly, for commercial fishers and shellfish growers in the United States of America. This last group tends to be made up of largely rural, politically conservative blue-collar men who are initially resistant to the concept of climate change. But by telling them the story of the oyster seed crisis — particularly when it is told by a fellow stakeholder — they are able to put themselves in those "threatened" shoes and emerge as strong champions for OA monitoring, research, and adaptation funding. Whereas hearing about carbonate chemistry, carbonic acid, or aragonite saturation only leads to a glaze-eyed audience being confirmed in its belief that climate change and OA are either scientific hoaxes or nothing that they need be concerned about.

GOH has found meetings between these "waterfront champions" and legislators or other policymakers to be highly effective. Where the testimony of a thousand politically liberal climate change activists has fallen on deaf ears, the voices of a just a few fishers who represent a rural conservative constituency as well as millions of dollars in economic activity and thousands of jobs, crosses party lines and compels legislative action.

The final piece of communicating climate change impacts — be they OA, sea level rise, hypoxia, warming, harmful algal blooms or another threat — is to find the focus that will make that subject relevant to the audience. Are they islanders whose shores are eroding and who experience constant flooding? Are they a coastal community reliant on tourism from coral reefs or recreational shellfish harvest? In 2010, about 40 percent of the global population lived in coastal communities (The UN Secretary General of the United Nations, 2016), and that number is increasing, making the world's population highly vulnerable to climate impacts. It is critical therefore to identify the target audience's core interests and tailor communications to speak to them.

Lessons from social marketing and small-scale fisheries

Increasing the capacity of local communities and fishers to manage their fisheries sustainably, conserving critical coastal habitats and strengthening both ecological and social resilience will be critical to help people cope with the devastating effects of climate change. These vulnerable communities are in greatest need of solutions, which maintain or enhance the contribution that fisheries can make to poverty reduction. Three out of seven people directly depend on marine and coastal resources to survive, with coastal and fishing populations and countries dependent on fisheries being particularly vulnerable to climate change (Ban Ki-Moon, 2015). By better understanding human beings, in this case small-scale fishers, as social beings and using existing behavioural approaches to natural resource management solutions, it is possible to build ecological and social resilience to climate change.

Better understanding of behavioural approaches

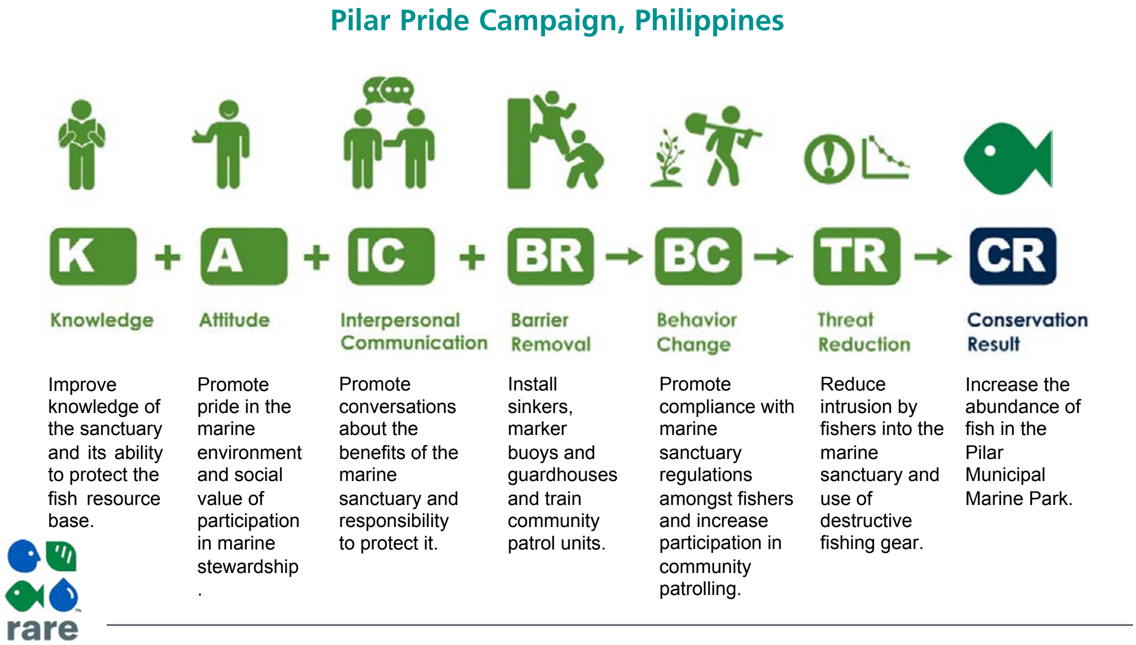
Applying behavioural approaches helps build a holistic understanding of human motivation. Through an in-depth diagnosis of, and engagement with, a specific target audience it is possible to deploy strategies that promote positive behaviours or social norms. These norms are developed to support particular pro-social goals, in this case resilience to climate change. The approaches utilize tools and techniques from social marketing, social and behaviour change communications, and behavioural economics. *Rare's* signature behavioural approach is a methodology called PRIDE, which has been carefully refined since the early 1980s (Butler *et al*., 2013). Rather than relying heavily on positive or negative *extrinsic* incentives, like fines or pay-for-performance, a PRIDE campaign focuses primarily on inspiring a community to change its own *social* norms around how its natural resources are used in everyday life. This essential logic has now been repeated in community-level PRIDE campaigns more than 350 times in over 50 countries. In each of these places, the approach begins with the same overarching theory of how change happens.

It is important to understand how this translates the features of *understanding* human behaviour, motivation and decision-making into a *tactical* methodology for promoting adoption of a new behavioural norm. It begins with a hypothesis that conservation is fundamentally a behavioural problem. Conservation outcomes, whether those outcomes are related to species population, habitat quality, or preservation of a natural resource base, are achieved by reducing existing threats, such as overfishing or habitat destruction, and those threats are reduced by replacing them with new, more sustainable behavioural norms.

The second hypothesis is that a behavioural approach — in this case a PRIDE campaign — can successfully promote a new behavioural norm among the target audience, such that those outcomes are ultimately achieved.

The PRIDE campaign starts with the assumption that knowledge is sometimes a necessary but *almost never* a sufficient condition for change (see Figure 3). A certain level of knowledge and awareness can be raised within the audience, and according to the PRIDE methodology, the most important types of knowledge are those having to do with understanding of the solution or new norm itself, and not of the ecological *problem*, which is so often the focus of environmental messages.

FIGURE 3
Steps in a campaign to remove barriers to behavioral change



A PRIDE campaign also focuses intently on changing attitudes, and in particular on promoting positive attitudes that are supportive of the new norm. Often this means identifying and understanding existing shared values within the group and allowing the group to form attitudes about how those values are tied to the solution.

One of the most important elements in the campaign is "word of mouth" or *interpersonal communication*. This is how social norms diffuse through a group, and research across virtually all the behavioural and social sciences has demonstrated that where interpersonal communication, group identity and social cohesion intersect, cooperation occurs (Janssen and Ostrom, 2008).

Context is critical, so it is important to go beyond simply inspiring a *desire* to adopt a new behavioural norm to actually creating the enabling conditions in which that behaviour can occur. In the PRIDE methodology, this is referred to as "barrier removal." The nature of a campaign's barrier removal strategy is highly dependent on the circumstances, but it often involves building technical capacity — from deploying buoy markers to policy change. Effectively removing barriers allows for easier adoption of a new behavioural norm.

Although Figure 3 lays out these steps in a linear manner that is not generally how it is implemented in the real world. For instance, people often talk about things they know nothing about, and people often form attitudes based on what they hear while communicating in their peer groups.

To date, these approaches have been focused on the more technical aspects of natural resource conservation and management, but these inherently occur in the context of a changing climate. Resilience to such change, therefore, is built in a number of ways, including:

- increasing the readiness with which a community approaches the need to adapt (which reflects both awareness and willingness);
- improving the level of trust within and between groups to engage in the cooperation needed to quickly and effectively adapt; and
- strengthening the institutions that exist to facilitate effective and rapid decision-making.

The following case study outlines how this behavioural approach applied to a conservation challenge resulted in positive resilience outcomes for the community of Pilar.

CASE STUDY: PILAR, PHILIPPINES

In the small community of Pilar in the Cebu province of the central part of the Republic of the Philippines, Rare's partner, the Local Government Unit of Pilar, and their campaign leader set out to implement a PRIDE campaign that would change the norms around their marine sanctuary (Pilar Municipal Marine Park, a 179 hectare near-shore reserve consisting of coral, seagrass and mangrove habitat). In order to increase the abundance of fish in the marine park, they needed to reduce intrusions into no-take areas and eliminate the use of destructive fishing nets. They needed to get the community of fishers more involved in patrolling and enforcing social norms around the sanctuary regulations, but more importantly they needed to create a culture of compliance amongst the fishers.

They employed the simple PRIDE methodology (see Figure 3) and developed a comprehensive marketing and behavioural change campaign. Extensive target audience research was conducted and used to diagnose the prevailing social norms, shared values and barriers to change. With that knowledge, a fully branded campaign was implemented, targeted toward increasing knowledge of the solution, promoting positive normative attitudes, and stimulating interpersonal communication and social interaction. This included removing the barriers to change by installing new sinkers and buoy markers, and building and repairing guardhouses.

Although campaign efforts and measurement of outcomes are ongoing, a number of positive outcomes have been observed already. Over 18 months, a dramatic shift in attitudes about fishing inside the no-take area was observed (Cataylo, 2014). Reported sightings of intrusions in the no-take area showed promising decreases, and early measurements of biomass changes were equally promising. One of the most fundamental shifts was a more cooperative approach to resolving the community's "tragedy of the commons" and working together to sustainably manage their fishery; a primary source of protein. In November 2013, Typhoon Haiyan, demonstrated that more than ever, the community was eager for a way to protect their marine resources. They had already been building the social trust and institutions to come together, deal with the disaster, and move forward.

As a result of the ongoing campaign, they had:

- more readiness
- increased trust
- improved institutions for decision-making.

Not only did the community have an existing solution that was helping to build *ecological resilience*, they now had the necessary elements in place to embrace change, cope, adapt and prosper in the increasingly intense and more frequent storm events.

CONCLUSIONS AND FUTURE DIRECTIONS

Communications targeted at each specific audience can lead to increased understanding and awareness of complex issues such as OA and climate change. Once people have overcome their inherent rejection of "bad news" and have come to understand their stake in the effects of climate change they become effective "champions" capable of influencing policymakers and decision-makers. Stakeholders that represent significant economic activity, such as commercial or charter fishers, and who come from a politically conservative viewpoint can be the strongest influencers of their peers and legislators.

Keeping scientific communications in lay terms and avoiding language — particularly scientific language — unfamiliar to the audience can define the difference between success and failure. Many scientific communicators are so immersed in their work that they become unaware of what the larger public is and isn't familiar with, thus falling into a trap of communicating in a manner they believe to be clear and concise but which leaves their audience bemused and befuddled. Communicating OA and other climate change impacts is best approached with a narrative or story-telling style that allows the target audience to empathize with the central player(s) and grasp the direct threat to their own way of life.

In addition to clear communication strategies such as these that are based on an understanding of the motivations of individuals and their social networks, it is possible and necessary to deploy strategies that promote positive behaviours or social norms that build resilience to climate change. If building ecological and social resilience to climate change is fundamentally a behavioural problem, then current practices that may be increasing the vulnerability of a natural resource base need to be replaced with new, more sustainable and resilient behavioural norms.

This can be achieved through the use of tools and techniques from social marketing, social and behaviour change communications, and behavioural economics. PRIDE campaigns provide one approach that is starting to demonstrate how communities can move from knowledge and attitudes to specific behaviours that strengthen ecological and social resilience to climate change. This is being achieved in the case of Pilar through *inter alia* by focusing on the promotion of positive attitudes that support the new norms, ensuring these social norms diffuse throughout the community, and creating the enabling conditions or "barrier removal" needed for the new behaviour to occur and be supported.

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Impacts of ocean acidification on shellfish aquaculture on the west coast of the United States of America and adaptation responses

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Introduction

Oyster growers from Alaska to California on the west coast of the United States of American (USA) have been challenged in recent years to find seed and oysters to keep their businesses viable. Scientists from the National Oceanographic and Atmospheric Administration (NOAA) and various universities have linked the oyster seed losses to ocean acidification. Shellfish growers' understanding of what has caused these oyster seed shortages and their responses to the issue has evolved in recent years through seawater monitoring and collaborative research.

From 2007 to 2009, west coast shellfish growers in the USA experienced a severe oyster seed shortage. Oyster larvae production at two of the four major seed production hatcheries declined by approximately 75 percent during this period. In addition to the drop in hatchery production, there was no significant natural recruitment of larval oysters in Willapa Bay from 2006 to 2012. Willapa Bay is one of the largest oyster producing estuaries in the country and many oyster growers rely on natural recruitment of Pacific oysters to seed their beds. These seed production failures had a real and profound effect on oyster businesses.

SUMMARY RESULTS

In 2012, the Governor of Washington State appointed an Ocean Acidification Blue Ribbon Panel to develop a response for the state. This diverse group of shellfish growers, business representatives, politicians, scientists and environmental non-government organizations arrived at 42 recommendations for the state, which the Governor incorporated into an Executive Order for implementation. This response garnered international recognition as one of the first to address ocean acidification. In December 2015, through an effort of the Pacific Coast Collaborative, the International Alliance to Combat Ocean Acidification (OA Alliance) was launched. The OA Alliance is providing collaboration and tools for countries and affiliates to combat changing ocean conditions.

Because of these initiatives, the west coast oyster seed situation has improved. The outstanding response from policymakers and an unprecedented collaboration between university, agency and industry scientists has advanced knowledge of the problem dramatically in a very short period of time. Created by the Washington State Legislature in 2013, the Marine Resources Advisory Council is overseeing implementation of the Blue Ribbon Panel's recommendations. Also created by the Legislature in 2013, the Washington Ocean Acidification Center at the University of Washington is studying the effects of ocean acidification on the state's marine resources. Today, west coast shellfish hatcheries in the USA have sophisticated monitoring equipment deciphering seawater chemistry sampled from the ocean and automated systems treat the water to make it more conducive to oyster larvae survival.

In addition to the monitoring systems in the hatcheries, equipment has been added to several buoys that are part of NOAA's Integrated Ocean Observation System (IOOS). This allows shellfish growers and scientists to understand changes in ocean carbonate chemistry around the hatcheries and farms. Five of the IOOS regions in the Pacific Ocean have linked to provide one data portal, the IOOS Pacific Region OA data Portal[15] that delivers data from all five regions. This online portal provides live real time data from various government, academic and Native American facilities and buoys including five major west coast shellfish hatcheries. On a larger scale, the Global Ocean Acidification Observing Network (GOA-ON)[16] is working to gather and exchange ocean acidification data internationally.

As a result of these responses, oyster production has improved, at least temporarily for shellfish growers. Hatchery production has largely recovered and ocean conditions have resulted in some limited natural oyster seed recruitment in Willapa Bay since 2012. Although oyster seed supplies have improved, they are still not adequate to meet all growers' needs.

WHAT DO WEST COAST SHELLFISH GROWERS KNOW ABOUT OCEAN ACIDIFICATION THAT THEY DIDN'T A FEW YEARS AGO?

Initial efforts to determine the causes of oyster larvae losses focused on the naturally occurring bacteria Vibrio coralliilyticus (initially misidentified at V. tubiashi). These bacteria thrive in the water conditions created by upwelling off the west coast of the USA. Filtration systems were designed and installed to eliminate the bacteria, however oyster larvae continued to die. In 2008, NOAA ocean acidification experts informed shellfish growers that the likely cause of the oyster larvae deaths was changing seawater chemistry resulting from the ocean absorbing anthropogenic carbon dioxide.

The ocean absorbs approximately 30 percent of all anthropogenic carbon dioxide emitted into the atmosphere. This results in the formation of carbonic acid, which reduces the ocean pH making it more acidic. Since the industry became aware that ocean acidification may be the cause of the hatchery issues, operators with the help of university scientists have identified the availability of carbonate ions as most critical. They are the building blocks for the oyster shells and carbon ion availability diminishes as the ocean acidifies.

The carbon dioxide from 250 years of burning fossil fuels has made the ocean surface waters more acidic and reduced the availability of carbonate ions by 16 percent. By the end of this century, scientists predict the acidity of the ocean surface waters will have increased by 100 percent to 150 percent and reduced carbonate ion availability by 50 percent. A more troubling message for shellfish growers from scientists is that water currently upwelling off the west coast is 30 to 50 years old. So even if carbon dioxide emissions were curtailed today, the waters along the Washington State coast will continue to become more acidic for decades because of the residual effects of the carbon dioxide already absorbed by the Pacific Ocean.

Shellfish growers have now come to understand through monitoring and research that natural factors associated with summer upwelling off the west coast can result in ocean chemistry conditions detrimental to the development and growth of oyster larvae. Research suggests these conditions occurred about 11 percent of the time prior to the industrial revolution. Corrosive events for oyster larvae are now happening an estimated 33 percent of the time and are more severe when they occur.

15 www.ipacoa.org
16 www.goa-on.org

Taylor Shellfish Farms has a second hatchery in the State of Hawaii that hasn't experienced the same ocean acidification related problems. As an additional adaption response to larval failures in the Washington State hatchery, the company has expanded production capacity at the hatchery in Hawaii. In 2012, another Washington State shellfish farming business, Goose Point Oyster Company started up a hatchery in Hawaii also in response to the west coast oyster seed shortage.

Currently, west coast shellfish growers have found a temporary solution to the impacts of ocean acidification by treating hatchery water to restore larval production. Juvenile and adult oysters on farms in the estuaries have not yet been visibly impacted. Growers expect under increasing ocean acidification that shellfish in the nurseries and on beds will eventually be impacted as well. Unlike in the hatcheries, there is no way to control the seawater chemistry over thousands of acres of beds in the ocean. To address this vulnerability the University of Washington and Oregon State University are working with shellfish growers to determine if selective breeding may yield oysters that can tolerate reduced levels of carbonate ions. Research is also underway to determine if culturing seaweed together with shellfish or culturing shellfish in or around seagrass beds may buffer acidic seawater and provide a refuge for the shellfish by naturally reducing carbon dioxide concentrations and increasing carbonate ion availability.

All these actions demonstrate measures that the shellfish industry is using to adapt to changing seawater chemistry.

WHAT CAN BE DONE TO IMPROVE THE ENVIRONMENT FOR THE SHELLFISH INDUSTRY?

The response from policymakers and scientists to date has been proactive and effective. Washington State Governor and the Legislature continue to fund the Marine Resources Advisory Council and the University of Washington's Ocean Acidification Center.

The science on ocean acidification is rapidly evolving and having a coordinated review and response by the Marine Resources Advisory Committee is critical. Efforts to expand this coordination throughout the west coast are underway and similar efforts are being undertaken on the east coast of the USA. Continued monitoring and the development of predictive models are also key for managing an adaptive industry.

It is important to remember the impacts of ocean acidification extend well beyond shellfish. They are just one of many calcifying organisms in the ocean likely being affected by changing ocean chemistry. In addition, scientists are finding other detrimental impacts beyond calcification. The governance, coordination and adaptation responses for the west coast shellfish industry[17] can be applied to other aquaculture ventures and fisheries that face similar climate change impacts.

[17] To learn more about Washington State's response to ocean acidification go to: http://www.ecy.wa.gov/water/marine/oceanacidification.html. To learn more about what individuals can do in response to ocean acidification go to: http://wsg.washington.edu/our-northwest/ocean-acidification/

Special Sessions

Gender as the missing link for improving climate change adaptation in fisheries and aquaculture

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ABSTRACT

The United Nations Framework Convention on Climate Change provides guidance on gender equality but this is poorly developed and often ignored in fisheries and aquaculture climate change adaptation. This omission arises because of weak national support generally for action on gender equality, a low priority accorded to it in fisheries and aquaculture, and a technical discourse on climate change in fisheries and aquaculture that appears to necessitate technical solutions. The present paper addresses gender equality in climate adaptation in the sector. It uses secondary sources and the authors' first-hand research experiences related to climate and other anthropogenic and natural disasters. Many of the studies were presented in the Asian Fisheries Society gender symposia and in "FishAdapt: the global conference on climate change adaptation for fisheries and aquaculture". Supplemental insights from forestry and land use were also used. The analyses found that existing social and fisheries sector norms constrain gender equality, resulting in low participation by women in formal and informal institutions, and restricting the ability to respond to climate change in gender-sensitive ways. Data weaknesses and a lack of knowledge of gender in the economy and society compound the problems. When gender is addressed, the rationale often is

women's vulnerability, but this downplays women's agency, and may exclude women from participating in consultations. Alternately, portraying women as "virtuous players" can overload them with additional adaptation responsibilities, unless current gender roles and relations in society are transformed.

Fisheries vulnerability assessments often ignore gender, potentially omitting key vulnerability issues and data on informal producers and workers in parts of the fish value chain where women dominate. In relevant vulnerability and other studies, a gender lens has exposed issues that were otherwise ignored, has permitted better targeting of interventions and has highlighted new intervention options. Gender-blind actions have risked exacerbating existing inequalities, e.g. in cash transfers. Because nearly half the fish value chain workers are women, their contributions are critical in sustaining household and national economies. Gender-sensitive research has also demonstrated the importance of diversified livelihoods in coping with disasters and declining resources.

Because the findings from vulnerability assessments are used to frame the agenda when developing national adaptation plans, as well as sectoral plans and adaptation projects, they should incorporate gender indicators and be used to inform gender-responsive budgets. The gender priorities need to go beyond simply a focus on women and recognize the complexity of gender roles and relations. To be able to integrate gender into their climate adaptation operations, fisheries and aquaculture institutions will need to be transformed, educate their staff in basic gender equality concepts, and employ gender experts and champions to provide fair solutions for women and men.

INTRODUCTION

Climate change can have impacts on aquatic ecosystems, and thus the communities that depend on fisheries and aquaculture for food security and poverty reduction are the most threatened (Monnereau *et al.*, 2017). In general, climate change adaptation provides a framework to address the negative impacts of climate change on ecosystems and people (both men and women). In the case of fisheries and aquaculture however, gender equity and equality principles as well as gender-sensitive approaches are missing in most undertakings on climate change adaptation, despite long-standing concerns that disasters tend to have differential impacts on women and men (Wiest *et al.*, 1994). Although not addressed in fisheries and aquaculture, these concerns are reflected in instruments of the United Nations Framework Convention on Climate Change (UNFCCC), such as the advice to developing countries to incorporate gender equality terminology when formulating national adaptation plans (UNFCCC, 2012).

Women make up nearly half the workforce in the fisheries and aquaculture value chain (FAO, 2016) but they and their work are under-recognized. Indeed, they are not perceived as important players by a public more familiar with masculine images of fishers. The actual number of women is underestimated in most statistics, especially because reports on the sector tend to focus only on the number of people directly engaged in fish production (10.7 million women representing 19 percent of 56.6 million workers), rather than on all those in the value chain where, according to 2014 estimates, nearly 50 percent are women (FAO, 2016). Also, the estimate of the number of workers in direct production does not include many women in non-formal work such as shellfish gatherers (Harper *et al.*, 2013; Kleiber *et al.*, 2015), others excluded by regulations from registering as professional fishers, and homestead-based fish farmers. In pre-harvest and post-harvest activities, women have traditionally dominated input supplies, processing and trading (Weeratunge *et al.*, 2010). This less visible work sharply raises the total proportion of women in fisheries to half the workforce but in most cases the focus is still on production rather than on the whole value chain. The production focus and the masculine culture that shape the discourse on fisheries development lead to few women participating in decision-making and relegates gender equality to a low order issue, including in the nexus between fisheries and climate change adaptation.

The discourse of climate change adaptation in fisheries and aquaculture is inherently technical, appearing to necessitate technical solutions. This leaves little room to incorporate gender and social issues and is compounded by the patriarchy inherent in societies. Fisheries and gender experts, however, observe progress, albeit slow, in getting gender into the fisheries agenda (Williams and Choo, 2014; Gopal *et al.*, 2016). In 2014, the Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries in the Context of Food Security and Poverty Eradication (FAO, 2015) became the first global fisheries policy to include a gender equality objective.

METHODS

The present study used evidence from secondary sources and the authors' own knowledge and experiences to examine how gender is considered (or ignored despite the prevailing guidance from formal higher-level instruments) in fisheries and aquaculture climate change adaptation, and the ways in which gender-sensitive action can support adaptation. These findings are supplemented by the lessons learned from forestry and land use sectors.

The first source was the UNFCCC guidance on gender for drafting the national adaptation plans of action (NAPA). The NAPA were directed to address urgent and immediate needs to adapt to climate change in the least developed countries (LDCs). Since 2010, UNFCCC guidance for adaptation planning has been through the long-term national adaptation plan (NAP) process for LDCs, and other developing countries in general. This source was used to gauge the extent to which the broader guidance on climate change adaptation supported or mandated taking gender into account.

The second source of material was selected fisheries and aquaculture vulnerability assessments for climate change adaptation. These were examined for the extent to which they incorporated gender analysis and used the findings to inform priority setting and project designs.

The third source was the research on gender in fisheries and aquaculture spanning more than 20 years that was presented in 11 Asian Fisheries Society (AFS) gender symposia. These research studies were used to gain an understanding of how gender is being addressed in conditions of resource distress and to determine the lessons learned. Reflecting the state of research on gender and climate change adaptation, these symposia contained few papers directly addressing climate change adaptation, and therefore studies on the following were also included: impacts and recovery efforts from natural and anthropogenic disasters, such as typhoons, the 2004 Indian Ocean tsunami, floods and the Philippine oil spill from the MT Solar I. These disasters had immediate and long-term impacts on people, and acted on a similar scale and in a similar manner as many effects of climate change. Emerging patterns from the data are discussed and analysed by the authors with experience in fisheries and supplemented by findings emerging from the forestry and the other land use sectors (Christie and Giri, 2011; WOCAN, UN-REDD and LEAF, 2013).

From the 11 women/gender in fisheries and aquaculture symposia held by the AFS from 1990 to 2016, 230 items were examined, comprising 172 published papers and 58 presentations from the most recent event, and relevant papers from the FishAdapt Conference. The AFS events are the only continuous series of women/gender events in the fisheries sector and reflect the state of research in the field. The articles covered work in all geographic regions, although with a preponderance of studies from Asia and the Pacific. Twenty relevant papers were found, the earliest of which was from 2007. From 2013, the AFS Global Symposia on Gender in Aquaculture and Fisheries (GAF) began holding thematic sessions, including on sectoral change and climate change, and the impacts of disasters, namely: Gendered Change (2013, GAF4), Climate Change and Natural Disasters (2014, GAF5), and Climate Change and Disaster Preparedness (2016, GAF6).

Despite the paucity of material on climate change and natural disasters from these symposia, they represent nearly 10 percent of the total number of published papers, indicating that funding for projects on climate change and disaster relief has provided significant opportunities for gender research.

RESULTS

Women in fisheries and aquaculture are not just climate victims but change agents

The counsel on the importance of taking account of gender in emergency relief arose at least 23 years ago when Wiest *et al.* (1994) chronicled the needs of women in disasters and emergencies. These authors underscored that nuanced and gender-sensitive approaches were important in disaster response and recovery. Today, with heightened and widespread risks brought about by anthropogenic climate change, evidence is still being gathered to strengthen the argument that environmental events have differential impacts on women and men, particularly those depending on natural resources. In general, research on the gender dimensions of climate change has developed more slowly than general social research on climate risks and adaptation (McGregor, 2010). In any sector, gender is treated belatedly, only addressed after other priorities. This is related to the masculine culture of the sectors of fisheries and aquaculture that gives little importance to gender equality.

Feminist critiques of climate change discourse have recently permeated academic and policy circles, including to some extent in fisheries and aquaculture, with women's vulnerability as the entry point or rallying cry. The arguments on the gender dimension of climate change have their strengths and weaknesses. They often focus on the fact that women and girls make up a disproportionate number of the poor or marginalized who are greatly affected by climate variability and/or they focus on women as virtuous and pro-environment (Arora-Jonsson, 2011).

When portrayed as passive victims of climate change, women are perceived as not being able to play an active role in policymaking. This can result in a lack of women's participation, lack of gender considerations in vulnerability and adaptive capacity assessments, and in gender-blind climate change mitigation and adaptation policies (Denton, 2002 and Shanthi *et al.*, 2016a). In coastal and inland aquatic systems, women are particularly invisible in management decision-making and during coastal emergencies standard institutional responses follow top-down militaristic traditions without regard for power differentials that leave certain groups marginalized (Badayos-Jover and Defiesta 2014). Proponents of the vulnerability argument call for positive discrimination approaches to remedy the status quo. The "virtue" argument highlights the agency of women as change agents and champions for climate change. Proponents posit that women, despite the complex climate problems, find ways to cope and find solutions. They call for tailored support that taps women's virtue and uses it as a force against the negative impacts of climate change.

Gender equality needs effective inclusion in global and national policy instruments

In the global policy instruments on climate change adaptation, gender equality was first mentioned in 2001 as one of the ten guiding elements of the national adaptation programmes of action (UNFCCC, 2001), but more specific guidance was slow to follow. In 2012, the UNFCCC included gender considerations in its primary technical guidelines for the NAP process (UNFCCC, 2012). These guidelines recommended that the NAPs should follow a country-driven, gender-sensitive, participatory and fully transparent approach, taking into account vulnerable groups, communities and ecosystems. The guidelines acknowledge women's historical disadvantages, their limited participation in decision-making and limited access to natural resources despite their dependency on these assets. The guidelines also provide advice on how to integrate gender perspectives into the NAP process: by focusing on the equal participation of women and men in decision-making, harnessing women's involvement in climate-sensitive work, including in fisheries, and in general in the implementation of adaptation activities.

Since 2015, the Green Climate Fund of the UNFCCC created a new incentive for incorporating gender by mandating a strong gender policy (Green Climate Fund Board, 2015). Despite this and the good intentions of the guidelines, constraints include weak national gender equality action, poor supporting structures and capacity, and strong underlying social norms that resist changes in established gender power relations. In the NAPs, the extent of integration needs to be evaluated using gender-sensitive indicators and gender-responsive budgeting.

In fisheries and aquaculture, climate change adaptation activities rarely integrate gender. Currently, climate change adaptation activities mainly focus on performing vulnerability assessments at national or local scales. Gender and gender analysis have been included in the FAO review of methodologies for fish sector vulnerability assessments, but in practice few vulnerability assessments address gender or women, e.g. only one of the six case studies in the FAO review (Brugère and De Young, 2015) does so. The one exception was the pilot study using participatory community level assessments in the Benguela Current Large Marine Ecosystem countries (Raemaekers and Sowman, 2015). The pilot study offered examples of how, in participatory processes, the vulnerability issues raised depended on which groups took part. For example, in Doringbaai, the Republic of South Africa, where women participated in stakeholder meetings, only they mentioned food security as a climate change impact, and they were markedly more concerned than men about drug and alcohol abuse, and unemployment.

In examining the vulnerability assessment ratings for small-island developing states (SIDS), Monnereau *et al.* (2017) found that the relative ratings depended critically on the choice of methods and data. Vulnerability assessments and project planning that ignore gender, therefore, may be flawed in their quantitative and qualitative outputs. For example, Monnereau *et al.* (2017) found vastly different national vulnerability scores depending on whether data for number of "fishers" were given as raw numbers or scaled by population size. They did not, however, also take into account how the estimates may have differed depending on the definition of "fishers." Were "fishers" only those engaged in primary production or those in the whole value chain? The total number of workers in the value chain, including estimates for informal fishers and secondary sector workers, would appear to be a more realistic indicator of a sector's importance, especially if also adjusted to produce a better estimate of the numbers in the informal economy.

To derive more accurate numbers for quantitative vulnerability assessments, and connect these to sensitivities to climate change requires knowledge of gendered patterns of work and how each type of work is exposed and sensitive to different climate change factors, for example, the availability of water and energy for drying fish. Sumagaysay (2016) pointed out the food-water-energy nexus confronting women fish dryers in Barangay Duljugan in Palompon, Leyte, the Republic of Philippines, detailing the water and energy needs of each stage of drying and how climate change affects the nexus, and ultimately the livelihoods and adaptation strategies that women have to undertake.

Lessons from 20 years of gender research in fisheries and aquaculture

From the 20 relevant papers presented in the gender in aquaculture and fisheries (GAF) symposia, and other selected literature, three key lessons have been learned: (1) a gender lens makes a difference; (2) gender-blind responses overlook adaptation potential; and (3) diversity and flexibility in livelihoods helps adaptation.

1. A gender lens makes a difference

Scholars working on the intersections of gender and fisheries use a gender lens to map out women's, men's, and young people's work, going beyond simple fish production to include value chains, gendered resource use and even gendered emotional responses to climate risks (e.g. Bagsit, 2014; Lebel and Lebel, 2016; Pedroza-Gutiérrez, 2016; Sumagaysay, 2016). In fisheries, the use of a gender lens allows a focus on issues that would otherwise be missed because of stereotypical assumptions (Williams, 2008).

Gender analysis also improves the targeting of beneficiaries (Defiesta and Badayos-Jover, 2014) and emphasizes the need to include women in various levels of decision-making, such as when determining criteria for paid work in rehabilitation (Badayos-Jover and Defiesta, 2014).

To enable women to articulate their needs in emergencies, researchers in the Republic of Philippines provided venues for women to express their agency. In an island-barangay (coastal village) in northern Iloilo in the aftermath of the 2013 Typhoon Yolanda (Haiyan), women requested disaster aid specifically for women, and separate from the usual fishing boats given by donors to male fishers (Badayos-Jover, 2016). The women's clamour highlighted the prevalent mismatch between community-defined needs and institutional interventions, something that could be averted if gender analyses were routinely employed in efforts to combat the effects of climate change in resource-driven communities.

Adaptation strategies must be based on the understanding of context specific vulnerabilities that vary across genders and phases of the disaster and recovery. In Typhoon Yolanda, for example, more men died, went missing or were injured than women, probably because many did not shelter in evacuation centres, preferring to try to save their homes and property. After a disaster, however, several studies in the Republic of Philippines have shown that many men left their households to search for jobs, leaving women to fend for the family and cope with the extensive damage to the houses and communities. Women have frequently risen on their own and developed coping strategies for dealing with these situations (Badayos-Jover and Defiesta, 2014; Defiesta and Badayos-Jover, 2014; Bagsit, 2014). A better understanding could have aided the women with better strategies and improved access to assistance to speed the recovery process.

Climate change adaptation plans should address the lack of access by women and men in fisheries to universal social protection schemes, which are already weak in the sectors of fisheries and aquaculture, and the development of targeted schemes that address specific vulnerabilities (Bene *et al.*, 2015). For example, in the Republic of Philippines during Typhoon Yolanda a lesson on the need for family planning services during emergencies was learned when couples in the evacuation centres requested pills and condoms. Subsequently, an Administrative Order was promulgated making family planning services (at a minimum, pills and condoms in evacuation centres) part of the disaster response.

At each stage of the fish value chain, women and men are vulnerable to risks associated with the type of activity in which they are engaged. During harvesting, fishing is a very dangerous occupation and fishers are vulnerable to storms and strong waves that lead to accidents and even loss of lives. When a fisher is injured or dies, the burden of raising the family falls on the wife or partner. For their part, women engage in gleaning and collecting shells, invertebrates and seaweed in intertidal and inshore areas, making them vulnerable to injuries, illness and changes caused by climate change. Women involved in smoking and drying fish are exposed to occupational illnesses which could be debilitating and shorten their lives. In marketing and distribution, women and men are exposed to the dangers of travel as they bring the fish from the landing site to the market.

Despite the risks, fishers frequently lack access to health services and social protection, for example, pensions, social insurance, and unemployment benefits that could help them and their families get by during times of illness, bad weather, and the death of a family member. Less visible fishing activities undertaken by women, such as gleaning, put them at a further disadvantage because they cannot get access to health insurance and retirement benefits that may otherwise be available to fishers and other recognized occupational groups.

The phenomenon of "sex for fish" is one example of complex fish value chain risks that could be increased by climate change. The impact of the high prevalence rate of HIV/AIDS in some fishing communities was first brought to the attention of the fisheries sector in the 2001 GAF Symposium (Williams *et al.*, 2002) and expanded on by Allison and Seeley (2004) and FAO (undated). Multiple risk factors include the fishers' mobility, risk-taking behaviour and use of alcohol and drugs, lack of access to health services, easy access to commercial sex in landing sites and the phenomenon of sex-for-fish (Béné and Merten, 2008), where a woman's access to fish is governed by her sexual relationship with male fishers. The literature on sex-for-fish points to at least three explanations: poverty and marginalization forcing women into coercive sexual relationships; their lack of negotiating power with male fishers and women's subordinate position in society; and women's agency whereby they knowingly use sexual favours to get access to fish that they need for their livelihoods. An additional factor is the deteriorating condition of fishing grounds, driving fishers to follow the fish and keeping them away from home for long periods, leading to new sexual relationships and disease risks (Mojola, 2011). This last is pertinent to the impact of climate change on fisheries, because lower abundance of fish and altered fish distribution patterns potentially also change relations in fishing communities. Any discussion therefore regarding climate change adaptation plans needs to use a gender lens to understand why the practice of sex-for-fish persists, and to address this.

2. Gender-blind approaches overlook adaptation potential

In recent decades in all economic sectors, women's participation in the labour market has increased, as has their participation as entrepreneurs and business owners. Currently women comprise 40 percent of the world labour force (World Bank, 2011). However, women are paid less and are more likely to engage in low-productivity activities and to work in the informal sector. If women were able to develop their full labour market potential, the macroeconomic gains would be significant (World Bank, 2011).

In gender-blind approaches, the role of women is commonly ignored or underestimated in the economy. Given the growing role of women in the economy as well as in other social sectors, the advantages that women's participation can have in climate change adaptation must be recognized. This is particularly critical in the fish sector where women make up nearly half the workforce but because of the informal nature of small-scale fisheries, they are overlooked, at times resulting in labour instability and work-based risks (Godoy, 2016).

Women and the community suffered doubly from gender-blind relief and rehabilitation after the 2006 Solar I oil spill in Guimaras, the Republic of Philippines. The rehabilitation efforts were publicly promoted as fair for families, but, in reality, women received a smaller share of cash and relief benefits despite the fact that their inshore fishing areas were more damaged for longer than those of the men (Defiesta and Badayos-Jover, 2014).

To avoid gender-blind action, appropriate tools are needed. In Tamil Nadu, the Republic of India, a new handbook was designed to undertake socio-economic and gender analysis (SEAGA) to assess the impact of environmental changes on coastal women (Shanthi *et al.*, 2016b). The handbook provides a gender-sensitive approach to climate adaptation and was based on experience gained from long-running practical studies to assist the Tamil Nadu women. Participatory Rural Appraisal (PRA) and SEAGA were used to study the impact of environmental changes on the livelihoods of women and men, the village environment, the village infrastructure and institutions, gender and social issues in fisheries and aquaculture (Shanthi *et al.*, 2016a).

FAO has prepared a handbook to support gender-equitable small-scale fisheries governance and development in the context of the Voluntary Guidelines for Securing the Sustainability of Small-scale Fisheries in the Context of Food Security and Poverty Alleviation (SSF Guidelines) (FAO, 2015). The SSF Guidelines are the first global instrument to include a gender equality objective as well as having a separate chapter addressing disaster risks and climate change.

Gender training is another instrument to sensitize planners and project developers. As a strategy, it should be part of the education system for students. One such example is the course on gender that the Central Institute for Fisheries Education (Indian Council of Agricultural Research), Mumbai, is delivering in its mainstream academic curriculum for fisheries students.

3. Diversification in livelihoods helps adaptation

Despite a lack of recognition, as in other economic sectors, women's work in fisheries and aquaculture is becoming more diverse and more important for the sustainability of these sectors, and as part of the adaptation and coping strategies in the face of climate change. Women's participation in the value chain is crucial in facing the new fisheries conditions created by climate change and scarcity. In capture fisheries, women target different species, and in the processing phase their work dominates value addition and product diversification. This is very important in designing new food and market approaches to face the new challenges. Administration and trading are other activities where women work, and which are also among the key elements that need to be addressed to diversify and keep the sector sustainable. For example, in Petatán on Lake Chapala in Mexico, declining water levels pose a threat to the fishery. Women have adapted by filleting low value tilapia and carp harvested there and from elsewhere, keeping the commercial fisheries afloat by adding value and making the fish marketable. They also earn reasonable incomes for themselves and their households (Predroza-Gutiérrez, 2016).

Flexible approaches to livelihood choices can help adaptation to climate change. In coastal districts of Tamil Nadu, South India, this has been well illustrated by studies and practical help to coastal women of the Irular tribal group given post-tsunami assistance (Shanthi *et al.*, 2016a). With the help of researchers from the Central Institute of Brackishwater Aquaculture (Indian Council of Agricultural Research) and women's self help groups, women learned and adopted a range of new livelihoods. These included rural government and private sector employment, small-scale aquaculture of crabs and sea bass, service industries such as fish feed manufacture, as well as continuing their previous fisheries labouring livelihoods that are mainly seasonal. With the new diversity of livelihoods, women achieved greater stability in income, and enhanced group savings that were reinvested in aquaculture. After the interventions, certain social taboos, including that women should not participate in meetings outside their villages, were overcome as some women travelled to market their crabs. The researchers also benefited from innovative ideas on the aquaculture trials, which then created a platform for other organizations such as state government departments, private entrepreneurs and NGOs to sustain the support.

DISCUSSION

The formal commitment to making climate change adaptation gender-sensitive was first mooted in 2001 in the global climate change adaptation policies[18]. Gender equality, however, only firmly entered the adaptation dialogue about ten years later and has yet to be fully embraced in planning and action. Existing social norms constrain gender equality action because most societies and institutions are patriarchal. The low participation of women in decision-making in both formal and informal structures has adverse implications on the ability to respond to climate change in gender-sensitive ways. The NAPs could be expected to struggle with incorporating gender equality principles and even participatory development processes may gloss over underlying gender biases. This situation is exacerbated by data weaknesses and a lack of knowledge of gendered patterns of economic and social roles. If women's vulnerability is the rationale for targeting women, then women's agency may be downplayed, along with their more complex individual and community needs. Women are then denied their voice and can be left out of consultations. Or, equally, if women are considered "virtuous actors", they can be overloaded with additional responsibilities in adaptation actions, unless current gender roles and relations are transformed.

Similar or greater challenges exist in fisheries and aquaculture, known for their masculine cultures and relatively recent attention to gender, e.g. 2015 SSF Guidelines. Despite the slow progress being made on "the long journey to gender equality" (Gopal *et al.*, 2016; Williams and Choo, 2014), a few encouraging steps have been taken specifically to make climate change adaptation activities more gender equal.

Progress is possible if gender analysis is applied in the vulnerability assessments now being used as the entry point for climate change adaptation action. A gender lens used in the design and conduct of the assessments would bring the whole value chain into focus, can highlight women's roles and risks associated with fisheries sectors, and may also strengthen the case for adaptation action. A gender lens changes a person's perspectives, and enables one to re-learn their discipline/sector, this time to include all the stakeholders and lead to policies that are gender-responsive. Using a clear gender lens when carrying out stakeholder analysis would ensure that nobody is left behind and would sharpen the focus on the similarities and differences in the vulnerabilities faced by women and men. These results can then be used to inform the planning processes for NAPs, including fisheries adaptation planning, further strengthening gender-integrated solutions for the fisheries sector and beyond.

For inclusiveness and gender sensitivity, however, tokenism should be avoided and women must not be portrayed in clichéd ways, e.g. using vulnerability/virtue theories. Qualitative social studies, based on well-considered theory must also be part of using a gender lens to gain a clearer perception of the issues, setting in motion the thinking process on the "whys" (Porter and Hapke, 2016). Fisheries and aquaculture can learn from good practices in forestry and other land use sectors that are more codified than in fisheries and aquaculture. These practices include ensuring women's representation and participation with legal mandates, skills building, gender-disaggregated analysis and planning to meet women's livelihoods needs, gender champions, women's networks, labour-saving and time-reducing technologies, equitable benefit sharing, and enterprise development opportunities (WOCAN, UN-REDD and LEAF, 2013).

Although the fisheries and aquaculture literature on climate change contains very few studies that focus on the gender implications of climate change, awareness is growing that the gender dimension is crucial in understanding issues and their impacts on communities and local economies (Gopal *et. al.*, 2016). As natural resource systems become more severely affected by climate change, the challenge remains to include the people experiencing the impacts of these changes and evolving adaptive strategies

[18] See UNFCCC Conference of Parties Decision FCCC/CP/2001/13/Add.4.

especially for fishing communities. The persistent use of gender-blind responses is dangerous for the sustainability of the sector, and restricts the possibilities of livelihoods opportunities for both women and men in fishing communities.

CONCLUSIONS AND FUTURE DIRECTIONS

Starting from the authors' knowledge of gender in fisheries and graduating to incorporating the gender dimensions in climate change adaptation discussions, this paper makes clear that in the fisheries and aquaculture sector gender is an important factor. However, limited studies and tools are currently available on gender and climate change. Now is the time to have wider discussions on how to ensure gender mainstreaming in climate change adaptation so as to set in motion a process to define the present "stocktaking" moment and begin to progress and enhance future climate action. In principle, gender could be integrated relatively easily into, for example, stakeholder and livelihoods analyses when new gender tools are developed and widely tested. However, planners have to be aware that equal participation in terms of numbers is not sufficient to address women's concerns. Gender expertise must be integral to projects and policymaking so that the practical and strategic needs of women and men are given due consideration. Gender-aware action will require transformed institutions capable of integrating gender into adaptation initiatives, and prepared to allocate a gender-responsive budget, and respond to indicators.

For more than 20 years the authors of the present paper have conducted women/gender in aquaculture and fisheries events within mainstream fisheries and aquaculture conferences. For a decade, the authors have encouraged researchers to integrate gender into climate change adaptation, and natural and anthropogenic disaster recovery. In a parallel world, experts such as those in the Global Partnership for Climate, Fisheries and Aquaculture (PACFA) working on climate change adaptation in fisheries and aquaculture have endeavoured to draw attention to the need for action. To date, they have focused mainly on biophysical changes and vulnerability assessments, including some socio-economic elements. The vulnerability assessments, with a few exceptions, are gender-blind, ignoring gender issues and lacking gender-disaggregated data. To make progress, those responsible for fisheries and aquaculture adaptation efforts must broaden their agendas to fully integrate gender, and not just through a focus on women but with a true recognition of the social complexity of gender. This also means that adaptation experts should be educated on basic gender concepts, preferably starting with their basic fisheries education, and priority should be given to employing gender experts rather than relying on hiring short-term gender consultants.

In addition to hiring gender experts in institutions, fisheries sector climate change adaptation and gender players need to identify, develop and empower gender champions in institutions and communities. Many of the champions will be women but men, equally, must be included. Grassroots women, the gender champions, and the experts could give voice to gender issues such as the shortcomings of gender-blind planning in national climate policies and agenda, the benefits of context-specific, gender inclusive disaster preparedness and recovery and focus on diversity in livelihood options.

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Charting a course after Paris: leveraging intended nationally determined contributions for action to address climate challenges for fisheries and aquaculture in the Asia-Pacific region

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ABSTRACT

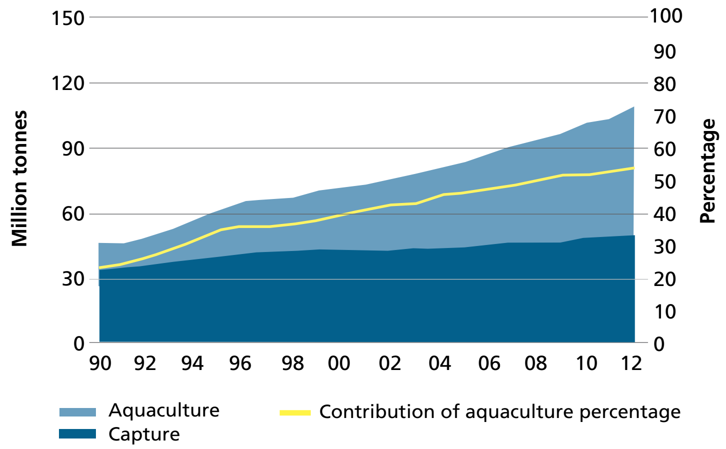
This paper aims to bring focus to the Asia-Pacific region and to how countries can address the priority actions for fisheries and aquaculture incorporated into their respective Intended Nationally Determined Contributions (INDC) under the Paris Agreement on climate change. The importance of the fisheries and aquacultures sectors in the region is significant in terms of food and nutrition security, trade, livelihoods and the economy, especially so for the large numbers of small-scale fishers and fish farmers. However, the fisheries and aquaculture sectors are generally not well represented in national climate change planning forums, and especially so in some countries where the sectors are important. Based on a review of country priorities for fisheries and aquaculture in the INDC from countries in the region and on associated planning documents, a number of key messages have been developed, including how to incorporate better these sectors into future national, regional and global actions so as to address climate change impacts and their drivers.

INTRODUCTION

Fisheries and aquaculture make a significant contribution to food and nutrition security and the livelihoods of millions of people in the Asia-Pacific region (FAO, 2016). There are about 48 million people (87 percent of the global total) engaged in fisheries and aquaculture production with an estimated 170 million directly and indirectly engaged in the value chain. More than 90 percent of the region's capture fishers are small-scale fishers. The amount of fish that people consume continues to rise and averaged more than 19 kg/capita per year in 2012. Women play a key role in the fisheries sector in the region. The key contributions the sector makes are to Gross Domestic Product (GDP), livelihoods, trade (the most traded commodity in the world), employment and food and nutrition security. The sector can also contribute to gender inclusiveness and poverty alleviation.

In the last 20 years, globally and regionally, capture fisheries production has levelled off with a concomitant increase in the number of fisheries and stocks classified as overexploited (FAO, 2016). The reasons for this include increased fishing effort, improved technology, increased trade, increased pollution and habitat modification. By contrast, aquaculture production continues to increase and by 2014 had exceeded that of capture fisheries in the Asia-Pacific region (Figure 1).

FIGURE 1
Fisheries and aquaculture production in Asia



Source: FAO (2016).

Ensuring sustainable fisheries and the sustainable development of aquaculture in the region will be a significant development challenge in the future. The impacts of climate change on fisheries and aquaculture production throughout the region are also expected to be significant (FAO, 2011a).

SUMMARY RESULTS OF THE REVIEW

The Paris Agreement between 196 Parties to the United Nations Framework Convention on Climate Change (UNFCCC) will act to limit the increase in global average temperature to below 2° C. This is a long-term commitment to balance emission sources and sinks from 2020 to 2025 and beyond. Implementation will be through INDC. Although the format and specific content of the initial INDC were left largely to countries to decide, these documents generally included priority areas for adaptation and climate resilience, policies or mechanisms to meet the mitigation and adaptation contributions, implementation requirements covering financial assistance, technology transfer and capacity-building.

A review of the INDC from Asia and the Pacific region and associated priority actions by sector reveals that agriculture (comprising crops, livestock, forestry, fisheries and aquaculture) is a key concern for countries in the region (Damen, 2017) and as many as 256 actions can be identified from INDC submitted by parties in the region (Figure 2).

Looking specifically at the fisheries sector, 12 priority actions were identified in INDC from eight countries in the region, the majority of which focused on adaptation in the fisheries sector more specifically (Figure 3). Proposed actions include employing stress-tolerant fish varieties, enhancing resilience to marine disasters, strengthening insurance schemes for fisherfolk and promoting adaptive aquaculture practices.

Other existing national planning processes to tackle climate change include National Adaptation Plans of Action (NAPA), National Adaptation Plans (NAPs) and Nationally Appropriate Mitigation Actions (NAMA), and are key pillars of INDC preparation and implementation. An assessment of how the fisheries and aquaculture sector were integrated into these instruments, particularly the NAPA,

FIGURE 2
Number of INDC actions identified for agriculture and land-use sectors in Asia-Pacific by sector

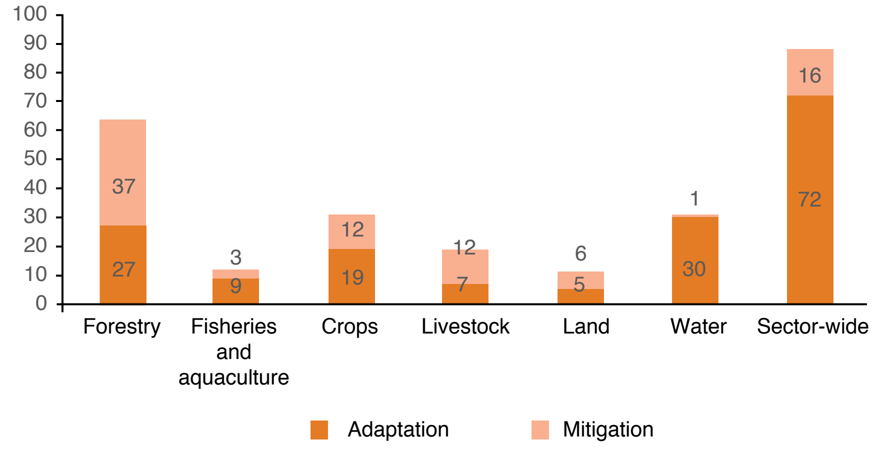
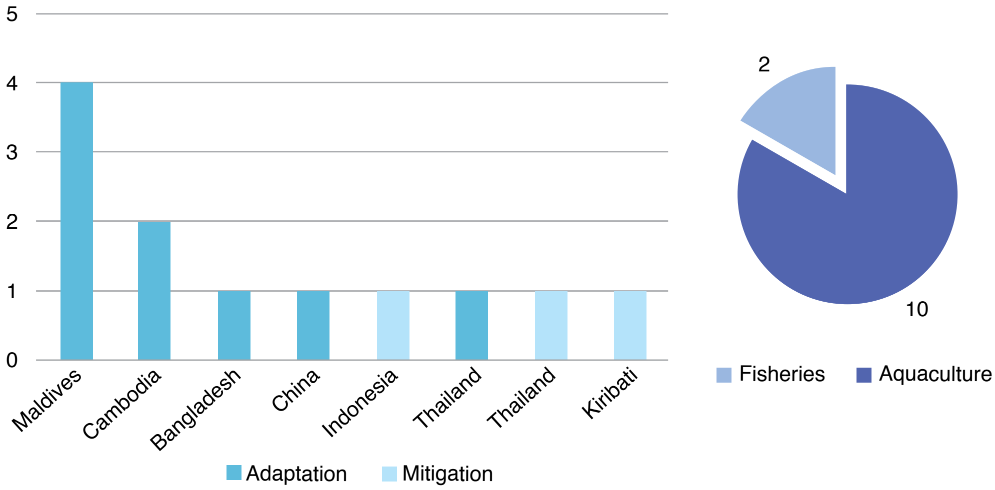


FIGURE 3
Number of fisheries and aquaculture specific INDC actions by country and activity focus

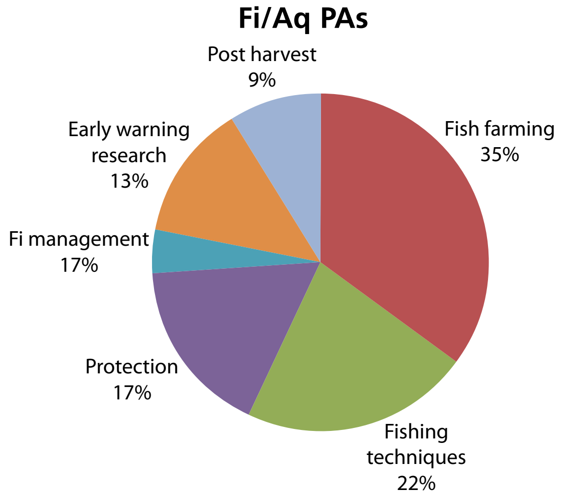


provides some indication of potential future challenges that lie ahead for these sectors and their integration into INDC planning and implementation. This analysis showed that despite the importance and vulnerability of the sector to climate change impacts in many countries, they were not well represented in these national plans (FAO, 2011b) (Figure 4). In addition, potential (negative) secondary impacts of many actions on the fisheries and aquaculture sector in the proposed NAPA were not fully identified (such as watershed management for irrigation, flood protection, mangrove replanting). Similarly, regional fisheries issues such as transboundary management of shared stocks were not considered.

Within the Asia-Pacific region, a range of actions are underway or planned by FAO and regional fisheries bodies including the Asia-Pacific Fisheries Commission (APFIC), the Southeast Asia Fisheries Development Center (SEAFDEC) and the Network of Aquaculture Centres in Asia (NACA).

FAO and APFIC have supported analyses of climate change related sector needs by countries in the past (FAO, 2011a) and a number of projects are underway to address these issues. Climate change has been identified as a major regional area of work for

FIGURE 4
Fisheries and aquaculture priorities in the examined NAPA



Source: FAO (2011b).

FAO. FAO is working with partners such as the Global Environment Facility (GEF) projects in the Republic of the Union of Myanmar and the Republic of Bangladesh, with more planned activities for the Democratic Republic of Timor Leste, the Kingdom of Cambodia and the Socialist Republic of Viet Nam. Broadly, these projects support capacity development, technical advice for policy and institutional development. Within the context of an Ecosystem Approach to Fisheries Management (EAFM) and an Ecosystem Approach to Aquaculture (EAA), climate change adaptation planning and implementation actions and monitoring at community and national level are being undertaken. FAO is also integrating climate change actions into regional programmes, such as the Bay of Bengal Large Marine Ecosystem programme (BOBLME).

SEAFDEC has 11 member countries, namely Brunei Darussalam, the Kingdom of Cambodia, the Republic of Indonesia, Japan, Lao People's Democratic Republic (PDR), Malaysia, the Republic of the Union of Myanmar, the Republic of Philippines, the Republic of Singapore, the Kingdom of Thailand, and the Socialist Republic of Viet Nam. It has a mandate to "develop and manage the fisheries potential of the region by rational utilization of the resources for providing food security and safety to the people and alleviating poverty through transfer of new technologies, research and information dissemination activities." As part of delivering this mandate, climate change resilience is addressed through integration into the SEAFDEC Program Framework. SEAFDEC have been carrying out a range of climate change adaptation and mitigation activities to support member countries. In particular, a project on "Optimizing energy use in fisheries in Southeast Asia" is ongoing.

The Network of Aquaculture Centres in Asia-Pacific (NACA) is an intergovernmental organization with 19 member governments, namely Australia, the Republic of Bangladesh, the Kingdom of Cambodia, the People's Republic of China, Hong Kong SAR (of China), the Republic of India, the Republic of Indonesia, Islamic Republic of Iran, Democratic People's Republic of Korea, the Lao People's Democratic Republic (PDR), Malaysia, the Republic of Maldives, the Republic of the Union of Myanmar, the Federal Democratic Republic of Nepal, the Islamic Republic of Pakistan, the Republic of Philippines, the Democratic Socialist Republic of Sri Lanka, the Kingdom of Thailand and the Socialist Republic of Viet Nam. Its mandate is to promote rural development through sustainable aquaculture and aquatic resource management and seeks to improve the livelihoods of rural people, reduce poverty and increase food security. The work programme structure of NACA includes thematic areas on aquatic animal health, sustainable farming systems, food safety, quality and certification, genetics and biodiversity and emerging global issues including responses to climate change. Three additional cross-cutting programmes facilitate and support implementation of the thematic work programmes, namely Education and Training, Gender, and Information and Communications.

In the past NACA has implemented specific projects related to climate, including one on strengthening adaptive capacities to the impacts of climate change (Aquaclimate Project). There has also been a workshop titled "Developing an environmental monitoring system to strengthen fisheries and aquaculture resilience and improve early warning in the Lower Mekong Basin" (Virapat *et al*., eds., 2017). Some of NACA's current activities and future work related to climate change adaptation and mitigation include:

- culture-based fisheries development in the Kingdom of Cambodia;
- adaptive learning in sustainable aquaculture (Best Practices for Small-Scale Shrimp Farmers in the Kingdom of Thailand);
- organization of the global conference on climate change adaptation within fisheries and aquaculture (FishAdapt);
- cooperation with the Bay of Bengal Large Marine Ecosystem programme (BOBLME);
- strategic network programme to promote smallholder farmers in aquaculture genetic improvement (National Broodstock Improvement Network);
- the installation of a monitoring and early warning system relevant to fisheries and aquaculture in the Lower Mekong Basin;
- regional training programme in aquaculture governance in the Asia-Pacific region;
- women, youth and aquaculture development programmes relevant to climate change adaptation and mitigation; and
- planting mangroves for integrated multiple benefits – a new paradigm.

CONCLUSIONS AND FUTURE DIRECTIONS

Climate change agreements are facilitating incremental progress toward global action on climate change with a move from differentiated to shared responsibilities. The role of agriculture, including fisheries and aquaculture, has been increasingly acknowledged in climate change agreements. The Paris Agreement is an important milestone that elevates the role that agriculture has in tackling climate challenges. The INDC provide a framework for action, which a number of countries in the region have used to identify specific actions for the fisheries and aquaculture sectors.

Enhanced engagement in INDC review and planning up to 2020 will be important to ensure the fisheries and aquaculture sectors' priorities are properly reflected. NAPA and other climate change planning processes are key pillars for planning and implementing INDC actions. Sub-sector engagement will be crucial for ensuring adaptation requirements are fully integrated.

In order for the fisheries and aquaculture sectors to contribute fully to INDC it is essential that they are able to participate fully in national planning processes. To do so they should strengthen coordination mechanisms to ensure participation of the sector in national planning to include and align with other national policies. Adoption of integrated/cross-sectoral approaches such as EAFM and EAA can help along with consideration of transboundary issues and management of shared stocks.

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Glossary

Definitions retrieved from the IPCC AR5 glossary (IPCC. 2014. *Climate change 2014: Impacts, adaptation, and vulnerability*. Intergovernmental Panel on Climate Change, Working Group II. **http://www.ipcc.ch/report/ar5/wg2/**)

Adaptation – the process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. In some natural systems, human intervention may facilitate adjustment to expected climate change and its effects.

Adaptive capacity – the ability of systems, institutions, humans and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences.

Adaptive management – A process of iteratively planning, implementing and modifying strategies for managing resources in the face of uncertainty and change. Adaptive management involves adjusting approaches in response to observations of their effect and changes in the system brought on by resulting feedback effects and other variables.

Autonomous adaptation – Adaptation in response to experienced climate and its effects, without planning explicitly or consciously focused on addressing climate change. Also referred to as spontaneous adaptation.

Biomass – The total mass of living organisms in a given area or volume; dead plant material can be included as dead biomass.

Capacity building – The practice of enhancing the strengths and attributes of, and resources available to, an individual, community, society or organization to respond to change.

Carbon dioxide (CO_2) – A naturally occurring gas, also a by-product of burning fossil fuels from fossil carbon deposits, such as oil, gas and coal, of burning biomass, of land use changes, and of industrial processes (e.g. cement production). It is the principal anthropogenic greenhouse gas that affects the Earth’s radiative balance. It is the reference gas against which other greenhouse gases are measured and therefore has a Global Warming Potential of 1.

Climate change – Climate change refers to a change in the state of the climate that can be identified (e.g. by using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcing such as modulations of the solar cycles, volcanic eruptions and persistent anthropogenic changes in the composition of the atmosphere or in land use.

Climate variability – Climate variability refers to variations in the mean state and other statistics (such as standard deviations, the occurrence of extremes, etc.) of the climate on all spatial and temporal scales beyond that of individual weather events. Variability may be due to natural internal processes within the climate system (internal variability), or to variations in natural or anthropogenic external forcing (external variability). See also Climate change.

Climatic driver (Climate driver) – A changing aspect of the climate system that influences a component of a human or natural system.

Community-based adaptation – Local, community-driven adaptation. Community-based adaptation focuses attention on empowering and promoting the adaptive capacity of communities. It is an approach that takes context, culture, knowledge, agency and preferences of communities as strengths.

Contextual vulnerability (Starting-point vulnerability) **–** A present inability to cope with external pressures or changes, such as changing climate conditions. Contextual vulnerability is a characteristic of social and ecological systems generated by multiple factors and processes.

Convection – Vertical motion driven by buoyancy forces arising from static instability, usually caused by near-surface cooling or increases in salinity in the case of the ocean and near-surface warming or cloud-top radiative cooling in the case of the atmosphere. In the atmosphere, convection gives rise to cumulus clouds and precipitation and is effective at both scavenging and vertically transporting chemical species. In the ocean, convection can carry surface waters to deep within the ocean.

Coral bleaching – Loss of coral pigmentation through the loss of intracellular symbiotic algae (known as zooxanthellae) and/or loss of their pigments.

Dead zones – Extremely hypoxic (i.e. low-oxygen) areas in oceans and lakes, caused by excessive nutrient input from human activities coupled with other factors that deplete the oxygen required to support many marine organisms in bottom and near-bottom water.

Disaster management – Social processes for designing, implementing, and evaluating strategies, policies, and measures that promote and improve disaster preparedness, response, and recovery practices at different organizational and societal levels.

Ecosystem approach – A strategy for the integrated management of land, water, and living resources that promotes conservation and sustainable use in an equitable way. An ecosystem approach is based on the application of scientific methodologies focused on levels of biological organization, which encompass the essential structure, processes, functions, and interactions of organisms and their environment. It recognizes that humans, with their cultural diversity, are an integral component of many ecosystems. The ecosystem approach requires adaptive management to deal with the complex and dynamic nature of ecosystems and the absence of complete knowledge or understanding of their functioning. Priority targets are conservation of biodiversity and of the ecosystem structure and functioning, in order to maintain ecosystem services.

Ecosystem-based adaptation – The use of biodiversity and ecosystem services as part of an overall adaptation strategy to help people to adapt to the adverse effects of climate change. Ecosystem-based adaptation uses the range of opportunities for the sustainable management, conservation and restoration of ecosystems to provide services that enable people to adapt to the impacts of climate change. It aims to maintain and increase the resilience and reduce the vulnerability of ecosystems and people in the face of the adverse effects of climate change. Ecosystem-based adaptation is most appropriately integrated into broader adaptation and development strategies.

El Niño-Southern Oscillation (ENSO) – The term El Niño was initially used to describe a warm-water current that periodically flows along the coast of Ecuador and Peru, disrupting the local fishery. It has since become identified with a basin-wide warming of the tropical Pacific Ocean east of the dateline. This oceanic event is associated with a fluctuation of a global-scale tropical and subtropical surface pressure pattern called the Southern Oscillation. This coupled atmosphere-ocean phenomenon, with preferred time scales of two to about seven years, is known as the El Niño-Southern Oscillation. It is often measured by the surface pressure anomaly difference between Tahiti and Darwin or the sea surface temperatures in the central and eastern equatorial Pacific. During an ENSO event, the prevailing trade winds weaken, reducing upwelling and altering ocean currents such that the sea surface temperatures warm, further weakening the trade winds. This event has a great impact on the wind, sea surface temperature, and precipitation patterns in the tropical Pacific. It has climatic effects throughout the Pacific region and in many other parts of the world, through global teleconnections. The cold phase of ENSO is called La Niña.

Eutrophication – Over-enrichment of water by nutrients such as nitrogen and phosphorus. It is one of the leading causes of water quality impairment. The two most acute symptoms of eutrophication are hypoxia (or oxygen depletion) and harmful algal blooms. See also Dead zones.

Extreme weather event – An extreme weather event is an event that is rare at a particular place and time of year. Definitions of rare vary, but an extreme weather event would normally be as rare as, or rarer than, the 10th or 90th percentile of a probability density function estimated from observations. By definition, the characteristics of what is called extreme weather may vary from place to place in an absolute sense. When a pattern of extreme weather persists for some time, such as a season, it may be classed as an extreme climate event, especially if it yields an average or total that is itself extreme (e.g. drought or heavy rainfall over a season).

Food security – A state that prevails when people have secure access to sufficient amounts of safe and nutritious food for normal growth, development, and an active and healthy life.

Flood – The overflowing of the normal confines of a stream or other body of water, or the accumulation of water over areas not normally submerged. Floods include river (fluvial) floods, flash floods, urban floods, pluvial floods, sewer floods, coastal floods, and glacial lake outburst floods.

Greenhouse gas (GHG) – Greenhouse gases are those gaseous constituents of the atmosphere, both natural and anthropogenic, that absorb and emit radiation at specific wavelengths within the spectrum of terrestrial radiation emitted by the Earth's surface, the atmosphere itself, and clouds. This property causes the greenhouse effect. Water vapor (H2O), carbon dioxide (CO2), nitrous oxide (N2O), methane (CH4), and ozone (O3) are the primary greenhouse gases in the Earth's atmosphere. Moreover, there are a number of entirely human-made greenhouse gases in the atmosphere, such as the halocarbons and other chlorine- and bromine-containing substances, dealt with under the Montreal Protocol. Beside CO2, N2O, and CH4, the Kyoto Protocol deals with the greenhouse gases sulfur hexafluoride (SF6), hydrofluorocarbons (HFCs), and perfluorocarbons (PFCs).

Hypoxic events – Events that lead to deficiencies of oxygen in water bodies. See also Dead zones and Eutrophication.

Ocean acidification – Ocean acidification refers to a reduction in the pH of the ocean over an extended period, typically decades or longer, which is caused primarily by uptake of carbon dioxide from the atmosphere, but can also be caused by other chemical additions or subtractions from the ocean.

Outcome vulnerability (End-point vulnerability) – Vulnerability as the end point of a sequence of analyses beginning with projections of future emission trends, moving on to the development of climate scenarios, and concluding with biophysical impact studies and the identification of adaptive options. Any residual consequences that remain after adaptation has taken place define the levels of vulnerability.

Oxygen Minimum Zone (OMZ) – The midwater layer (200 to 1000 m) in the open ocean in which oxygen saturation is the lowest in the ocean. The degree of oxygen depletion depends on the largely bacterial consumption of organic matter, and the distribution of the OMZs is influenced by large-scale ocean circulation. In coastal oceans, OMZs extend to the shelves and may also affect benthic ecosystems.

Resilience – The capacity of social, economic, and environmental systems to cope with a hazardous event or trend or disturbance, responding or reorganizing in ways that maintain their essential function, identity, and structure, while also maintaining the capacity for adaptation, learning, and transformation

Risk – The potential for consequences where something of value is at stake and where the outcome is uncertain, recognizing the diversity of values. Risk is often represented as probability of occurrence of hazardous events or trends multiplied by the impacts if these events or trends occur. Risk results from the interaction of vulnerability, exposure, and hazard.

Salt-water intrusion/encroachment – Displacement of fresh surface water or groundwater by the advance of salt water due to its greater density. This usually occurs in coastal and estuarine areas due to decreasing land-based influence (e.g. from reduced runoff or groundwater recharge, or from excessive water withdrawals from aquifers) or increasing marine influence (e.g. relative sea level rise).

Sea level change – Sea level can change, both globally and locally due to (1) changes in the shape of the ocean basins; (2) a change in ocean volume as a result of a change in the mass of water in the ocean; and (3) changes in ocean volume as a result of changes in ocean water density. Global mean sea level change resulting from change in the mass of the ocean is called barystatic. The amount of barystatic sea level change due to the addition or removal of a mass of water is called its sea level equivalent. Sea level changes, both globally and locally, resulting from changes in water density are called steric. Density changes induced by temperature changes only are called thermosteric, while density changes induced by salinity changes are called halosteric. Barystatic and steric sea level changes do not include the effect of changes in the shape of ocean basins induced by the change in the ocean mass and its distribution.

Sea Surface Temperature (SST) – The sea surface temperature is the subsurface bulk temperature in the top few meters of the ocean, measured by ships, buoys, and drifters. From ships, measurements of water samples in buckets were mostly switched in the 1940s to samples from engine intake water. Satellite measurements of skin temperature (uppermost layer; a fraction of a millimeter thick) in the infrared or the top centimeter or so in the microwave are also used, but must be adjusted to be compatible with the bulk temperature.

Sensitivity – The degree to which a system or species is affected, either adversely or beneficially, by climate variability or change. The effect may be direct (e.g. a change in crop yield in response to a change in the mean, range or variability of temperature) or indirect (e.g. damages caused by an increase in the frequency of coastal flooding due to sea level rise).

Storm surge – The temporary increase, at a particular locality, in the height of the sea due to extreme meteorological conditions (low atmospheric pressure and/or strong winds). The storm surge is defined as being the excess above the level expected from the tidal variation alone at that time and place.

Thermal expansion – In connection with sea level, this refers to the increase in volume (and decrease in density) that results from warming water. A warming of the ocean leads to an expansion of the ocean volume and hence an increase in sea level.

Thermocline – The layer of maximum vertical temperature gradient in the ocean, lying between the surface ocean and the abyssal ocean. In subtropical regions, its source waters are typically surface waters at higher latitudes that have subducted and moved equatorward. At high latitudes, it is sometimes absent, replaced by a halocline, which is a layer of maximum vertical salinity gradient.

Upwelling region – A region of an ocean where cold, typically nutrient-rich waters well up from the deep ocean.

Vulnerability – The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements, including sensitivity or susceptibility to harm and lack of capacity to cope and adapt.

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ANNEX 3

FishAdapt Conference programme and presentations

Note: presentations are reproduced as submitted (Presentation titles in blue are hyperlinked to internet).

Sunday 7 August 2016	
15.00 – 18.00	**Registration**

Monday 8 August 2016	
8.00 – 9.00	**Registration**
9.00 – 9.45	**Opening ceremony** • Welcome address by Director General, Thailand Department of Fisheries • Welcome address by Dr Cherdsak Virapat, Director General, NACA • Welcome address by Assistant Director General, FAO
9.45 – 10.15	**Group photo and coffee break**
10.15 – 11.45	**Invited speakers** • **Scaling up adaptation action from the local to the national, regional and global level through national adaptation plans** *Paul Desanker* • **Impacts of ocean acidification on United States west coast shellfish aquaculture** *Bill Dewey*
11.45 – 12.45	**Presentations Theme 1: Vulnerability assessments** • **Vulnerability assessments in fisheries social-ecological systems: some experiences in their development and implementation for adaptation planning** *Cassandra De Young* • **The impact of methodological choices on the outcome of national-level climate change vulnerability assessments: an example from the global fisheries sector** *Iris Monnereau* • **Potential vulnerability of artisanal fisheries to ocean acidification in the Western Indian Ocean** *Kennedy Osuka* • **Mapping climate change vulnerability in fisheries sector of Bangladesh using composite index approach and GIS** *Md Monirul Islam*
12.45 – 13.45	**Lunch**
13.45 – 14.45	**Invited speakers** • **The gender dimension in climate change adaptation: gleanings from 20 years of gender in aquaculture and fisheries symposia** *Meryl Williams* • **Impacts on and adaptations to climate change in the fisheries communities of the Lake Chad Basin** *Solomon Ovie*

14.45 – 16.00	**Presentations theme 1 (continued): Vulnerability assessments** • **Livelihood vulnerabilities of fishing households in the Volta Basin, Ghana** *Francis Amevenku* • **Are climate change impacts the cause of reduced fisheries production on the African Great Lakes? The Lake Tanganyika case study** *Martin Van der Knaap* • **Teasing out the impacts of climate change on fisheries in the Lower Mekong Basin** *Ian Cowx* • **Potential effects of climate change in reservoir fisheries: a gender analysis** *Arpita Shama*
16.00 – 16.30	**Coffee break**
16.30 – 18.00	**Presentations theme 1 (continued): Vulnerability assessments** • **Socio-economic impacts of sargassum on the fishery sector of Barbados** *Neema Ramlogan* • **Climate change implications for Torres Strait island fisheries: assessing vulnerability to inform adaptation** *David J. Welch* • **Climate change impacts on livelihood vulnerability assessment-adaptation and mitigation options in marine hot spots in Kerala, India** *Shyam Salim* • **Climate change and vulnerability of fishing communities** *Sibananda Senapati* • **Climate change perception in a fishers' community from southern Brazil: traditional ecological knowledge and meteorological time-series data** *Marcio Cure*
18.30 – 21.00	**Welcome dinner**

Tuesday 9 August 2016	
8.45 – 9.00	**Reconvene**
9.00 – 10.00	**Invited speakers** • **Effects of climate change on the world's oceans: footprints to adaptation in fisheries food production and security** *Maria Gasalla*
10.00 – 10.30	**Coffee break**
10.30 – 12.00	**Presentations theme 2: Adaptation** • **Adapting to climate change in fisheries management in Micronesia** *Michael Guilbeaux* • **Promoting behavioural change for territorial user rights for fisheries implementation as climate change adaptation strategy** *Endang Hidayat* • **Building fishing community's resilience to climate change through a social marketing drive** *Susan Cataylo* • **Conservation organizations need to consider adaptive capacity: why local input matters** *Brian Szuster* • **Adaptation strategies to climate change in marine systems** *William Cheung*
12.00 – 13.00	**Lunch**

13.00 – 14.00	**Invited speakers** • **Key factors governing the potential for adaptation of artisanal fisheries to climate change in the La Plata River basin** *Claudio Baigun* • **Adaptation strategies of the aquaculture sector to the impacts of climate change** *Doris Soto*
14.00 – 15.30	**Presentations theme 2 (continued): Adaptation** • **Genetics programmes that can help rural aquaculture communities cope with climate change** *Roger Doyle* • **Kole fish culture: an alternate option for climate change adaptation to support livelihood of fishers in drought prone northwest Bangladesh** *Md. Amimul Ehshan* • **Climate change adaptation efforts in coastal shrimp aquaculture: case from north-western Sri Lanka** *Eranga Galappaththi* • **Aquatic farming systems will require a range of diverse adaptations to combat and mitigate climate change impacts: case studies from Asia** *Sena De Silva* • **Experiences in building climate change resilience in fisheries and aquaculture sector through international and domestic funding mechanism in India** *K. Palanisamy*
15.30 – 16.00	**Coffee break**
16.00 – 17.30	**Presentations theme 2 (continued): Adaptation** • **Development of sustainable rice-shrimp farming in coastal communities in the Mekong River Delta, Viet Nam** *Chinh Ngo* • **Integrated shrimp aquaculture for climate change adaptation** *Munir Ahmed* • **Aquaculture insurance as an adaptation strategy: experiences from China and Viet Nam** *Tipparat Pongthanapanich* • **Adaptation strategies for climate change impacts of major aquaculture systems in the Philippines** *Rafael Guerrero* • **Local environmental monitoring systems to strengthen fisheries and aquaculture resilience to climate change** *Doris Soto*

Wednesday 10 August 2016	
8.45-9.00	**Reconvene**
9.00 – 10.00	**Invited speakers** • **Pacific small island developing states: climate change vulnerability and adaptation of fisheries and aquaculture** *Johanna Johnson* • **Considering climate and disasters in Caribbean fisheries and aquaculture management planning** *Patrick McConney*
10.00 – 11.20	**Presentations theme 2 (continued): Adaption** • **Capacity development of stakeholders to integrate fisheries and aquaculture in emergency response and preparedness** *Gopal Krishna* • **Embracing the value chain framework for post-disaster livelihood interventions: the milkfish industry in a Haiyan-affected area in Leyte, Philippines** *Marieta Sumagaysay* • **Co-managing disaster risk: spending, legislation, and the non-government organizations in agricultural and fishing communities in central Philippines** *Rhea Subong* • **Adaptation of fishermen in the Philippines to climate change** *Maria Rebecca Campos* • **Climate change and variability adaptation effort in fishing and aquaculture in the Central American Integration System participating countries** *Jorge López*
11.20 – 11.40	**Coffee break**
11.40 – 12.40	**Presentations theme 2 (continued): Adaptation** • **Lake Chapala's fisheries: coping and adapting to water level fluctuations** *Carmen Pedroza-Gutierrez* • **Local skill and indigenous knowledge in building socio-ecological resilience to climate change with particular reference to aquatic resource utilization in north eastern India** *Shaikhom Singh* • **Empowering climate change adaptation-driven innovation in Brazilian fishing communities through science-based support** *Maria Gasalla* • **Climate change initiatives for fishing communities in Indian Sundarbans by non-government organizations** *Amitava Ghosh*
12.40 – 13.40	**Lunch**
13.40 – 14.40	**Invited speakers** • **Does climate change need behaviour change? A behavioural approach to communication and building community resilience** *Gerald Miles* • **Communicating ocean acidification where it impacts the most, and where communication is hardest** *Julia Sanders* • Brief introductions to special sessions *Special Session Chairs*
14.40 – 15.00	**Coffee break**

15.00 – 17.00	**Special sessions (parallel, please see detailed schedule on following page)** • **Climate change in small-scale fisheries: vulnerability, adaptive capacity and responses** • **Integrating gender considerations into climate change and disaster risk reduction strategies for fishing communities** • **Mangrove-based fisheries and aquaculture in support of climate change adaptation** • **Preparing for climate change in European fisheries and aquaculture: lessons learned and transferability to the global context** • **Charting a course after Paris: leveraging NDCs for action to address climate challenges for fisheries and aquaculture in the Asia-Pacific region**
17.00 – 17.50	**Feedback from the special sessions**
17.50 – 18.30	**Wrap up presentation and closure of the conference by FAO Representative**

Parallel sessions schedule
Wednesday 10 August

Climate change in small-scale fisheries: vulnerability, adaptive capacity and responses	
15.00 – 17.00	• **Climate change in small-scale fisheries: vulnerability, adaptive capacity and responses** *Ratana Chuenpagdee* • **Adaptive capacity in small-scale fisheries: role of resilience and fisher knowledge** *Fikret Berkes* • **Bringing gender dimension into the debate about ocean and climate change** *Katia Frangoudes* • **I-ADApT: A tool for coastal communities to respond to global environmental and food security challenges in Africa** *Moenieba Isaacs* • **Vulnerability of coastal fishers to disasters in Bangladesh** *Mahmud Islam* • **Can FAO Small-scale Fisheries Guidelines (2015) promote better community-based adaptation to rapid environmental change?** *Prateep Kumar Nayak*
Integrating gender considerations into climate change and disaster risk reduction strategies for fishing communities	
15.00 - 17.00	• **Keynote address: How do we get gender into the agenda? Lessons from other sectors** *Kalpana Giri* • **Panel discussion** *Nisha Onta* *Arpita Sharma* *Carmen Pedroza* *Susana Siar* • **Q&A** • **Key messages and concluding remarks** *Marieta Sumagaysay*

Charting a course after Paris: leveraging NDCs for action to address climate challenges for fisheries and aquaculture in the Asia-Pacific region	
15.00 – 17.00	• **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* • **Optimizing energy use in fisheries in Southeast Asia** **Bundit Chokesanguan** • **NACA initiatives on addressing climate change in aquaculture and fisheries** Cherdsak Virapat • **Facilitated discussion on next steps to support national climate change planning processes**
Mangrove-based fisheries and aquaculture in support of climate change adaptation	
15.00 - 17.00	• **The concept of mixed fish-mangrove forest farming system for poverty alleviation and mangrove restoration: an experience from the Sunderbans** *Madhumita Mukherjee* • **Vulnerability of Munroe Island, Kerala, India to the sea level rise: current concerns and thoughts for the sustainable future** *K.N. Balagopal* • **Mangroves – climate change – industry perspectives** *Roy D. Palmer* • **Exploring the impacts of future global change on mangrove-fishery-community linkages** *R. Seary* • **Species diversification in the mangrove-based ecosystem of Kannur District of Kerala, India** *Geeji M.T.* • **Mangrove conservation: a source of sustainability and sustenance in Australia** *Roy D. Palmer* • **On mangroves and mangrove associates of Puthuvypin of Ernakulam District, Kerala (South India)** *Sahadevan P.*
Preparing for climate change in European fisheries and aquaculture: lessons learned and transferability to the global context	
15.00 – 17.00	• **Preparing for sustainable fish production in Europe under climate change** *M. Aschan* • **CERES – Climate change and European aquatic resources** *Ian Cowx, Myron Peck, Mike Elliott* • **Decision support for seafood production under climate change** *P. Olsen* **Discussion session: Preparing support for good decisions when adapting to climate change. exchange of experience and identification of future needs**

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Proceedings of FishAdapt: the Global Conference on Climate Change Adaptation for Fisheries and Aquaculture

8–10 August 2016
Bangkok, Thailand

Climate variability and change are affecting hydro-meteorological cycles and altering aquatic ecosystems, driving shifts in physical and chemical processes, ecological communities and the distribution and abundance of species. These changes have implications for fisheries management, food security and the livelihoods of more than 600 million people worldwide that are employed in fisheries and aquaculture, their value chains and related industries.

This conference, *FishAdapt: the global conference on climate change adaptation for fisheries and aquaculture*, held in Bangkok from 8 to 10 August, 2016, provided a forum for scientists, development professionals and natural resource managers working in the context of fisheries, aquaculture, rural development and related fields to share practical experiences in understanding the vulnerabilities associated with climate change and ocean acidification and the development of risk management and adaptation strategies. The conference bridged interdisciplinary gaps and provide a wider, shared perspective on the issues and the current state of knowledge. These proceedings share the experiences of the 110 participants from 27 countries and show that much can be done at the household, community and sector levels to support the resilience of the sector and its dependent communities in a changing climate.

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