ASSESSING VULNERABILITY TO CLIMATE CHANGE AND BUILDING ADAPTIVE CAPACITY IN CAMBODIA'S FISHERIES SECTOR

A report prepared for the Fisheries Administration project, "Building Capacity for Integrating Climate Change Adaptation in Fisheries Sector in Cambodia"

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Introduction

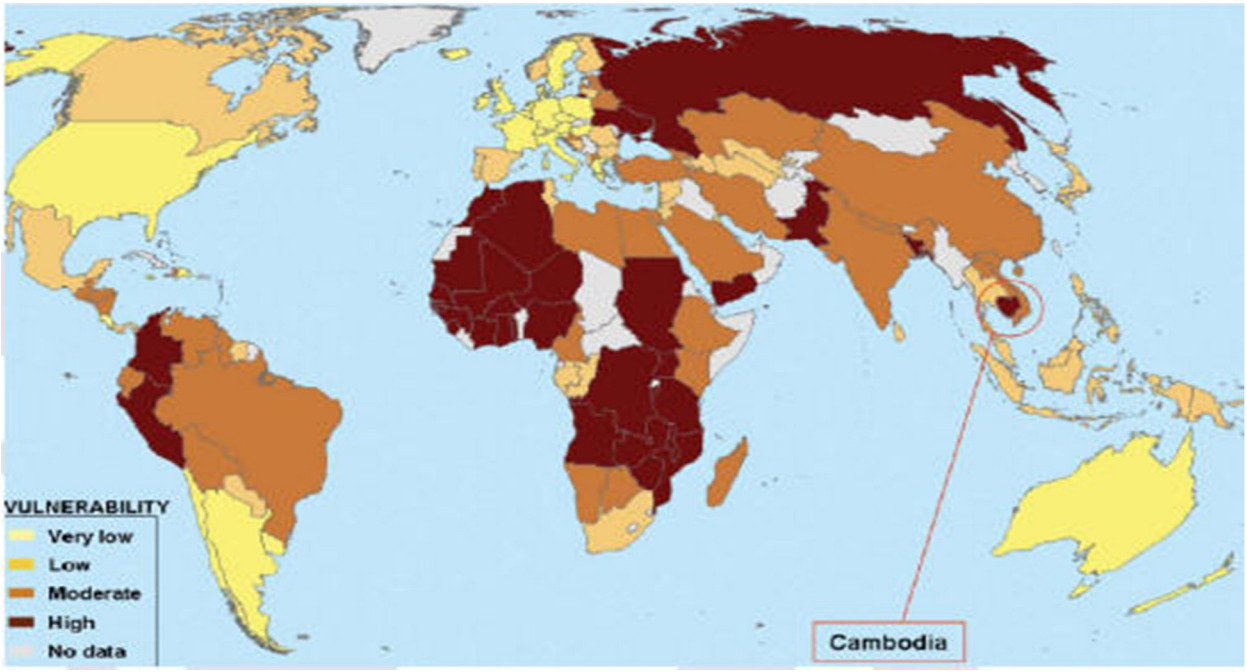
Climate change has become the focus of increasingly urgent discussion and action as its impacts have become more visible. Cambodia is highly vulnerable to the effects of climate change (Baran *et al.* 2009). One of the main reasons for this vulnerability is its limited capacity to adapt to the effects of climate change (MoE/UNDP 2011). The most immediate and dramatic of these effects are likely to be felt in Cambodia's fisheries sector (MoE/UNDP 2011). The purpose of the present study is to review existing information on the impact of climate change on Cambodia's fisheries and suggest future work to build adaptive capacity in the sector.

The Mekong River and the Tonle Sap Lake are Cambodia's key geographical features. The complex hydrology of this system sustains the most productive inland fisheries in the world (MoE/UNDP 2011). These fisheries supply livelihoods for millions of people and contribute up to 80 percent of the animal protein consumed in the country. Small-scale fisheries and their influence on various sub-sectors are largely underrepresented in official fisheries statistics (World Fish Center/SIDA 2009). Many rural people depend on Cambodia's lakes and rivers and have few livelihood options other than fishing. Even small changes the hydrological system that sustains Cambodia's fisheries could have a disastrous consequences for food security.

A number of changes related to climate trends in Cambodia have already been observed. The average number of cold nights per year has decreased and the average frequency of hot days has increased significantly (World Bank Group 2011). The low levels in the Mekong River in 2010 were attributed to both upstream dam development and climate change (MoE/UNDP 2011). It is thought that Cambodia is highly vulnerable to the effects of changing climate trends. This vulnerability is defined by the Intergovernmental Panel on Climate Change (IPCC) as "the degree to which a system is susceptible to or unable to cope with the adverse effects of climate change" (Yusuf and Francisco 2011). According to Allison *et al*. (2009), Cambodia is particularly vulnerable to climate change impacts because of the magnitude of these impacts, the reliance of people on fisheries, and its limited adaptive capacity.

The impact of climate change on Cambodia's fisheries sector will occur through multiple pathways and interactions. The changing productivity of natural capture fisheries is closely related to natural hydrological patterns and the integrity of fish habitats. There are many uncertainties and indirect impacts from changing hydrological regimes. These include changes to migration patterns and the level of flood peaks and area of land flooded. In the short term, climate change is expected to impact freshwater fisheries through incremental changes in water temperature, nutrient levels and lower dry season water levels. Climate change will also increase the uncertainty of fish production in capture fisheries and aquaculture (Ficke *et al*. 2007). The effects of climate change on fisheries are therefore likely to be felt both at the level of local households and the level of the national economy (MoE 2006). A full account of the vulnerabilities across the fisheries sector is attached in the results.

Figure 1 Illustrates the vulnerability of fisheries to climate change with Cambodia highlighted as one of the most vulnerable countries (Allison *et al*. 2009)



Although there are many uncertainties, the Greater Mekong sub-region has been identified as one of the regions least able to respond to climate change impacts (Johnston *et al*. 2009). The effect of changing temperatures and hydrologic regimes is expected to have a major impact on the Greater Mekong Sub-Region (Johnston *et al*. 2009) including a temperature change of 0.02-0.03 per year, a seasonal shift in rainfall with drier dry seasons and shorter and wetter wet seasons, and an increase in the overall flow in rivers and lakes, with an increase of flood events by 5-7% (Johnston *et al*. 2009). Although climate change is complex, the following impacts of climate change have been predicted by Badjeck *et al*. (2010) and others for fisheries in general (Table 1).

Table 1 Symptoms of climate change for inland fisheries (Badjeck *et al*. 2010)

Symptoms	Effects On	Impacts
- Rainfall changes - Evaporation changes - Modified river flows - Changing lake levels - Changing thermal structure of lakes - Increased severity of extreme weather - Increased frequency of extreme	- Ecology	- Species composition
		- Production and yield
		- Species distribution
		- Species diversity
		- Fish diseases
	- Fishing operations/Post-harvest	- Safety and ability to get fish
		- Ability to process fish
		- Infrastructure damage
	- Livelihoods (local)	- Loss of livelihoods
		- Changes in livelihood

- Temperature increases/decreases		strategies
		- Health risks
		- Displacement and migration of fishers
	- Wider society/Public policy	- Adaptation costs
		- Market impacts/Impacts on demand

In Cambodia, the impact of climate change on fisheries operates on many levels. The timing of the flood along with the number of peaks during the flood season are important factors in how fish migrate, breed and spawn (Baran *et al*. 2009). Climate change is also likely to have an impact on the methods fishers use and the social-economic context in which fishers operate. One of the concerns is that Cambodian fish catches are increasingly made up of species such as Henicorhynchus spp. (*trey riel* in Khmer) that are considered unstable because their abundance is largely driven by the annual flood pattern. The *trey riel* migration could significantly be impacted with implications for food security.

There is a lack of information on climate change in the fisheries sector specific to Cambodia. Thus, predicting consequences is difficult. However, it is clear that the impact of climate change on fisheries will be both indirect and direct. Fisheries constitute the sector most vulnerable to the development of water resources (MoE/UNDP 2011). An ecosystem already stressed by overfishing, hydropower development, and habitat destruction is particularly vulnerable to the effects of climate change. A combination of these factors can push an ecosystem toward a tipping point from which there is an unstoppable decline in productivity. These impacts will have direct and synergetic impacts. Unfortunately, there have been no reliable studies of how changes to the hydrological regime caused by damming projects could interact with climate variables and affect fisheries (Baran *et al.* 2009, ICEM and MRC 2010).

It is important to remember that climate change will not be all doom and gloom. There are 300 species of fish in the inland fisheries of the Lower Mekong Basin, and they may react differently to climate change. In some cases, changing water levels or other impacts may boost the fisheries sector in Cambodia and provide opportunities to improve livelihoods (Baran *et al.* 2009). Negative impacts are extensively presented in the literature while positive impacts of climate variability and change on the fisheries sector are yet known (Badjeck *et al.* 2010).

The current lack of information about climate change in Cambodia makes it hard to assess the potential impacts on the fisheries sector. The first step in tackling climate change is framing the problem as uncertainty about its impacts on Cambodia's fisheries. One of the challenges for the fisheries sector is that the NAPAs (National Adaptation Programs of Actions) and plans of the Least Developed Countries (LDC) do not address the fisheries sector. Fisheries sector management plans are only partly considered in the NAPA programs because of lack of appropriate knowledge on the sector (FAO 2007).

Indirect impacts and repercussions from climate change will require a holistic approach and integration of sectors. A key to successful adaptation is to diversify livelihoods so when one economic option fails another is available. For example, agriculture and fisheries are often very intertwined within livelihoods, so it is difficult to separate them from each other when considering climate impacts (Béné and Friend 2011, World Fish Center/SIDA 2009, Smith *et*

al 2005). Adaptation should be a combination of diverse and flexible livelihoods, plus diverse and adaptable institutions and policies.

It is also about providing options for poor fishers and the education/skills required to upgrade the powerful adaptation skills that they already posses. Thus diversification and occupational mobility should be considered in developing a climate change adaptation strategy (Béné and Friend 2011). Reducing the stress on fishery resources through removing or mitigating external stresses such as the degradation of ecosystems will increase the capacity of people to adapt to changing fishery resources. Degradation of forests and wetland ecosystems makes the agriculture and fisheries sectors more vulnerable to climatic variation.

Across all levels of government, conserving wild fisheries and promoting aquaculture should be considered twin strategies of adaptation to climate change (Baran *et al*. 2009). It is vital to understand the effects of climate change and how these will likely impact the fisheries sector. In light of so much uncertainty and unpredictability, there need to be mechanisms in place to build adaptive capacity for local communities to adapt to these changes. This review seeks to identify the current gaps in the literature on climate change adaptation in the fishery sector.

Objectives

The present review aims to provide an overview of the impacts of climate change on the fisheries sector in Cambodia. The objectives of the literature review are as follows:

- To share current knowledge about the impacts of climate change on the fisheries sector and about adaptation strategies for stakeholders with 1) National and Sub-national FiA staff (Strategists, Policy-makers and project implementers); 2) Local authorities (Commune Councils and village authorities) and Community Fisheries committees (also project implementers); and 3) Fisheries-dependent community members who are most vulnerable to climate change impacts (women, children, poor families)
- To help develop best practices in climate change adaptation across partners/stakeholders for pilot site implementation
- To learn from other projects and international research as applied to Cambodia. As much information is unknown, these gaps need to be clearly identified by stakeholders and through the literature.
- To strengthen the collaboration between stakeholders in order to promote integration of climate change adaptation in the fisheries sector in Cambodia and to inform national adaptation strategies.

Methodology

The methodology of the present study was qualitative. It consisted of reviewing articles and studies, holding meetings and focus group discussions with FiA technical department representatives, and developing of questions to collect baseline information. These initial actions also involved bringing together FiA officials at the national and local level to discuss the challenges around climate change adaptation. This happened during the project inception workshop held by FiA in November 2011.

Literature Review

The literature review included articles, project reports, and scientific studies on climate change impacts on fisheries, with an emphasis on freshwater environment. The most important findings were compiled into a review of current knowledge related to fisheries, food security and predicted climate change impacts. The results of the literature review were summarized in an excel table. Case studies pertaining to both Cambodia and regional neighbors were reviewed for lessons learned.

Stakeholder Focus Group Interviews with FiA Members

The present study used a multi-stakeholder approach, holding discussions with stakeholder groups across the fisheries sector. These discussions provided an overview of the impacts of climate change on the fisheries sector. During the inception workshop, participants were divided into five groups (aquaculture, fishery post-harvest/fish processing, fisheries conservation, community fisheries, and development partner representatives/international advisors). Guiding questions surrounding climate change adaptation in the fisheries sector were shared at the workshop.

Survey Design and Consultation

During the design of the survey, key stakeholders were consulted so as to obtain their views on the potential impacts of climate change. Discussions were completed with FiA technical department representatives from the field, and fishers and administrators were interviewed during the developing of the survey.

Case Study Overview

The present study also reviewed case study evidence and lessons learned in building adaptive capacity in agriculture and other sectors. This included case studies from databases such as the Adaptation Learning Network.

Results: Vulnerability to Climate Change Impacts across Sectors

A full review of the projected impacts of climate change on fisheries in Cambodia is attached (Appendix A).

In light of the lack of literature and scarcity of case studies in the field, we have separated the results related to projected and observed impacts of climate change. The following is a summary of the key findings about adaptation from the literature review and the results of our focus group discussions at the inception workshop. A full overview of projected impacts can be found in the Excel spreadsheet. The overview summarizes the most important findings.

According to interviews with the FiA and the inception workshop, climate change has many potential impacts including sea surface temperature increases, floods, droughts and sea level rises. There are some predicted positive impacts, such as the impact on primary productivity, which might be able to increase the productivity of

filter feeding organisms (Baran *et al*. 2009). The adaptation options are largely unknown, but there are technical adaptation options that should be piloted as well as capacity building options at the local level.

Conservation Sector

The fishery conservation group was concerned about the destruction of fish habitat, the appearance of new fish diseases, and the disappearance of vulnerable species. This group noted that experience has shown drought can kill fish and create habitats unsuitable for raising fingerlings.

The focus groups echoed claims in the literature (Abell *et al*. 2007) that climate impacts can be buffered by increasing and protecting conservation areas. By developing protected areas, freshwater systems will have more capacity to buffer some of the impacts (Abell *et al*. 2007). There also needs to be integration with the agricultural sector to prevent over exploitation of water from reservoirs. Floodplain fish refuges are an option to create rural livelihoods resistant to climate change (MoE/UNDP 2011). The productivity of natural capture fisheries of Cambodia is closely related to natural hydrological patterns and the integrity of fish habitats.

Table 2. Results from the focus group FiA meeting - Conservation group

Anticipated Impacts	Observed Impacts	Adaptation Options
- Harm to fingerlings - Damage to fish habitats - Appearance of new diseases - Unusual levels of rainfall or drought - Vulnerable species affected the most	- Fish killed and habitat made unsuitable for brood stock and fingerlings by drought - Lower rainfall - Higher temperatures - Loss of forest cover - Changes to water temperature and pH rates	- Increase and protect conservation areas - Extend/promote knowledge of climate change - Solve problems together - Rehabilitate and re-plant flooded forests - Rehabilitate ponds and build more reservoirs - Develop freshwater protected areas

<u>Projected Impacts of Climate Change:</u>

Changes to the hydrologic cycle and adjacent vegetation affects species ranges and system productivity (Abell *et al*. 2007), reduces primary productivity and changes the food web, modifies fishery distributions and reduces biodiversity and production (Johnston *et al*. 2009). Some experiments have shown that fish will likely experience interrupted breeding cycles, which will influence fertility and extend the spawning season (Beznosov and Suzdaleva 2004)

- Temperature increases are projected to impact fish metabolism, growth and distribution, while lower trophic levels could affect the food web (Johnston *et al*. 2009).

- Breeding cycles could be interrupted, which would influence fertility and extend the spawning season (Beznosov and Suzdaleva 2004).
- Climate change could generate anoxic conditions in the bottom layers of rivers and lakes (Beznosov and Suzdaleva 2004).
- These ecological impacts could change production and yield, species distribution, species diversity, migration patterns and instances of fish diseases.
- Climate change could favor some species over others, thereby changing the relative abundance of various species.
- Changing flood pulses could reduce key fish habitats such as flooded forests (MoE/UNDP 2011).
- Changes to hydrological flows could be amplified by an increasing number of hydropower dams (World Fish Center/SIDA 2009). Climate change is expected to reduce dry season flows in rivers and negatively impact water quality.
- The degradation of forests and wetland ecosystems could make the agriculture and fisheries sectors more vulnerable to climatic variation.

Adaptation Responses:

Stakeholders involved with conservation suggest that rehabilitating important spawning habitats in the flooded forest could be an important adaptation mechanism.

- Conservation can help buffer climate change impacts by providing opportunities for fish to migrate and spawn, restore and promote habitats (Ficke *et al*. 2007).
- For example, fish refuges such as conservation zones can help the fish to adapt to climate change (Abell *et al*. 2007).
- Invasive species are a concern for conservation; proper infrastructure can discourage invasive species that might appear as a result of climate change.
- The ecological impact of climate change also depends on land management, so there should be collaboration between the Ministry of the Environment and other departments/ministries.

Community Fishery Organizations (CFi) / Local Communities

Community Fishery Organizations and local communities will have to adapt as the abundance and distribution of fish species change.

The capacity of local institutions in the fisheries sector needs to be strengthened (AIT-UNEP RRCAP 2011). This needs to start with identifying with the effects of climate change at the district or local level. There is a need for practitioners who understand the interconnectedness of livelihoods and fisheries resources and who can facilitate community reflection and adaptive management.

Implementing changes to promote climate change adaptation requires the involvement of the CFi. The impact of climate change on fisheries has wide implications for local economies. This includes implications for nutrition and health, given that fish are the main source of protein for many rural Cambodians. One strategy to promote local

adaptation include is to mobilize local users groups and community fisheries organizations. It is important to integrate climate change concerns into a portfolio of other risks and concerns associated with growth, poverty alleviation, equity and sustainability (Agrawal 2008). Members of the FiA report that there is a lack of education and awareness in local communities with regard to climate change impacts. Furthermore, in local communities it is difficult for people to recall or reflect on seasonal variations.

In some areas of Cambodia, the number of Community Fisheries (CFi) is high, but progress other areas has been limited. Women, and female-headed households in particular, tend to be poorer, to have less social capital and access to published information, and to have less influence in decision-making (MoE/UNDP 2009). Furthermore, as fisheries resources become scarcer and there is an increase in market value, the poorer and more vulnerable members of society, especially women and children, are assumed to have the most difficulty adapting. Fishing is one of a variety of livelihood activities including wage labor and farming (Béné and Friend 2011). Thus, livelihood diversification and agricultural extension should be seen a complementary adaptation strategies.

The declining natural productivity in the fisheries sector has implications for fish security and nutrition at the community level. The focus of efforts at the community level should be on increasing adaptive capacity.

Vulnerable Areas (MoE/UNDP 2009)

- Upper Mekong and 35 tributaries in Stung Treng, Kratie, Rattanakiri and Mondulkiri
- Tone Sap fisheries

Table 3 Results from the focus group at the FiA meeting - CFi group

Anticipated Impacts	Observed Impacts	Adaptation Options
- Unknown by participants	- Flood damage, storms, irregular warming, storms	- Adapt by making ponds for conservation, making conservation areas, and developing new crops - Improve understanding (sanitation, disasters, storms) - Build capacity for problem solving -Create and improve livelihood options; diversify livelihoods - Create/build self-help groups - Extend/promote understanding of climate change - Grow/re-grow forests and the flooded forest - Dig ponds, rehabilitate canals, make conservation areas - Select livelihoods option to adapt to climate change - Build networks and provide information on climate change

Projected Impacts of Climate Change:

There could be reduced fish catches in the inland capture fisheries sector because of changes to water level and hydrology (UNDP/MoE 2011).

- Inland capture fisheries could provide a decreased yield (Johnston *et al*. 2009).
- Changes to natural hydrology could alter the flood pulse (the reverse flow of the Mekong into the Tonle Sap Lake), which drives the productivity of the whole region.
- Climate change could have a negative impact on the health and spawning ability of (Ficke *et al*. 2007).
- The diversity of fish and migration patterns of key fish species could change (Abell *et al*. 2007).
- The movement of people into fishing areas with higher yields may cause human conflicts (World Fish Center/SIDA 2009) and increase the vulnerability of riparian and floodplain communities.

Adaptation Responses:

- It is important to focus on the ability of small-scale producers to adapt by improving productivity and diversifying income sources.
- Responses are needed that integrate fisheries and agriculture (integrated rice-field fisheries and fish reservoirs run by CFi).
- Aquaculture in reservoirs near communities should be developed to reduce pressure on native fisheries in response to declining yields.
- The governance of CFi needs to be improved to reduce destructive fishing and encourage conservation (Metret 2011). Other adaptation programs include disaster preparedness and financial insurance to mitigate risk (i.e. micro-credit).
- Fishers could be encouraged to change some of their fishing methods (World Fish Center/SIDA 2009).
- Insurance schemes could be introduced and physical defenses and infrastructure strengthened.
- A disaster preparedness or early warning system could be introduced.
- Integrating pond aquaculture and other farming activities is generally considered to improve farm income (World Fish Center/SIDA 2009).
- The type of fishing gear used can be changed to increase its efficiency and affordability.

Aquaculture

Aquaculture has the opportunity to buffer the impact of climate change by providing livelihood alternatives. Aquaculture is useful in adaptation because a farmer can wait until food prices are high to sell his fish (Johnston *et al*. 2009). Intensification through aquaculture is also an opportunity to diversify farmer income. The diverse range of environments in which aquaculture can be used (ponds, cages, rice fields) may allow farmers to switch to aquaculture in areas affected by saline intrusion related to rising sea levels (Johnston *et al*. 2009). As Cambodia's agriculture sector is extremely vulnerable to climate change, rice-field fisheries and fish sanctuaries could help mitigate the effects of climate change (MoE/UNDP 2011).

Table 4 Results from focus group at the FiA inception workshop - Aquaculture group

Anticipated Impacts	Observed Impacts	Adaptation Options
- Lack of water resources - Reduced water quality - Higher salinity - Less oxygen in water - Fish easily affected by viruses - Lower food quality - Not enough fingerlings produced on time; not enough fish to meet market demand; lower quality fish - Declining aquaculture productivity and lower incomes	- Reduced aquaculture productivity caused by changing weather patterns - Lost income - Fish easily affected by viruses - Brood stock killed - Harm from floods because of destroyed infrastructure	- Set up floating cages - Build dikes surrounding fish farms - Set up fences or nets surrounding fish ponds - Dig big and deep ponds - Dig wells - Prepare farms near the water resources - Culture fish that grow easily, need less water, and survive diseases - Prepare for infrastructure protection

Projected Impacts of Climate Change:

- Area with potential for aquaculture may shift or expand due to changes in seasonal flooding and water availability.
- Water levels also could limit freshwater abstraction for aquaculture.
- The availability of trash fish as an input for aquaculture may not be as reliable, and there may be a limited supply from the marine sector (World Fish Center/SIDA 2009).
- Damage to fishing infrastructure and aquaculture installations (World Fish Center/SIDA 2009).
- Rising temperatures may increase diseases in aquaculture (Johnston *et al*. 2009)
- Storms and extreme weather may become more frequent.

Adaptation Responses:

- Species that are resilient in the context of climate change need to be selected.
- In order to improve water productivity, fish farming/small-scale aquaculture should be integrated into irrigation production systems, i.e. rice-field fisheries. If areas are no longer cultivable then small-scale producers can switch to aquaculture systems (Johnston *et al*. 2009).
- The capability of brackish water aquaculture should be improved with proper infrastructure design as well as land and water use policies (Johnston *et al*. 2009).
- Aquaculture should be diversified by findin*g and* growing species that are more climate-adaptable.

- Aquaculture producers will have to avoid overfeeding and overstock*ing fi*sh and to monitor water temperature.
- Technologies need to be adapted to suit the capability of diverse groups of people including the poor (Johnston *et al*. 2009). There is also the possibility of reviving indigenous techniques of fish aggregation and floating beds.
- Indigenous species should be used and culture technology improved to prevent overfishing and overfeeding.
- Species should be screened and better-adapted species selected, or strains could be developed that are physiologically more tolerant to the changing environment (World Fish Center/SIDA 2009).
- There is a need for feeding practices that are more ecologically efficient and less polluting, and for disease treatment and prevention measures (World Fish Center/SIDA 2009).

Post-harvest

The following table summarizes the results of the post-harvest discussion group:

Table 5 Result from the focus group at the FiA inception workshop - Post-harvest group

Anticipated Impacts	Observed Impacts	Adaptation Options
- Processing (post-harvest) areas and roads destroyed by floods - Temperature changes - Lack of raw materials - Increased rainfall	- Floods - Storms - Irregular rainfall - Extreme weather	- Improve transportation options and equipment (boats) - Create alternative safe areas to continue processing activities - Establish dry kilns for drying fish - Improve understanding and knowledge about climate change and prevention

<u>Projected Impacts of Climate Change:</u>

- The overall impact of climate change increases as fish catches decline (FAO 2007).
- Storms and other extreme coastal events are expected to increase over time.
- Large-scale processing is expected to become less profitable.
- Fisheries and aquaculture installations could be damaged (Johnston *et al*. 2009).
- As Cambodia only exports a small portion of its fish and fish products, the impacts will have a relatively small impact on the national economy.

<u>Adaptation Responses:</u>

- Insurance schemes could be introduced.
- Investment in better infrastructure could be increased and a disaster response plan developed.

- Traditional post-harvest methods that are more resilient could be promoted; i.e. local materials, traditionally smoking fish (Johnston *et al*. 2009).

Adaptive Management and Capacity at the Local Level

According to Agrawal (2008), "An adaptive perspective on development will require the willingness to experiment, capacity to take the risk of making mistakes, and flexibility to make space for social and institutional learning."

Figure 2. Adaptive Management Cycle (SOURCE: CSIRO Marine and Atmospheric Research Adaptive Management Cycle: **http://www.cmar.csiro.au/research/mse/**)

With the exception of regions bordering the Mekong River Delta in northern Vietnam, which are susceptible to flooding and sea level rises, most of Cambodia has relatively little exposure to serious climate hazards. However, the low adaptive capacity of most Cambodian provinces makes them vulnerable to the effects of climate change (Yusuf and Francisco 2009).

Understanding the multi-scale causes of vulnerability can help identify the multiple social, economic, and political scales for intervention. If we are to complete a vulnerability assessment, it is important to understand the variables affecting vulnerability and adaptive management. The list in Allison *et al*. (2009) provides a good summary of these variables.

Adaptive capacity and vulnerability are related to health, education, economics and governance (Allison *et al*. 2009). Local institutions should be seen as the starting point for developing adaptation strategies for the fisheries sector in Cambodia.

Elements of adaptive management include constantly revising management plans (see Figure 1)

- Planning for uncertainty
- Building local responses
- Diversifying livelihood options
- Modifying management regimes based on emerging conditions

When planning in the fisheries sector, it is important to take climate change into account. However, we must not forget to focus on vulnerability. The groups of people that are marginalized because of poverty are the ones that will have the most difficulty adapting. They are the groups that have the least representation within decision-making bodies in communities as well as the least access to education, health care and social security (Ribot 2011). Local institutions should be the starting point for developing adaptation strategies for the fishery sector in Cambodia. Local communities and Community Fishery Organizations know more about local conditions of vulnerability.

Conclusions and Recommendations

Demand for detailed accounts of local adaptations to climate change is growing. These accounts can serve as the basis for exchanging knowledge and lessons learned across Cambodia (AIT-UNEP RRCAP 2011). Vulnerable groups have lower institutional access than to those that are wealthy (Agrawal 2008). Thus, adaptation strategies should focus on such vulnerable groups as women or landless fishers.

The most immediate and dramatic effects of climate change will be felt in Cambodia's fisheries sector. The changes that will occur to the country's natural hydrology will impact key fisheries habitats and fisheries productivity. The climate is changing, and fishing practices and aquaculture in Cambodia must adapt if many negative impacts on livelihoods are to be avoided. The changes that will take place in the fishery sector are many and diverse, and these changes will be felt in different ways at the local level, depending on local circumstances and ecosystems.

Although awareness of the threat climate change poses to the fisheries sector is growing, there is also much uncertainty regarding the nature and scale of the impacts (FAO 2007).Therefore, more research, case study evidence and local knowledge are needed. The absence of local information about the impact of climate change on livelihoods combined with the importance of fisheries for the nutrition and livelihoods of many people makes Cambodia highly vulnerable (Moorehead 2009). Existing national plans for adaptation seem to have given local institutions (CFi) a limited role in designing, supporting and implementing adaptation (Agrawal 2008).

- There needs to be a focus on adaptive capacity on the local level, and adaptation needs to be seen a complex matrix of changes. The focus should be on helping vulnerable groups and strengthening sectors such as health, education, and local economies (Allison *et al.* 2009).
- There needs to be more scientific research on the impact of changing hydrological regimes on fish species, especially *trey riel*. The science of climate change and the impact on fishers is largely uncertain. More research is needed.
- An early warning system should be developed along with a regional map showing areas that are particularly vulnerable to loss of fishing capacity or other indirect impacts of climate change (World Bank Group 2011).

- There needs to be sharing of information on innovation and adaptation. Funds for adaptation need to be accessible to local communes. Downstream and upstream communication needs to be put in place.
- Tools for knowledge development include natural resources mapping and hazard mapping, unstructured focus group discussions, studies of elements of ecosystem change (see UNEP RRCAP 2011).
- There need to be clear and concrete village-level problems and objectives (AIT-UNEP RRCAP 2011) related to conservation and management of fishery resources and adaptation to the changing availability of these resources.
- More holistic planning is needed between sectors including more dialogue with the forestry and agricultural sectors. Adaptation in the fisheries sector needs to integrate other hazard reduction programs such as those related to flooding. Adaptive strategies need to be designed with a multi-sector perspective (Badjeck *et al.* 2010).
- Useful tools for adaptation should be developed. These tools must be easy to use and accessible for people with little knowledge of the larger climate change context. Technologies suggested in each sector need to be piloted and knowledge shared.
- The awareness of all relevant stakeholders should be increased through successful communication. To communicate effectively about climate change, it is essential to know how people understand it and experience it at the local level (MoE, BBC Trust, 2011).
- Long-term adaption strategies and measures are needed for the fisheries sector.
- A network of fresh water protected areas is needed to provide refuge to fish populations.
- There is a need for baseline or socio-economic data that can provide a comprehensive picture of the degree and nature of participation of CFi (World Fish Center/SIDA 2009).

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