# PREPARING FOR CLIMATE CHANGE ON MARINE SYSTEMS IN AUSTRALIA AND INDIA

## STRATEGIC RESEARCH PLAN

## SUMMARY

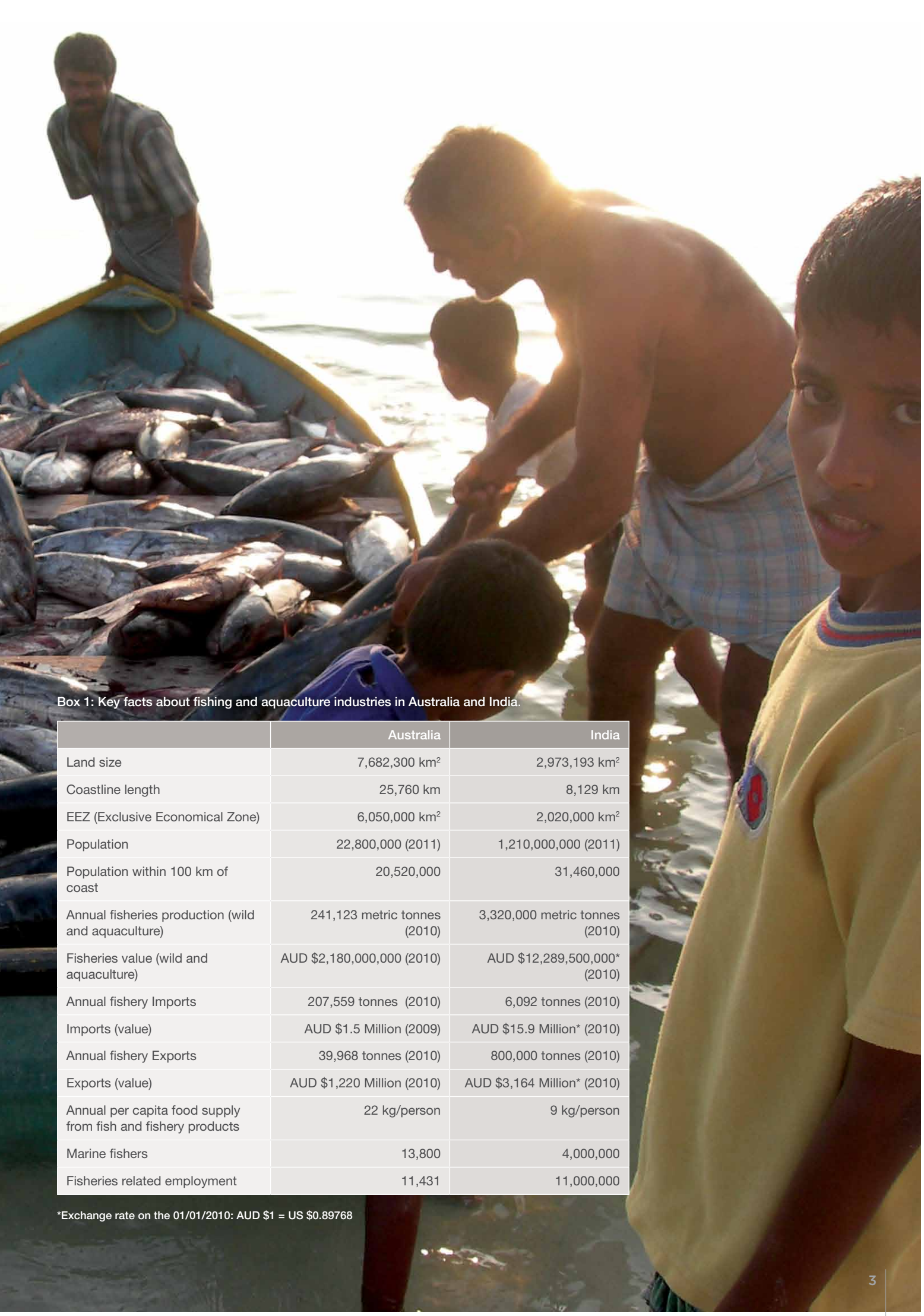
Australia and India have coastal marine waters warming at a rate faster than 90% of the world's oceans. Both countries have extensive coastlines and marine jurisdictions with the majority of the population living adjacent to the coast (Box 1).

Marine industries play important roles in sustaining the livelihoods of people in coastal rural towns. Increasing food production, minimising carbon emissions and prioritising carbon sequestration opportunities are key issues facing both countries and form the basis of this research plan.

In addressing these issues India and Australia are well placed to become leaders in the development of adaptation options, and pioneers of transformational industries.

Please cite this report as:

Frusher S., Syda Rao G., Haward M., Hobday A., Holbrook N., Jennings S., Vivekanandan E., Menon M., Nursey-Bray M., Pecl G., Radhakrishnan E., Ramachandran C., Shyam S.S., Sathianandan T.V., van Putten I. (2012). **Preparing for climate change on marine systems in Australia and India.** Report to the Australia-India Strategic Research Fund, Department of Industry, Innovation, Science, Research and Tertiary Education, Australia.



**Box 1: Key facts about fishing and aquaculture industries in Australia and India.**

| | Australia | India |
|---|---|---|
| Land size | 7,682,300 km$^2$ | 2,973,193 km$^2$ |
| Coastline length | 25,760 km | 8,129 km |
| EEZ (Exclusive Economical Zone) | 6,050,000 km$^2$ | 2,020,000 km$^2$ |
| Population | 22,800,000 (2011) | 1,210,000,000 (2011) |
| Population within 100 km of coast | 20,520,000 | 31,460,000 |
| Annual fisheries production (wild and aquaculture) | 241,123 metric tonnes (2010) | 3,320,000 metric tonnes (2010) |
| Fisheries value (wild and aquaculture) | AUD $2,180,000,000 (2010) | AUD $12,289,500,000* (2010) |
| Annual fishery Imports | 207,559 tonnes (2010) | 6,092 tonnes (2010) |
| Imports (value) | AUD $1.5 Million (2009) | AUD $15.9 Million* (2010) |
| Annual fishery Exports | 39,968 tonnes (2010) | 800,000 tonnes (2010) |
| Exports (value) | AUD $1,220 Million (2010) | AUD $3,164 Million* (2010) |
| Annual per capita food supply from fish and fishery products | 22 kg/person | 9 kg/person |
| Marine fishers | 13,800 | 4,000,000 |
| Fisheries related employment | 11,431 | 11,000,000 |

*Exchange rate on the 01/01/2010: AUD $1 = US $0.89768

## VISION

Resilient and sustainable communities and marine systems that can adapt to the challenges of, and capture the opportunities afforded by, a changing climate

## MISSION

To develop the capacity and knowledge base that enables coastal communities, fisheries and mariculture sectors, to strategically and positively respond to climate change

## OBJECTIVES

- To develop adaptation options through innovative and novel projects that enable fisher communities and industries to take advantage of the opportunities that climate change offers
- To ensure that developments maintain ecosystem integrity and, given uncertainty about future changes, operate under a precautionary approach
- To take advantage of the multi-disciplinary researcher capability and experience and our locations within the fastest warming regions globally to facilitate the uptake of new opportunities
- To facilitate global learning and knowledge exchange that enhances uptake and implementation of adaptation solutions
- To develop tools for predicting, evaluating and monitoring climate change impacts and adaptation on socio-ecological marine systems
- To build capacity and the “next generation” of interdisciplinary researchers to address future climate change challenges

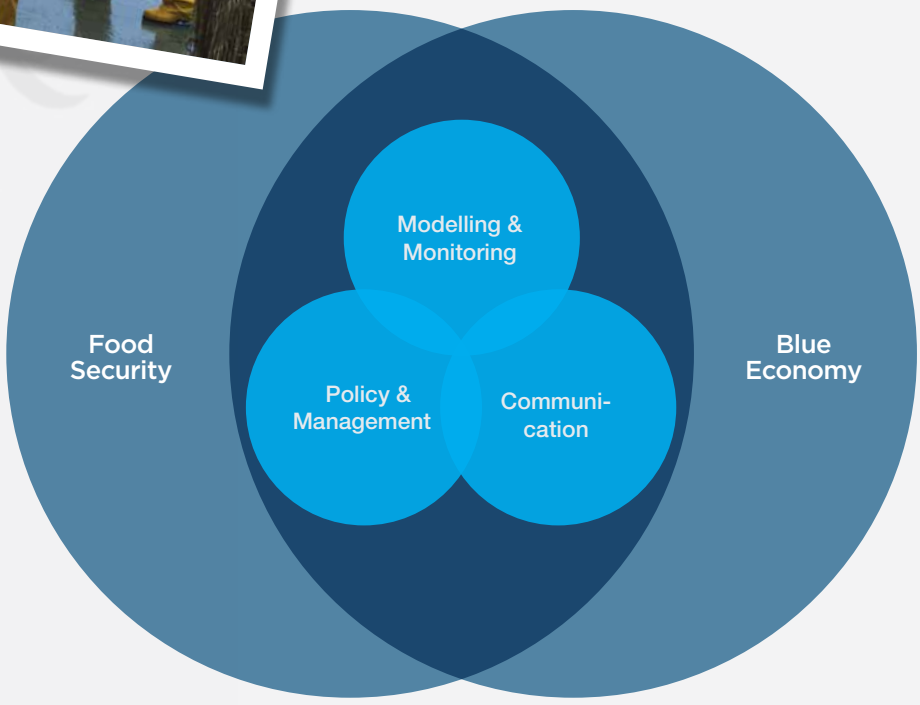



Figure 1: Two theme areas (Food security and Blue economy) and three programs (Modelling & Monitoring, Policy and Management, Communication).

# BACKGROUND

The global climate is warming due to the increased radiative 'forcing' (causing warming) caused by additional accumulations of greenhouse gases, in particular carbon dioxide, in our atmosphere (Solomon et al., 2007). This warming is already resulting in changes to species distributions and abundance. Given projections of continued change, significant ramifications are likely for both marine and terrestrial production systems and their ability to continue to supply essential ecosystem services that society is dependent on, such as food and biodiversity. Commensurate with the changing global climate is the rapidly expanding human population – expected to increase by over 50% in less than four decades – which will put marine production systems under increasing pressure. There is increasing recognition that major transformations will be required to meet society's needs over the coming decades.

The marine environment is expected to play a significant and proportionately larger role in meeting the future needs of society. Projections indicate that our main terrestrial protein sources are unlikely to keep pace with population growth – primarily due to the impacts of climate change on food production systems. While the ability of marine production systems to meet this gap is unknown, marine production systems, particularly in aquaculture, have been the fastest growing primary production systems globally over the last three decades. Employment in the primary fisheries and aquaculture sector has grown at a rate faster than the world's population and faster than employment in traditional agriculture. Nearly 200 million people are directly or occasionally engaged in fisheries or aquaculture production.

Marine production is highest in coastal ecosystems – covering only 8% of the Earth's surface, they produce 25% of global productivity including 90% of marine fisheries production and account for 14% of the world's animal protein needs. They are major regions of global biodiversity and their overall economic value has been estimated at approximately 40% of the world's ecosystem services and environmental goods and services.

Whilst meeting the needs of future generations under a changing climate is a long term vision, this Research Plan has been developed to focus attention on the immediate actions that can be undertaken to assist in meeting the longer term needs of society. While the Plan does not underestimate the magnitude of the challenge and the very real concerns for society, this Plan reflects our optimism that the marine domain will offer food production and livelihood opportunities for individuals, communities, industries and nations into the future.

The Plan has been developed around two central themes: food security and blue carbon economy. These themes focus on development of: (i) adaptation options to increase food production under a changing climate; and (ii) mitigation and sequestration options to minimize continued carbon emissions including recognition of the potential value of coastal habitats as carbon sinks. Essential to delivering practical and applied outcomes is the need to link the science to individuals, communities, industries and managers. To achieve this we have developed three core programs that span both themes: modelling and monitoring; policy and management; and, communication (Figure 1).

The Plan was developed by a team of scientists from Australia and India with expertise in marine physical, biological, economics and social science disciplines. Both the themes and cross cutting program emerged from a process of identifying and prioritizing the issues faced by each country. While not exhaustive, the issues identified have the potential to deliver the short-term needs (5 years) that will provide the pathway to addressing the longer-term issues implicit in the themes. We recognize that the Plan will need to be updated as future insights necessitate refinement. The Plan will foster inter-disciplinary science and solutions for both current and future generations to take advantage of the opportunities that a changing climate offers for marine food production and carbon sequestration.

The scope of this Plan covers commercial, recreational, artisanal and subsistence fisheries, aquaculture and marine tourism and the habitats these activities rely on. It explicitly recognizes the need for sustainable development to be embedded in the conservation of marine biodiversity to ensure healthy and productive marine systems. This Plan provides a foundation for investment in developing positive adaptation options and preparing communities in India and Australia for the challenges of a changing climate.

**This plan has been endorsed by University of Tasmania, CSIRO and the Central Marine Fisheries Research Institute of India.**


NORN AT ALL TIMES

# THEME 1: FOOD SECURITY – ENSURING FUTURE FOOD SECURITY IN A CHANGING CLIMATE THROUGH SUSTAINABLE MARINE PRODUCTION AND DESIGNING NEW OPPORTUNITIES IN INDIA AND AUSTRALIA

## Objectives

- To enhance and develop existing and new marine production systems to meet the increasing need for marine based food.
- To enhance resilience of marine dependent communities through engagement in sustainable marine production. To ensure adaptive capacity and well being, social inclusion, and gender equity through food security.
- To enable adoption of the new opportunities through effective communication.
- To benefit from and build on scientific expertise in climate change hotspots.

## Background

Marine products provide nutrition to large components of the population in both Australia and India. Although fish consumption per capita varies between the two countries, protein provided by fish and other marine products are important in addressing food security issues. Food insecurity is an underlying cause of malnutrition and mortality. Not only can acute food insecurity lead to malnutrition, morbidity and mortality, it can indirectly cause damage to longer term livelihood (Young et al. 2001).

The role of marine products in combating food insecurity issues, have been the subject of research in both developing and developed countries (Salagrama, 2006). Prevalence of hunger and malnutrition can be a seasonal phenomenon (monsoon period) in some fishing villages, but food security issues become particularly relevant at times of natural disasters (Salagrama, 2006). Food security plays a pivotal role in the risk posed to longer-term livelihoods. When taking a 'livelihood approach', both the short-term nutritional risks as well as the longer-term livelihood risks, can be assessed. Livelihoods are recognized as a key element in people's adaptive capacity and vulnerability to climate-related stresses (Vivekanandan, 2011).

To assess the potential consequences of predicted climate changes in the marine environment on food security, both in terms of threats and opportunities, the impact on livelihood and the capacity to adapt will need to be assessed.

In this theme we will develop an understanding of the issues affecting food security in two climate change hotspots recognising that food security based on fish protein has different meaning and relevance in the respective countries.

A major challenge for the future is to provide the knowledge to fuel innovation in Australian and Indian marine production systems to meet domestic and global demand for seafood in a changing climate. This will necessitate the application of inter-disciplinary approaches to enhance existing, as well as developing a range of sustainable and novel production systems. Meeting this challenge will require research across complex biophysical and human systems to sustain industries, ecosystems, livelihoods and communities and to ensure that sectoral transformation are sustainable, balance competing marine uses and values, and has social license.

## Priority Research Areas

1. To investigate the role of fish protein in food security and characterise the social, cultural, and economic value of marine production systems and their management.
2. To investigate the link between food security and sustainable livelihoods including the effects of climate change and variability, and natural disasters.
3. To predict the implications of future potential climate change impacts on productivity and extractive potential through application of an ecosystem approach to food security.
4. To identify, assess and evaluate alternative and emerging production systems to meet the increasing demand for seafood under a changing climate.
5. The impact of climate change on existing, alternative and emerging production systems (fishers, fishing communities and fishing industries) needs to be identified, assessed and evaluated.

# THEME 2: BLUE CARBON – AN INTERDISCIPLINARY ASSESSMENT OF FISHERY SYSTEMS IN THE CARBON ECONOMY: CARBON FOOTPRINT AND SEQUESTRATION OPPORTUNITIES IN INDIA AND AUSTRALIA

## Objectives

- To identify efficient carbon mitigation actions across the supply chain for selected commercially important fisheries in India and Australia.
- To develop carbon mitigation strategies for selected commercially important fisheries in India and Australia.
- To identify the potential for efficient carbon sequestration in the key coastal ecosystems in India and Australia.
- To develop strategies for incorporating blue carbon into integrated coastal management systems and coastal livelihoods.

## Background

Carbon dioxide is a greenhouse gas emitted from anthropogenic and natural sources, which is now modifying the atmosphere and terrestrial and ocean systems. Increasingly, carbon will be regulated and priced under national legislation (e.g. emissions trading schemes) and international agreements (e.g. Copenhagen agreement).

One of the main ways in which fishery systems will be impacted is through market and government-driven increases in the price of carbon-based fuels. The high exposure of many fisheries systems to rising carbon prices is a major source of climate-risk, and results in high vulnerability of many fisheries, and their linked supply chains and communities. 'Carbon-proofing' fisheries production systems through cost-effective adaptations can reduce this vulnerability and will also mitigate the sectors' carbon footprint.

The term 'blue carbon' describes the natural processes by which atmospheric carbon is captured and stored (sequestered) by marine environments. 'Carbon sequestration' means carbon storage that is unlikely to be reintroduced to the atmosphere for more than some period of time (say 100 years). Coastal wetlands and marine plants have the potential to sequester carbon in sediments and the tissues of plants, just as trees on land sequester carbon. Carbon sequestration and storage in seagrass, mangrove and wetland ecosystems is considered to be extremely high (rates of up to 5 times those of tropical forests) and turnover is low in undisturbed systems.

Australian and Indian coastal ecosystems also support many valuable inshore fisheries, creating jobs and providing high quality protein, and are a source of rich biodiversity. They also support a wide range of other coastal activities including recreation and aquaculture. Both countries have lost large quantities of coastal ecosystems. It is suggested that restoration or protection of these coastal habitats presents a win-win-win situation: (1) positive biodiversity outcomes, (2) enhanced fishery production (many species use these habitats as nursery areas), and (3) an important opportunity for ecosystem-based climate change mitigation. However this suggestion needs to be tested within the context of specific coastal ecosystems in both Australia and India.

In the case of blue carbon, there is also a viable market that could be created for carbon trading (as on land), although significant efforts are required to develop this into reality, including science knowledge and policy reform.

## Priority Research Areas

1. To characterise supply chains for selected marine production systems, and identification of the main points of carbon impact and of opportunities across the supply chain for carbon mitigation.
2. To undertake an economic evaluation of alternative carbon adaptation strategies.
3. To identify the barriers to, and strategies for, adoption of efficient carbon mitigation actions and assess the role of incentives in adopting carbon mitigation strategies by the stakeholders.
4. To identify and measure the blue carbon potential of alternative sequestration systems (such as sea grass, mangroves, sea weeds) in coastal ecosystems and identification of potential for increase in production through conservation, restoration and enhancement.
5. To identify current and anticipated threats to maintaining and enhancing carbon sequestration (over fishing, resistance to alternative coastal livelihoods opportunities, pollution, coastal development, anthropogenic activities, climate change etc.) in coastal ecosystems.
6. To evaluate the alternative carbon sequestration systems including an understanding of the interaction between the use of coastal ecosystems for carbon sequestration and other uses.
7. To assess the opportunities and barriers to coastal communities participating in the blue carbon economy and development of strategies for addressing these barriers.

# PROGRAM 1: MODELLING AND MONITORING – DEVELOPING DECISION SUPPORT TOOLS THAT ADDRESS INDIA AND AUSTRALIA'S MARINE-BASED FOOD SECURITY AND CARBON ECONOMIES IN A CHANGING CLIMATE

## Objectives

- To review and evaluate integrated assessment models and frameworks that capture the different data streams essential for predicting and evaluating climate change.
- To develop appropriate regional specific decision support tools that effectively capture the physical, biological, social and economic dimensions of marine production systems.
- To model future climate change scenarios on the social-ecological system, and identify the consequences on marine-based food security and carbon economies in India and Australia.
- To evaluate the social and economic implications in the development of adaptation options.
- To develop cost effective monitoring programs across all disciplines.

## Background

The complex nature of physical, ecological and social marine systems challenges our capacity to accurately predict change and consequently to develop adaptation strategies based on realistic forecasts.

However quantification of feedbacks between the biophysical environment (climate and oceanography and species biodiversity) and socio-economics (marine communities, market drivers and policy and governance arrangements) provides a means to advance our understanding of the health of the marine social-ecological system and the resilience and productivity of both the ecological and human systems.

Thus, strategically designed monitoring programmes at spatial and temporal scales that will capture processes driving both the biological and human systems and link across the biophysical and socio-economic arenas are integral to advance our modelling capabilities and to generate innovative assessment tools.

While there are a number of integrated assessment models being developed (e.g. Ecosim, ecopath, Atlantis) and the incorporation of economic and social data into fishery assessment models (e.g. fleet dynamic models, employment, pricing and trade) there is limited understanding of how these models: (a) effectively include and account for climate change; (b) can be used to project climate change futures; or (c) can be used to assess and evaluate adaptation options.

## Priority Research Areas

1. To evaluate conceptual modelling frameworks that captures the biophysical and human systems to inform decision-making that supports industries in choosing optimal adaptation pathways.
2. To develop effective integrated monitoring programs that provide the necessary data to develop and validate models, inform decision making and evaluate the social and economic performance of enhanced or new marine production systems and their impact on biodiversity and marine resources.
3. To develop new and innovative modelling approaches that integrate across disciplines and that can capture both qualitative and quantitative modelling techniques to address risk and uncertainty in the development of future adaptation scenarios.
4. To develop tools based on ecosystem modelling approaches to address complex problems in the marine system as they relate to food security and blue carbon.

# PROGRAM 2: MANAGEMENT AND POLICY – POLICY AND MANAGEMENT OPTIONS FOR ADAPTING TO CLIMATE CHANGE IN MARINE ECOSYSTEMS IN AUSTRALIA AND INDIA

## Objectives

- To gain understanding of existing management and policy frameworks for marine ecosystems in India and Australia.
- To document the risks, barriers and incentives for developing sustainable and innovative industries, maintaining ecosystem integrity and promoting sustainable livelihoods and communities under a changing climate.
- To document and identify the drivers affecting policy and management arrangements for climate change in marine ecosystems and communities.
- To benchmark existing options and develop alternative options for adapting to and managing climate change in the context of food security and carbon economy.

## Background

Improved understanding of policy and management in marine ecosystems will be an important tool in facilitating interdisciplinary and international responses to climate change in the context of food security and the development of a blue carbon economy.

The success or failure of future policy and management arrangements in this context will not only be contingent on the availability of the fish stocks, but also on culture, gender, economic factors, education levels, enforcement and compliance capacity, religion and many other socio-economic factors that characterise any society.

Policy systems need to ensure ecological resilience, maintenance and sustainability of target species.While India and Australia are very different countries with quite different fisheries and management challenges, the aspiration for socially just and inclusive fishing practice is a common one, and moreover, one that will become ever more pressing as climate change impacts on species and fishing communities.

Importantly, further research into this area can assist in reducing the uncertainty in the science-policy interface.

## Priority Research Areas

1. Mapping of policy, management and planning arrangements across India and Australia.
2. Cross national risk perception and values assessment that evaluates how climate change is perceived by different fisheries and communities in India and Australia, and the implications that this has for both management and policy arrangements and for communities.
3. Benchmarking existing and alternative options for adapting to and managing climate change in the context of food security and a blue carbon economy.

# PROGRAM 3: COMMUNICATION – STRATEGIC COMMUNICATION AND EDUCATION FOR CLIMATE CHANGE PREPAREDNESS

## Objectives

- To evaluate and compare climate change communication contexts.
- To identify the knowledge, attitude and skill drivers and barriers that affect climate change communication.
- To document citizen's ecological knowledge and to explore it's potential to enhance models and tools for adaptation and mitigation.
- To explore the use of advanced information and communication technologies to enhance climate change communication and knowledge exchange.
- To design and validate cost effective communication tools and strategies for the exchange and mainstreaming of climate change knowledge.

## Background

Climate change is projected to have a range of direct and indirect impacts on marine capture fisheries, with implications for fisheries-dependent economies, coastal communities and fishers.

This will impact on the ability to maintain or enhance productivity to ensure food security for an increasing global population.

Fishers also work in a carbon economy and opportunities exist to both minimise carbon footprints and to take advantage of carbon sequestration options. The vulnerability of fisheries and fishing communities depends on their exposure and sensitivity to change, but also on the ability of individuals or systems to anticipate, adapt and take advantage of opportunities.

To minimise the detrimental impacts of a change climate and to exploit opportunities there is a need to educate fishers on what is climate change, how they are affected by climate change, the effects of climate change on fishing stocks, and to understand the opportunities that may exist.

Not only can this be gained from education and communication of scientific knowledge but there is also traditional fisher ecological knowledge that can be used to communicate and educate coastal communities.

This program aims to enhance climate change knowledge and awareness in coastal villages and rural communities through testing and trialling a wide variety of communication media such as print, electronic and mass media, including information and communication technologies, multimedia and traditional media.

## Priority Research Areas

1. To document the understanding by coastal communities and fishers of the current and past knowledge and perceptions of climate change on marine systems in India and Australia.
2. To evaluate ways of incorporating traditional fisher knowledge about the marine systems into assessment and modelling frameworks.
3. To develop innovative and effective communication tools to educate and improve awareness of climate change impacts and opportunities.

# PROJECTS

**During the development of this plan a range of issues were identified for each theme and program and these were developed into a range of projects. Areas that were consider as priorities over the next 5 years have been identified below.**

To demonstrate the connectivity between objectives and priority research areas within this plan, the projects have been listed under the appropriate themes and programs.

Single projects can form the basis of individual study, especially as post-graduate studies, however, these projects were developed by an inter-disciplinary team of researchers and many of the projects identified in the programs have been developed to address key projects identified in the themes.

We strongly encourage that future research directions maintain an interdisciplinary focus and incorporate projects across all programs to address priority research areas in each of the themes.

## Food security theme

- Understand the role of marine protein with respect to food security.
- Understand the interaction between food security and short term nutritional issues and long term livelihood assessment.
- Develop an understanding of consumer demand for marine protein.
- Develop simple indicators to monitor the relationship between food security and livelihood over time.
- Model future productivity and extractive potential using an ecosystem approach.
- Assess the impact of the productivity changes to the economy (cost and revenue for different stakeholders and economic agents).
- Assess the climate change impact on existing fishing communities and identify threats and opportunities with respect to food security.
- Assess the potential of alternative or emerging enterprise systems and identify food security opportunities.
- Assess potential climate change pressure on domestic food security that may affect international trade patterns, barriers, and agreements.

## Blue carbon economy theme

- Identify fisheries systems important to India and Australia and selection of those fisheries for study.
- Characterise supply chains, and identify the main points of carbon impact for selected fishery systems.
- Quantify the carbon footprint across the supply chain for selected fishery systems and identify opportunities across the supply chain for carbon mitigation.
- Assess identified carbon mitigation actions.
- Identify the barriers to adoption of identified efficient carbon mitigation actions.
- Assess the role of incentives in adopting carbon mitigation strategies by the stakeholders.
- Develop strategies to support adoption of efficient carbon mitigation actions.
- Economic evaluation of alternative carbon adaptation strategies.
- Identify and measure the blue carbon potential of alternative sequestration systems (such as sea grass, mangroves, sea weeds) in coastal ecosystems in India and Australia and identify the potential for increase in production through conservation, restoration and/or enhancement.
- Identify current and anticipated threats to carbon sequestration (over fishing, resistance to alternative livelihoods, pollution, coastal development, anthropogenic activities, climate change etc.) in these ecosystems.
- Understand the interaction between the use of coastal ecosystems for carbon sequestration and other uses.
- Evaluate alternative carbon sequestration systems.
- Assess the opportunities and barriers to coastal communities participating in the blue carbon economy and development of strategies for addressing these barriers.

### Modelling and monitoring program

- Evaluate past impacts of climate change on production and the ecosystems through different modelling approaches, including an evaluation of existing integrated assessment modelling frameworks.
- Adapt and/or develop a suitable integrated assessment model/s for assessing the future impacts of climate change on marine food security and the carbon economy in India and Australia.
- Incorporate social, economic, biological and governance parameters in models to derive optimal adaptation pathways.
- Develop qualitative and quantitative models to help manage complexity, diversity and risk.
- Consider novel approaches for estimating model output uncertainty that can be incorporated into decision frameworks (e.g., compound error).
- Use different modelling approaches to provide a consensus-based approach to evaluate the impact of climate change on production and ecosystems.
- Identify optimal system measurement programs to monitor marine system changes.
- Identify appropriate temporal and spatial scales of monitoring required to detect biophysical change that can usefully inform ecosystem and socio-economic models.

### Management and policy program

- Benchmark 'good' marine governance systems (identification of effective attributes and characteristics of management systems).
- Map existing management arrangements and comparatively analyse the strengths and weaknesses of management and governance systems between the two countries.
- Identify the economic incentives for optimal compliance of the different regulatory and management practices.
- Evaluate the performance of different input-output control mechanisms and suggest appropriate policy mix.
- Economic evaluation of different adaptation options (planning, process, measures) and the scope of adaptability.
- Identify planning and management alternatives for fisheries including alternative sites based on long-term scientific projections for fishing and aquaculture (e.g., prawn farming is now only in specific areas on the Indian coasts and in the future may shift).
- Forecast modelling using remote sensing (e.g., chlorophyll-based fisheries forecast and validation) for management support.
- Identify and analyse the adoptability of potential climate change mitigation and adaptation mechanisms within management.
- Document and explore the incorporation of diverse forms of knowledge into management and governance.
- Identify regulatory barriers to the development of alternative fisheries/ aquaculture.
- National assessment of how climate change risk is perceived by different fishers and communities, and the implications this had for management and governance arrangements.

### Communication program

- Identify current levels of understanding/awareness of climate change issues.
- Climate change communications barriers analysis.
- Communication/information needs analysis.
- Design of and validate/trial climate change communication tools.
- Document and validate traditional and historical indigenous (technical) knowledge and using it to develop pictures of past climate change.
- Capture and use current fisher observational information and knowledge and incorporate this knowledge into models.
- Perception studies of stakeholders perceived risk of climate change on fisheries and implications for decision making.
- Develop tools and protocols that address communication of climate change impacts and adaptation options.
- Identify innovative opportunities to gather real time economic data for developing adaptive and mitigation measures.
- Analyse the cost of communication to the different stakeholders for their perceived change in their knowledge and attitude toward climate change.
- Identify the impact of information and communication technologies on the efficiency of fishing operations, markets and price.
- Develop physical knowledge based communication systems.

# GLOSSARY

**Blue carbon:** A low carbon, resource efficient marine and freshwater economy that is socially inclusive. In this Plan, it is the marine component.

**Blue Economy:** Refers to the economic activity associated with the marine and freshwater domains. In this plan it is the marine component.

**Ecosystem resilience:** The capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure, identity, and feedbacks.

**Food security:** When all people at all times have access to sufficient, safe, nutritious food to maintain a healthy and active life.

**Integrated assessment model:** A modelling tool that combines knowledge from a wide range of disciplines to generate information and assess climate change risks and policies.

**Multi-disciplinary study:** A study involving several academic disciplines or professional specializations in an approach to a topic or problem.

**Inter-disciplinary study:** A study that integrates more than one branch of knowledge in an approach to a topic or problem.

**Social-ecological system:** A system that includes and links people and nature.

**Sustainability development:** Development that meets the needs of the present without compromising the ability of future generations to meet their own needs.

**Trans-disciplinary study:** A study that brings together academic experts and stakeholders in an approach to a topic or problem.

# APPENDIX: PLAN DEVELOPMENT PROCESS

This plan was developed in two intensive week-long workshops (in Australia and India) involving the whole project team (University of Tasmania/CSIRO/University of Adelaide from Australia and Central Marine Fisheries Research Institute of India), and reflects work before and after each workshop.

**Workshop 1:** 16th to 20th January, 2012 in Hobart, Tasmania, Australia

- Initial scoping on fisheries, marine environment, marine sectors and climate change.
- Discussion on key issues and drivers
- Identification of themes

**Workshop 2:** 6th to 10th March, 2012 in Cochin, Kerala, India

- Development of Vision, Mission and Key Objectives
- Development of themes and programs
- Identification of indicative projects

### Participants

| Name | Organisation | Project role |
|---|---|---|
| Associate Professor S. Frusher | University of Tasmania | Project Manager (Australia): Fisheries Science |
| Dr G. Syda Rao | Central Marine Fisheries Research Institute | Project Manager (India) and Director (CMFRI): Fisheries Science |
| Ms E. Gärtner | University of Tasmania | Research Assistant & Administration |
| Associate Professor M. Haward | University of Tasmania | Governance |
| Dr A. Hobday | CSIRO | Biological Oceanography |
| Associate Professor N. Holbrook | University of Tasmania | Physical Oceanography |
| Dr S. Jennings | University of Tasmania | Natural Resource Economics |
| Ms M. Menon | Central Marine Fisheries Research Institute | Fisheries Science |
| Dr M. Nursey-Bray | University of Adelaide | Social Science |
| Dr G. Pecl | University of Tasmania | Biological Science |
| Dr E. V. Radhakrishnan | Central Marine Fisheries Research Institute | Fisheries Science |
| Dr C. Ramachandran | Central Marine Fisheries Research Institute | Social Science |
| Dr S. S. Salim | Central Marine Fisheries Research Institute | Natural Resource Economics |
| Dr. T. V. Sathianandan | Central Marine Fisheries Research Institute | Fisheries Statistics |
| Dr I. Van Putten | CSIRO | Natural Resource Economics |
| Dr E. Vivekanandan | Central Marine Fisheries Research Institute | Fisheries Science |

# APPENDIX: COUNTRY COMPARISONS

| 1. Metric | Australia | India |
|---|---|---|
| PHYSICAL COMPONENT | | |
| Land size (km2) | 7,682,300 | 2,973,193 |
| Coastline length (km) | 25,760 | 8,129 |
| Continental Shelf (km2) | 2,070,000 | 530,000 |
| EEZ (km2) | 6,050,000 | 2,020,000 |
| Seasonality | 4 seasons | 2 monsoons |
| Nutrients: Upwellings | Minor (south) | Major (southwest coast) |
| Nutrients: Land based | Minor | Major (e.g. northwestern Bay of Bengal: $12x10^9$ tonnes) |
| Productivity | Low | Medium |
| Spatial variability in productivity | All low | Low – high |
| Cyclones | Northern | East coast |
| PRODUCTION AND TRADE | | |
| Fisheries production (wild and aquaculture) (metric tonnes) | 241,123 (2010) | 3,320.000 (2010) |
| Share of aquaculture in total production | 39% | 55% (mainly inland) |
| Main aquaculture type | Vertebrates | Vertebrates |
| Main production systems | Monoculture | Integrate and multi-species |
| By-catch for main species | Low | Medium |
| Main value group | Lobsters | Shrimp |
| Main volume group | Aust. Sardines | Oil sardine, Indian Mackerel |
| Balance of Trade (volume) | Importer | Exporter (10%) |
| Balance of trade (value) | Imports~exports | Exports (25%) |
| Fishery Imports (tonnes) | 207,559 (2010) | 6,092 (2010) |
| Fishery Exports (tonnes) | 39,968 (2010) | 800,000 (2010) |
| Fisheries production (wild and aquaculture) (value-$) | AUD $2,180 million (2010) | AUD$12,290 million* (2010) |
| Imports (value) | AUD $1,500 million (2010) | AUD $16.1 million* (2010) |
| Exports (value) | AUD $1,220 million (2010) | AUD $3,164 million* (2010) |

| 1. Metric | Australia | India |
|---|---|---|
| FISHERY DESCRIPTION | | |
| Thermal regime | Tropical to temperate (polar) | Tropical |
| Main target groups | Single species | Multi-species |
| Fish groups | Pelagic: 32% Demersal: 37%<br>Crustaceans: 22% Molluscs: 9% | Pelagic: 55% Demersal: 26%<br>Crustaceans: 15% Molluscs: 4% |
| Main region of fisheries production | SE | SW |
| Management | Input and output | input |
| Assessment | Separate to management | Stock assessment independent of fishers |
| HUMAN COMPONENT | | |
| Population | 22,800,000 (2011) | 1,210,000,000 (2011) |
| Population within 100 km of coast | 90% | 26% |
| Per capita food supply from fish and fishery products | 22 kg/person | 9 kg/person |
| Per capita supply (variability) | Low | High |
| Marine fishers population | | 4 million |
| Employment | 11,431 | 11 million |

*Exchange rate on the 01/01/2010: AUD $ 1 = US $ 0.89768

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# USEFUL LINKS AND RELATED MATERIALS


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This project has been supported by / funded by:

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