Mainstreaming Natural Resource Management at Cambodian Inland Fisheries Communities

Resilience Mechanisms in Fisheries Communities

CONSERVATION INTERNATIONAL

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Executive Summary

Cambodia is one of the South East Asian countries most sensitive to climate change impacts and its population is highly vulnerable. In the past few years, local community fisheries (CFi) around the country have already experienced extreme and unexpected climate variations which have dramatically affected livelihoods and exacerbated the difficulties related to unsustainable use of natural resources.

Yet Cambodia's population is resilient, and initiatives have emerged all over the country to adapt to these new extreme weather patterns and environmental changes. Here we detail several mechanisms set in place in the three fish-dependent regions of the Tonle Sap Lake, the Mekong river and its tributaries, and the Coastal Area. Mechanisms encompass a variety of activities such as replanting, sustainable fish farming, the use of solar power, or crop diversification.

Local CFi are also advised to diversify their sources of income, as opposed to relying on a single livelihood, especially if it is prone to climate vulnerability. Potential new income sources can be eco-tourism, small businesses, savings groups, etc. CFi are encouraged to request the Government to provide more financial support to communes for climate change adaptation measures.

If these mechanisms are locally implemented, there are opportunities to learn from those which are successful and replicate them in other CFi. We have compiled selected case studies highlighting successes and turned these into "How to" guides to be disseminated with national level stakeholders in Cambodia. Close collaboration with the Royal Government of Cambodia will entail advocating for large scale implementation of these mechanisms.

The current review concludes by providing recommendations to enhance resilience at fisheries communities in Cambodia including: providing technical training and raising awareness of climate change impacts amongst CFi members; increasing funding available to implement resilience mechanisms; creating knowledge sharing networks and promoting synergies amongst stakeholders; and actively restoring vital ecosystems as well as enhancing their protection and conservation.

Photo credit: Kristin Harrison & Jeremy Ginsberg

Introduction

The current report is framed within the Mainstreaming Natural Resource Management (MNRM) project carried out by the Scientific Capacity Development initiative (Sci-Cap). Sci-Cap is dedicated to enhancing technical capability and scientific research skills of Cambodian nationals through collaboration with governmental, non-governmental and academic institutions in the country. The MNRM project aims at gathering information and spreading awareness of natural resource management, promote collaboration and knowledge sharing and contribute to sustainable resource management at Cambodian fisheries communities.

The aim of this report is to outline the main mechanisms that contribute to increasing resilience and decreasing vulnerability of Cambodian fisheries communities to face the challenges presented by climate change, fish stock decline and ecosystem degradation from unsustainable use and large-scale infrastructure development. The report compiles examples and case studies of resilience mechanisms implemented successfully at fisheries communities on the three-main fish-dependent areas of the country: the Tonle Sap lake and flood-plain, the Mekong river and its tributaries, and the coastal areas.

The challenges facing these communities are complex and the pressures they are subject to come from the combined effects of these challenges. There is no right recipe for resilience, only a battery of options that will provide safety nets to combat environmental and economic threats. Just as in evolution, the higher the diversity of adaptations developed, the better the chances of surviving and thriving in changing, complex environments will be.

Definitions

Resilience – Amount of change a system can undergo without changing state. (IPCC, TAR, 2001)

Resilience – Resilience is a tendency to maintain integrity when subject to disturbance. (UNDP, 2005)

Resilience – The ability of a system to recover from the effect of an extreme load that may have caused harm. (UKCIP, 2003)

Resilience – The capacity of a system, community or society potentially exposed to hazards to adapt, by resisting or changing in order to reach and maintain an acceptable level of functioning and structure. This is determined by the degree to which the social system is capable of organizing itself to increase its capacity for learning from past disasters for better future protection and to improve risk reduction measures. (UN/ISDR, 2004)

Resilience – Refers to three conditions that enable social or ecological systems to bounce back after a shock. The conditions are: ability to self-organize, ability to buffer disturbance and capacity for learning and adapting (Tompkins *et al*,. 2005).

The definitions provided by the IPCC, UNDP and UN/ISDR focus on the capacity of a system to withstand disturbance and remain functional whereas the UKCIP defines resilience in terms of the system's ability to recover from the impact. These interpretations consider two different aspects of resilience; as the ability not to sustain damage and as the implication that damage may occur but the system can recover from it. Considering the practical application of the term resilience, some scholars have proposed use of a more comprehensive definition based around ***"adaptive capacity as the umbrella concept that includes the ability to prepare and plan for hazards, as well as to implement technical measures before, during and after a hard event… the resilience be regarded as one property that influences adaptive capacity."*** (Klein *et. al.*, 2004).

In this context, ***"vulnerability"*** may be viewed as inability to cope and resilience as ability to cope, placing these terms as two ends of the spectrum (OECD/IEA, 2006).

Throughout this report, the resilience mechanisms described apply to the broader adaptive capacity both to withstand impacts and to enhance the communities' ability to recover.

The Cambodian context

Cambodia has been ranked as one of the countries in the world most vulnerable to the impact of climate change on fisheries. This vulnerability stems from the combined effects of predicted warming and the high significance of fisheries in the national economy and diet (Allison *et al.*, 2009).
Cambodia's economy, food security and biodiversity are highly dependent on fisheries. Inland, the Tonle Sap Great Lake and the Mekong river and its tributaries are closely interconnected. The yearly "flood-pulse" pushes water from the Mekong into the Tonle Sap flood plain to almost double its size creating essential habitats for many fish species to reproduce. The extent of flooded area can fluctuate greatly between years and has a direct impact on fisheries' productivity. Analysis of cumulative impact assessments (CIA) concludes that infrastructure development, large irrigation schemes and rapid urban development, as well as climate change effects will result in highly damaging changes in ecosystem dynamics (Kummu & Sarkkula, 2008).
Inland fisheries in particular are affected by precipitation changes which influence the extent of flooded forest available for fish species to spawn and the distribution of aquatic habitats. In addition, changes to the hydrology provoked by infrastructure, including hydropower dam construction, further exacerbate deterioration of aquatic habitats (Ishikawa *et al.*,, 2017). Fish stocks are influenced more by climate and hydrology changes than by fishing activities (Takagi *et al.*, 2005).
Severe climate change effects have already been felt around the Tonle Sap in recent years. Floods and drought- sometimes occurring within the same year- have provoked considerable losses (Danida, 2008). More recently, the severe impact of El Niño-driven drought in 2016 resulted in forest fires that consumed more than 250.000 hectares around the Tonle Sap lake (Phnom Penh Post, 2016).
Coastal fishing communities are also vulnerable due to a combination of threats. Fish stocks are directly affected by overfishing both by local communities and international vessels, particularly due to the use of illegal and highly destructive fishing methods such as trawling. Urbanization, industrialization and agricultural activities are responsible for the degradation and pollution of some coastal areas. Loss of mangrove forests decreases coastal protection and extent of area available for healthy aquatic ecosystems. Sea-level rise of potentially 1 meter by 2100 is likely to be the most apparent and severe effect of climate change in the coastal areas (Rizvi and Singer, 2011).
Both inland and offshore, studies indicate that fish stocks are declining whilst overall fish catch in terms of biomass remains stable or is increasing, adding up to potential difficulties in the future (Rizvi and Singer, 2011; KC *et al.*, 2017).

Community Fisheries (CFi)

Fisheries in Cambodia are managed through Community Fisheries (CFi). In 2012, the Deep Fisheries Reform conducted by the Cambodian government encouraged local villages to establish CFi which are managed by Community Fisheries Committees (CFCs). According to the sub-decree on Community Fisheries Management a CFi is:
"a group of Khmer citizens who live in or near the fishing area and voluntarily establish the initiative to achieve:
(a) the management of inland fisheries where fishing lots have been canceled
(b) to manage fisheries resources in a sustainable and equitable manner
(c) to increase understanding and recognition of benefits of fisheries resources through participation in protection and management
(d) to provide a legal framework to establish community fishery and
(e) to improve the standard of living and reduce poverty"

Resilience Mechanisms available in Cambodian CFi

To promote resilience means to enhance the ability of the ecological and social environment to cope with disturbance and re-shape while going through change (Walker *et al.*, 2004). Resilience however, also brings an element of opportunity; disturbance often opens up spaces for the renewal of structures and processes and the possibility of innovation (Folke, 2006).

Organizations working in the country as well as the Royal Government of Cambodia have long been working with vulnerable communities in a variety of mechanisms to promote resilience to face a changing environment. Beyond implementing specific techniques, one conclusion arises from their experience: promoting awareness and facilitating learning for innovation and change has a profound impact on the ability of communities to adapt and become resilient (Diepart, 2015). The report *"Learning for resilience: Insights from Cambodia's rural communities"* offers examples of resilience mechanisms applied all over the country and is a source of valuable insights on their practical implementation.

Considering learning as the main driver for resilience, the mechanisms reviewed here represent examples which revolve around three main avenues of adaptation: using infrastructure and innovative technology to protect communities and promote sustainable use of resources; restoring and conserving habitats which provide ecosystem resilience; and promoting diversification of livelihood options and economic activities.

Tonle Sap Lake

Rehabilitation of small-medium irrigation schemes in Tonle Sap basin

A number of technologies are available for community based water management, some new and others old and as such very familiar in Cambodia. The systems available include the construction of reservoirs and ponds as well as associated canals for irrigation; wells; rain-harvesting and the use of renewable technologies such as wind and solar to power pumping as well as more sophisticated drip irrigation for farming purposes.

The United Nations Development Programme (UNDP) carried out a project designed in response to the priorities identified in Cambodia's National Adaptation Programme of Action to Climate Change (NAPA). To train communities in the implementation of resilient water management systems the project published the *Climate Resilient Irrigation Training Manual*, also available in *Khmer*.

The manual reviews two types of small-scale water sources, ponds and rain-water harvesting as well as two renewable technologies to pump water, solar and wind power (MAFF PSU, 2015). Ponds and reservoirs are the most familiar systems of water storage used in Cambodia. While not ideal for domestic water supply due to the threat of contamination, they can be a very useful water source for fish raising watering of vegetable gardens. To enable use of storage systems for irrigation, canals were constructed in the past in some areas but have fallen into disrepair over the years. The rehabilitation of such systems presents an opportunity to improve water-management resilience mechanisms as illustrated by the case study below.

Rehabilitation of irrigation canals in Kampong Thom

Kampong Ko Leu village, situated along the Stung Sen river in Kampong Thom province, was selected as a pilot village for Small-scale and community-based irrigation systems.

As of 2015, farmers reported being affected by drought and dry spells in the 10 years proceeding, affecting their rice crop. Access to irrigation could help shift the cropping calendar for early wet season rice thus limiting the risk of flood damage during the harvest period.

For 2016-2020, NGO Caritas plans to rehabilitate a canal of about 3,000 meters and construct two water gates that could control and manage water in the canal and allow irrigation year-round. Other NGOS will implement rehabilitation of the secondary and tertiary irrigation canals. On the basis of their study, the Tonle Sap Authority (2015) recommendations include strengthening farmer capacity building by way of short training on management of irrigation systems.

MAFF PSU (2015). Climate Resilient Irrigation Training.

Replanting flooded forests in Tonle Sap basin

The importance of the flooded forests around the Tonle Sap both for biodiversity and livelihoods cannot be overestimated; 95 percent of the 3 million inhabitants of the lake are directly dependent on the natural resources of the lake for their livelihoods (IFReDI, 2012). The flooded forests hold essential habitats for fish to reproduce and grow; without the flooded forests fisheries would collapse along with the food security.

Moreover, the flooded forest of the Tonle Sap is the largest continuous area of savannah swam forest and inundated forest in all of Asia (ADB, 2005) and supports great biodiversity; almost a third of threatened species in Cambodia. The lake and flooded forests have been recognized as wetlands of international importance by establishing two Ramsar sites.

Restoring and promoting the regeneration of the Tonle Sap flooded forests directly combats the threat of deforestation, helps fish recover spawning and nursery areas and enhances resilience of the surrounding communities.

Conservation International replanting activities in the Tonle Sap

CI's approach to conserving the flooded forest and its wildlife is three-fold: to help the communities understand the value of the forest and wildlife and find ways to reduce their wood consumption; to replant previously cleared areas; and to protect the regenerating and remaining stands of flooded forest.

Regular education sessions delivered by CI's Tonle Sap Team have helped communities understand the critical function of the forests in sustaining the fish that the communities base their livelihoods on. These sessions have broached the topic of illegal hunting of wildlife, and made clear to the community the ecological and legal ramifications of continued harvest of protected species. CI has also delivered technical trainings for the CFC to share with broader communities on the correct way to harvest wood when needed so as to not kill trees unnecessarily; and introduced household technologies which have reduced families' reliance on wood (see section on fuel efficient stoves).

CI has worked with the CFCs to build re-vegetation into their management plans. Since 2012, CI has collaborated with the FiA and CFCs to replant over 160 ha of flooded forest in five different locations. To ensure the most cost-effective supply of seedlings, each CFC established a tree nursery close to replanting areas, sharing the responsibility of collecting seeds from surrounding flooded forest areas. It is worth noting that the tree nurseries established under this project have gained wide recognition, such that the community has been receiving orders for seedlings from outside buyers, and this will continue to be another sustainable revenue source for the CFCs in the long term.
The seedlings are raised until they reach between 30-40 cm, and then they are replanted. The assessment on survival rate of replanting has been conducted annually in each location, with dead seedlings replaced by the replanting teams. The rate of seedling survival has proven to be 41 to 59 percent, averaging about 53 percent, not including replacement seedlings. This is a positive achievement, especially in light of at least one 'failed' wet season due to El Niño in 2015. CFCs are now able to manage the entire process of raising, planting, maintaining, and replacing seedlings themselves, with very little technical assistance from CI.

Conservation International (2016). A Rising Tide Lifts All Boats. CI on the Tonle Sap Lake. Achievements to Mid 2016.

Photo credit: Sokrith Heng

Sustainable Fish Farming

In Cambodia, aquaculture accounts for approximately 10% of total fish production with the actual yield of six main production systems estimated at 37,000 metric tons in 2011 (Joffre *et al.*, 2010).
The Royal Governement of Cambodia's Fisheries Administration has developed a national Aquaculture Development Plan (2000–2020), which aims to expand aquaculture production to at least 300,000 metric tons of fish per annum by 2020 to maintain the annual per capita consumption level of 30 kg (Joffre *et al.*, 2010), necessitating a significant increase in total aquaculture production.

To this end, a study by WorldFish, in partnership with the Stung Treng Fishery Administration Cantonment and the Culture and Environment Preservation Association, beginning in 2011, aimed to improve the uptake of small-scale aquaculture by communities with limited experience in fish culture in Stung Treng Province, in North East Cambodia. The system was called "WISH ponds," an amalgam of "water" and "fish" to reflect the integration of fish cultivation with water for storage and vegetable growing (Johnstone *et al.*, 2012).

The "WISH" ponds consist of raised concrete tanks (3 x 4 x 1.2 meters), stoked with a maximum of 800 fingerings per pond. The species chosen for this small intensive aquaculture system was African catfish (*Clarias gariepinus*) due to its known high resistance to low water quality conditions. Ponds were equipped with a water outlet for drainage, water exchange and harvesting. Most ponds were covered with a shading structure to protect them from excessive sunlight and had a light bulb installed above to attract insects at night to provide supplementary feeding for the fish (Figure 1). The "WISH" protocol instructed participating farmers to change the pond water at least once every 10 days, weight the fish once a month, calculate weekly feeding rates and observe the fish whilst feeding them daily.

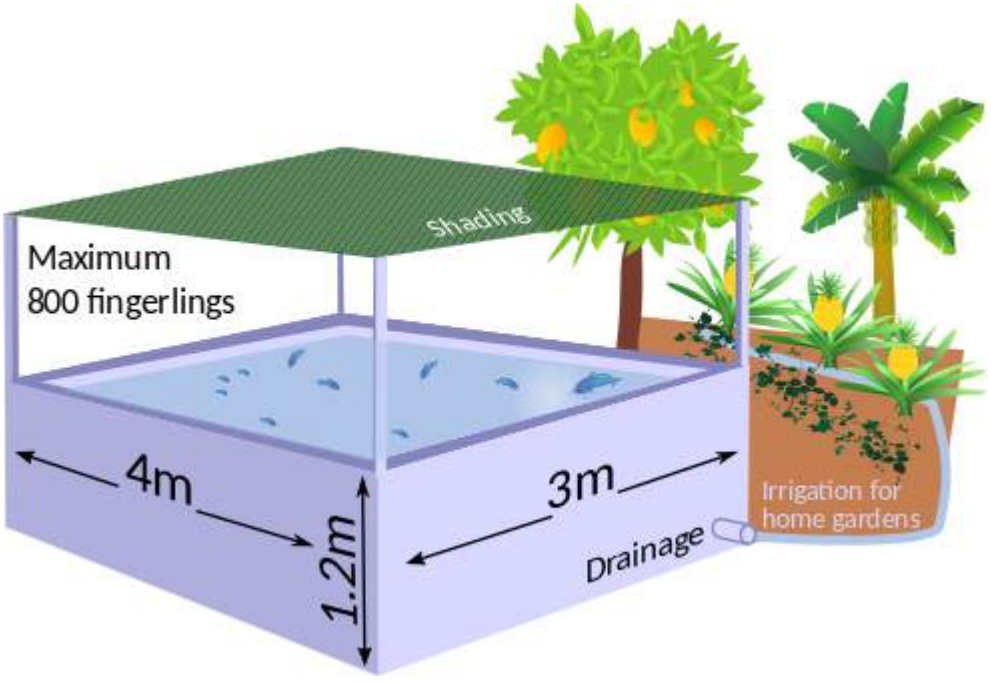


Figure 1: The "WISH" pond system. Graphical representation created by the authors.


Photo credit: WorldFish / Sylyvann Borei

With focus on how research was used by the community to test and develop aquaculture ponds that met the needs of households, the study developed a learning platform to explore different techniques to improve small-scale aquaculture by understanding costs and benefits and identifying potential sustainable methods for introducing and adopting ponds (Johnstone *et al.*, 2012).

The study concluded that farmers need more practice to become familiar with the requirements for fish feeding, feed handling and water management to ensure the end product (fish market size, overall fish biomass at harvest and vegetable production) becomes profitable.

However, when the profit from fish consumed by the most successful households was included in the total profit, a result of 33.5% of farmers with benefits was achieved, suggesting that the income potential could significantly improve if the farmers followed appropriate WISH management practices.

The following constraints to sufficient aquaculture development were identified: lack of access to external support, including private sector and/or extension services and knowledge sharing and cooperation within the community; high initial costs; lack of technical knowledge; and poor market access (Joffre and de Silva 2015).

Adjacent to the house, the WISH system eliminates the need for mobility for women normally restricted to the household. Therefore, this placement can be an opportunity which contributes to economy and nutrition, particularly in villages that currently depend profoundly on a declining fishery during the dry season.

The system requires farmers to obtain sufficient water for their ponds with the increasing market price of fish later in the dry season to provide a significantly increased return for WISH pond fish.

The report concludes: “The WISH system should be further evaluated, possibly through a scale-out involving more households in other target areas.” (Kwasek *et al.*, 2015).

Rice Field Fisheries

In Cambodia, farmers have a long tradition of a semi-natural aquaculture that is an intrinsic part of rice paddy farming. Fish are common throughout rice paddies and migrate in and out of the flooded rice fields from adjacent rivers and ponds as the monsoon comes and goes. The connection between rice and fish is reflected in the Cambodian proverb *"plant rice and harvest fish"* .The presence of wild fish in rice paddies brings multiple benefits to farmers (Thi *et al.*, 2015).

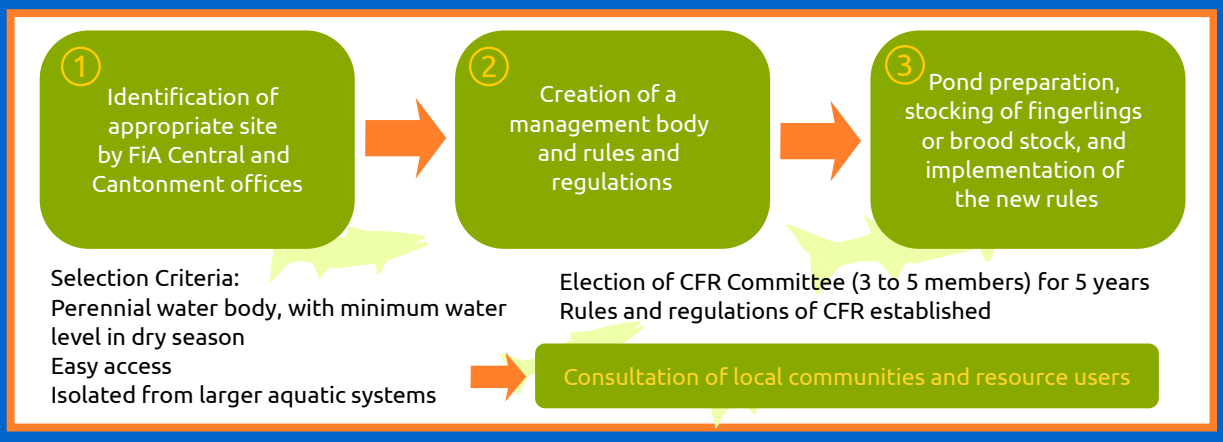
Rice field fisheries account for 20-25% of the total inland fisheries catch. To enhance their potential WorldFish partnered up with local NGOs and government institutions at 40 CFis around the Tonle Sap lake. Phase I of the program run from 2012 to 2016 and focused on making physical improvements to the infrastructure connected to the rice field fisheries as well providing capacity building to improve governance of the CFis. The infrastructure improvements focused on enhancing the capacity of Community Fish Refuges (CFRs) to provide breeding and dry season habitat for fish (Brooks and Sieu, 2016).

As result of CFR improvements and training, households in the areas of influence reported a 9% increase in fish catch, with the poorest quarter of households seeing a 71% increase over the same period (WorldFish, 2017). Fish productivity in the rice fields increased 20-120% per hectare and the income generated from selling fish increased 10-fold from 2012 to 2015. Phase II (2016-2021) includes expanding the sustainable management practices to 100-120 CFRs, developing a water management model and continue promoting the nutritional value of fish.

Community Fish Refuges

A community fish refuge (CFR) is a natural or artificial pond connected to the rice fields that retains water during the dry season allowing fish to survive. Rice field fish migrate into the pond at the start of the dry season and return to the fields with the wet season floods to feed and spawn. CFRs can also be re-stocked with native species fingerlings. Re-stocking is usually undertaken during the first year of the CFR to stabilize fish populations.

Creating new wetland habitat such as artificial fish ponds near the village can provide a reliable supply of fish and support other wildlife. Fish ponds should not be created at the expense of existing natural wetlands. The ponds should have natural vegetation around their banks, have shallow and deep parts, and have varied curved banks rather than straight ones. Only native species of fish and plants should be used because they will be healthier and will not pose a danger to wild fish populations if they escape (Thi *et al.*, 2015). Community participation, technical support and effective coordination with government institutions and local authorities are essential elements to improve CFR management and productivity or to establish new CFRs (Joffre *et al.*, 2012)



Main steps in CFR establishment. Adapted for Thi *et al.,* (2015) from Joffre *et al.,* (2012).

Solar Power Irrigation in Kratie Province

Changing weather patterns mean Cambodian farmers can no longer rely on rain-fed agriculture alone for subsistence and income generation. Setting up resilient water management systems, including resilient irrigation methods can make a significant difference to rural communities throughout the country.

One of the technologies recently implemented is the installation of solar pumps for irrigation. This system provides a clean technology which given the reliability of sunshine in Cambodia, can be potentially used in combination with a pipe system to provide water to different parts of the village. Set up costs are high ($7500) which means villagers will only use this technology if there is support available for the capital cost.

In 2014, 35 solar pump systems (20 in Kratie and 15 in Preah Vihear Provinces) were installed in 37 villages, from which 1,481 households benefited. Field visits indicated that about 50% of beneficiaries started practicing home-gardening, earning an average 30,000-50,000 Riels (US$7.5 – US$12.5) per day from selling their surplus vegetable to the local small market.

Water User Groups (WUGs) were formed to manage those water supply systems and user fee collection mechanisms were put in place. For each solar pump system, the WUG could collect approximately 300,000 Riels (US$75) per month.

Three new irrigation schemes (two in Kratie and one in Preah Vihear) were rehabilitated in late 2014, with the potential to irrigate 541 hectares of paddy fields and benefit around 248 households.

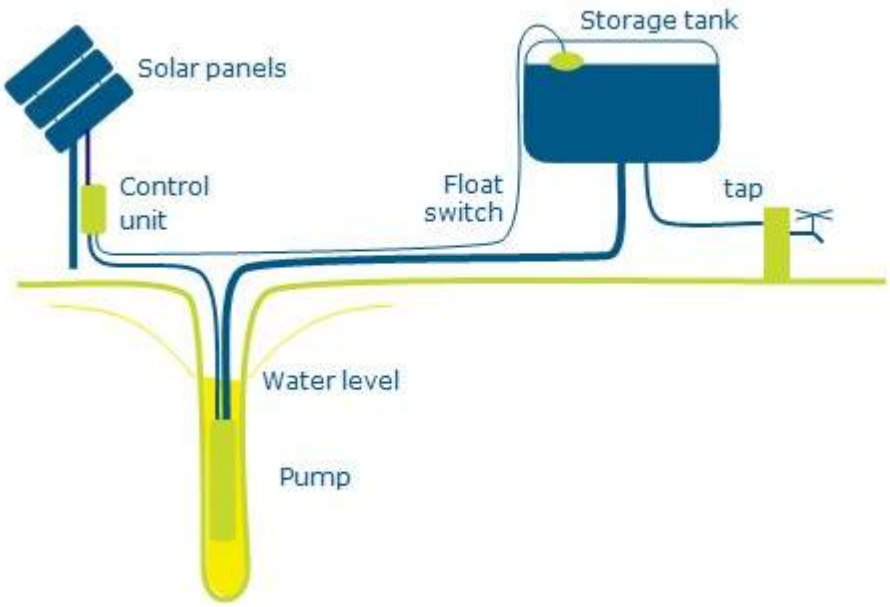


Figure 2: Solar pump system layout. PicoSol website.

Photo credit: Kla Trey / Reaksmey Sophatt

Coastal Area

Cambodian coastal areas are already experiencing the impact of climate change. Irregular rainfall, storms and salt water intrusion from sea level rise affect crops, reducing or destroying yields. Weather events also hinder fishing activities at communities where fish stocks are in decline (Rizvi and Singer, 2011).

In 2013, the Mangroves for the Future (MFF) initiative developed their National Strategy and Action Plan (NSAP) with the mission *"to promote healthy coastal ecosystems through a partnership-based, people-focused, policy-relevant and investment-orientated approach, which builds and applies knowledge, empowers communities and other stakeholders, enhances governance, secures livelihoods, and increases resilience to natural hazards and climate change"* (MFF, 2013).

Activities focused on promoting resilience have been carried out in communities along Cambodia's coastline over the past few years mainly focusing on mangrove forest conservation and restoration, livelihood diversification through the promotion of sustainable farming techniques and raising awareness (Jones & Diepart, 2015; MFF, 2017).

Restoring mangrove forests

Mangroves' ability to trap organic sediment and thus store carbon explains why mangroves are increasingly referred to as 'blue carbon' sinks. Moreover, as mangroves age, they store proportionally more carbon in their biomass because of higher productivity (Kristensen *et al.*, 2008).

Peam Krasop Wildlife Sanctuary (PKWS) holds one of the largest and densest mangrove forests in Southeast Asia. The relatively-intact mangroves mean that the area contributes significantly in the stabilization of the coast against coastal erosion from storm and tidal bore. Furthermore, the mangroves are an essential nursery and feeding grounds for fish and numerous invertebrate species that go on to feed the fisheries of the Gulf of Thailand. (PMMR, 2000).

With funding from the MFF initiative and in collaboration with the Department of Environment at PKWS and Toul Korki local authorities, Toul Korki Community Protected Area (CPA) restored 10 hectares of mangrove degraded areas with over 25000 mangrove seedlings. The project also provided education on fisheries law and protected area law to 92 families, installed 50 cement posts demarcating the CPA area, erected 6 information signboards and provided support for patrolling activities.

Introducing sustainable farming practices

Reducing overfishing and diversifying livelihood options to decrease dependency on fishing activities promotes resilience and sustainable use of resources. To this end, MFF funded actions have also focused on improving farming practices. In 2016, training workshops were conducted at Tuol Korki, testing resistant rice varieties, demonstrating drip irrigation systems that save water and increase yields and chicken de-worming practices which increase their survival rate.

Testing resistant rice varieties in Tuol Korki

The TKK CPA [Tuol Korki Community Protected Area] is situated on the mainland and most people's livelihoods depend on farming. Farmers in TKK explained to the research facilitator team the problems they have with rice production, namely frequent weather variations leading to both lack and excess of water over limited periods of time, thus negatively affecting the yield. Through the network established by the project, a research facilitator contacted a Cambodian NGO involved in farmer-led agricultural innovation. CEDAC (Centre d'Etude et de Développement Agricole Cambodgien) has been conducting field experiments in Kampong Chhnang to test rice varieties resistant to problems that are similar to those occurring in Koh Kong.

The research facilitator purchased an assortment of seeds and brought them to TKK to be tested. Subsequently, 30 households were selected for pilot activities to test five varieties of rice seeds. These included the varieties Phka Rormiet, Sen Pidaor, Phka Malis, Phka Khnei and Raing Chey. In addition, some households volunteered to carry out chicken-raising activities and home gardening.

The participatory evaluation of farmers who conducted the experiment on the five varieties of rice ranked Raing Chey in first place, Phka Romduol in second, Phka Khnei in third, and Phka Rormiet in fourth. Sen Pidaor had no ranking because this variety has very low growth rate when broadcast. After the rice seeds were selected, and the experimentation on chicken- raising and home gardening had taken place, the project team organized sessions to disseminate the results to villages in the target communes. Farmers directly involved in the experiments were required to present their results to other farmers in order to share their experience and raise awareness about the selection of high-yield rice seeds.

Through the dissemination of the results, other households have become interested in increasing agricultural production through both livestock-raising and crop cultivation. Due to the location of TKK Community Protected Area there is good potential for the expansion of agriculture to meet the high market demand for rice, livestock and natural vegetables in Koh Kong province and to supply tourists whose numbers continuously increase. On the other hand, fishing, which is a supplementary occupation of the people in TKK, has dramatically decreased. These factors have prompted people in TKK to change rice seeds, to raise chickens and to grow vegetables to increase the household income and to promote food security.

Kim, N., Kim, S. and Perfitt, K. R. (2015) Environmental change and rural livelihoods in coastal Cambodia: Understanding and enhancing adaptive capacities in Peam Krasaop Wildlife Sanctuary, Koh Kong province. in Diepart, J.-C., (ed.) Learning for resilience: Insights from Cambodia's rural communities, Phnom Penh: The Learning Institute. pp. 205-235.

Reducing dependence on forests for fuel

Another MFF funded action helped install 12 manure-powered biogas reactors in local farms. These reactors turn animal manure into energy and can last up to 40 years. The use of biogas reduces the need to get firewood from the mangrove forests or produce charcoal.

The biodigesters are a perfect alternative to the use of firewood for rural household and in Cambodia the National Biodigester Programme has been promoting and deploying this alternative technology since 2005. In 2012, the initiative celebrated the installation of their 15000th biodigester during a national level workshop in Phnom Penh. The local NGO Cambodian Rural Development Team (CRDT) have also adopted the technology to support local communities in the Mekong area.

Cambodian Rural Development Team (CRDT) Biodigesters

In Cambodia it is well known that wood and charcoal are the traditional and main sources of energy for domestic cooking. The main reason why most families prefer to burn firewood and charcoal, is the low cost and plentiful availability when compared to alternatives. Other energies such as electricity, and solar power, do not exist in most rural villages. Meanwhile, the decrease of natural forest gradually makes it harder and harder to collect firewood, and produce charcoal. They must travel further spend a great deal of time gathering fuel, so have little time for more productive activities. The renewable and sustainable energy produced by biodigesters is a good option for rural villages, as it has had a very positive effect on women's practical lives, in that domestic activities are simplified and time is saved on cooking and collecting firewood. It results in a cleaner environment in the kitchen and on the farm, also cleaner pots and pans and, generally, saves money and effort. (Mette Ide Lauridsen, 1998).

With the many years of experience in biodigester design and construction, combined with the knowledge from training courses and workshops, CRDT has developed its own technical expertise in biodigester design.

http://www.crdt.org.kh/biodigesters/

Income Diversification for Resilience

Excessive dependence on only one or a limited number of livelihood strategies, such as fishing or climate-sensitive agriculture increases community vulnerability. Communities may mitigate risks and become increasingly resilient by finding strategies that promote income diversification such as the creation of sustainable business alternatives.

Eco-tourism

According to the International Eco-tourism Society (2014), *"eco-tourism is responsible travel to natural areas that conserves the environment, sustains the well-being of the local people, and involves interpretation and education"*.

Eco-tourism can be distinguished from more general sustainable tourism through the principles expressed on the Québec Declaration on Eco-tourism (2002):
- Actively contributes to the conservation of natural and cultural heritage.
- Includes local and indigenous communities in its planning, development and operation and contributing to their well-being.
- Interprets the natural and cultural heritage of the destination to visitors.
- Lends itself better to independent travelers, and organized small group tours.

It is also important to note that tourism in natural areas can have negative consequences, including the destruction and degradation of landscapes to tourism operators drawing benefits away from communities and pushing them to exert even more pressure on the natural resources (Thi *et al.*, 2015).

In Cambodia the Ministry of Tourism recognizes and promotes *"community-based eco-tourism (CBET) [which] addresses the well-being of the community and the surrounding environment. While supporting local communities and improving livelihoods, the natural and cultural resources of the area are protected and conserved. Eco-tourism is a type of sustainable tourism in which tourists experience, appreciate and enjoy the nature and culture of their destination. The negative impacts of tourism are minimized while an incentive for conserving natural and cultural features is provided"* (MoT, 2017).

Eco-tourism in Prek Toal Bird Sanctuary

Situated in the northwestern area of the Tonle Sap Great Lake, Prek Toal Bird Sanctuary is home to awe-inspiring numbers of large waterbirds in some of the largest colonies in South East Asia.

Wildlife Conservation Society (WCS) conducted the first surveys of the area in the 1990's and soon became aware of its significance for threatened waterbird populations. Communities in the area threatened the colonies due to the intense exploitation of eggs and chicks. In 1997, IUCN and the government started restricting hunting and promoting awareness. By 2001, WCS's Tonle Sap Program was set up and focused on providing employment and training to villagers and former bird collectors as a conservation team dedicated to conduct monitoring of nests and conservation activities in the core area (Goes, 2005).

The CBET at Prek Toal started operating in 2004 with the support of WCS and Belgian NGO OSMOSE (Dowley, 2007). The eco-tourism activities help provide environmental education for children in the area, material support for village development and medical support to villagers (OSMOSE, 2017). OSMOSE remained the main eco-tourim operator in Prek Toal for several years and more recently Sam Veasna Centre for Wildlife Conservation has also started providing bird-watching specialized tours.

WCS biodiversity monitoring protocols became standardized early on and provide very accurate figures revealing the evolution of population numbers at the water-bird colonies and estimation of the effectiveness of the conservation measures deployed. By 2014 all populations had experienced significant rises in numbers and eco-tourism activities were increasingly contributing to the sustainable management of the conservation area (Visal and Mahood, 2015).

Additionally, OSMOSE helped create Saray Tonle, a community-based enterprise dedicated to the production of handicrafts from water hyacinth, an invasive plant species that clogs waterways throughout Prek Toal. Products are sold mainly in Siem Reap and currently provide income for 30 women and their families, some of which have now completely abandoned fishing as a livelihood activity and rely mainly in handicraft production (OSMOSE, 2017).

Small Businesses

Conservation International: Women's Fish Processing Groups

There is a case for small businesses promoting resilience at the community level by diversifying incomes, therefore mitigating against income shocks.

Fish processing activities make up an important source of income for floating households in Tonle Sap Lake communities, and are managed solely by women who are particularly vulnerable to poverty. Limits on access to tools of the trade and knowledge products perpetuate the poverty trap and limit the success of women entrepreneurs in floating communities. After discussion with women fish processors, CI identified ways that they bring about more return for their efforts, including:

- Organizing 17 Women's Fish Processing Groups (WFPGS) with 194 women members;
- Improving knowledge and tools at their disposal (including an innovative new fish smoking stove);
- Developing a platform for women to begin saving their earnings and supporting each other with collective access to credit.

Once WFPGs were established, CI conducted needs assessments, from which a training package for each group was designed and delivered, covering good hygiene practices, business skills and building markets for their products.

The women's exercise of collective bargaining power allowed them to negotiate higher returns and their products, which went on to gain recognition and support in external markets. Groups capitalized on these new opportunities by transporting their products to market collectively, leading to reduction of transport costs of between 50% and 70%. In addition, at the group level, the selling price of prahok increased between 14% to 133%, and smoked fish prices trebled.

The benefits realized by the groups supported by CI motivated other fish processors in the village to shift production away from producing less valuable 'semi-prahok' and selling raw fish, towards production of prahok.

Savings Groups

Savings Groups are community-led groups dedicated to saving together and lend money to members as credit. The groups are owned, managed and operated by members through simple and transparent methods. Optionally, a service fee may be charged to earn additional income for the group (World Vision, 2015).

Based on a study of savings groups set up by Oxfam, CARE and Pact in Cambodia, Oxfam America (2012) provided the following recommendations for successful implementation and running of these programs:
- Place greater emphasis on the 'right' committee members and subsequent capacity-building to increase their ability to carry out their roles and responsibilities: Trainers should help groups fully understand the roles of the committee members to help them better choose committee members.
- Ensure clear lines of communication within savings groups to promote ownership: Trainers should make sure that trainings are clear and that suggestions are not taken as rules to follow, but instead as guidelines that can be changed to best suit the group-specific dynamics.
- Encourage self-selection of membership throughout the life of the savings group: Encouraging a healthy turnover in savings groups would be positive for savings groups, so that individuals who want to be part of the group stay or join, while people leave who do not want to remain members.
- Work to define appropriate group sizes for savings groups in Cambodia in order to grow demand for the product: Implementing organizations could further examine the possibility of increasing group sizes in order to promote sustainability, given its reported benefits, including a larger savings pool.
- Examine the possibility of integrating activities into groups to promote long-run stability: Implementing organizations should think about activities besides saving and lending, such as small non-farm businesses, which could be integrated into the group to help strengthen their intra-group relationships and promote sustainability.
- Examine the impact of adopting a more flexible approach to delivering training: Implementing organizations should look at the effects of more flexible training delivery mechanisms, such as condensing some sessions in some cases, and expanding them in others, based on the capacity of the group, and its effect on sustainability.

Photo credit: Chanthorn Srorn

Conservation International women-only Savings Groups in the Tonle Sap

By June 2016, there were eight Savings Groups operating in CI's target village on the Lake. Seven of these had been directly supported by CI, and the eighth formed spontaneously when other women saw the benefits being enjoyed by the members of the CI-initiated groups.

After running information sessions and then extending an open invitation to women in the community to join a group, CI assisted the groups to elect leaders and various other key roles within their groups. CI then embarked on a series of systematic training to build the capacity of the women to save and manage savings together. These included the basic concepts of savings, credit, credit risk/mitigation strategies and book keeping as well as the benefits of teamwork and different approaches and options for resolving conflict.

With support from the CI team, the groups then developed lending policies and procedures. Savings policies across the groups are usually based on a monthly contribution of 5,000 KHR to 30,000 KHR. Loans are provided to members based on a group's approval and on funds available. Participating women have reported they usually need to take loans for buying fishing gear, investing in home gardens, fish and pig raising, paying off loans taken from outside the group and other family purposes. The loans are provided at an average 1% interest rate, lowering the likelihood of women and their families becoming trapped in debt. They are approved depending on business-related urgency and the member's loan repayment history. At the end of the one-year cycle, the interests and the Savings Group's other income are distributed among members. Community members not belonging to Savings Groups can access loans but only if none of the groups' members require one. The savings capital is re-invested for the next year. In Akol and Along Raing groups, some clients have already invested their interest in the capital, to obtain higher interest yields in year two. To give the groups an additional boost, CI invested $1000 each in five of the Savings Groups' accounts, and this capital will be rotated between the groups to fairly share the benefits of the extra interest over time.

The Savings Groups are contributing to two significant shifts in the target communities. The first of these is the overall wealth of families in CI's target area. Through household surveys that measure a range of indicators such as house construction materials, boat ownership, household assets, and investment in family businesses, CI has found that between 2011 and 2016, the percentage of families ranked as 'very poor' decreased from 68% to 34%. Meanwhile, middle-income families increased from 20% of the families to 48%.

A second positive result of the Savings Groups is that some are now contributing some of their profits to the Community Fisheries Committees (CFCs), a traditionally male-dominated domain. When Savings Groups become 'donors' to the CFCs, the power balance shifts. Their financial stake in the CFCs mean that women's voices are amplified in debates about the management of local fisheries and forests, and their views now carry weight in decision making. CI staff have observed a step change in women's confidence levels through their participation. Initially shy and hesitant individuals have now become organized groups of outspoken and active women. These shifting power bases are new territory for these villages – but crucial to effective local management of the Tonle Sap that will preserve its riches for coming generations.

Conservation International (2016). A Rising Tide Lifts All Boats. CI on the Tonle Sap Lake. Achievements to Mid 2016.

Request for Increased Commune Funding for Climate Change Adaptation

As illustrated by the case studies and examples described in this report, there are a great variety of avenues to enhance resilience at Cambodian CFis. However, the main issue they face is lack of funding to implement actions. Climate change impacts combined with continued fish stocks decline and habitat degradation from infrastructure development are set to increase the vulnerability of communities, continue eroding food security and further damage the ecosystems they depend on. It is precisely dependence on fish that makes Cambodia one of the countries in the world most vulnerable to climate change impacts and it is therefore fishing communities that face the most daunting challenges in the years to come.

Communes need further funding and support from the RGC in order to put in place resilience mechanisms that safeguard the habitats they depend on, enhance food security and provide sustainable and diverse sources of income. CFi should build their capacity in voicing their needs and thus ensure that climate change adaptation is considered a priority by communes and included in the annual Commune Investment Plan (CIP). A share of the annual average CIP ($20,000) should be prioritized for climate change adaptation initiatives.

Opportunities to build on the Resilience Mechanisms

Generating Case Studies and How To Guides

The current report is only a snapshot of the resilience mechanisms potentially available to fishing communities. In order to implement such mechanisms in the field, there is now the opportunity to develop further case studies that focus on particular communities as good practice examples. In addition, the current project has developed technically detailed and easy to use “How To” guides to enable implementation of resilience mechanisms by NGOs, government bodies and communities themselves. The “How To” Guides encompass the following topics: forest replanting; co-management practices for fishery conservation; basin development; and natural resource management learning through games.

National Level Dissemination

In order to provide the technical knowledge and support networks necessary for large scale application of resilience mechanisms, the current project provides a unique opportunity to roll out national level dissemination. The participation of CFi representatives and members in nation-wide workshops organized as part of this project, greatly enhances knowledge sharing and provides avenues of communication between communities and key stakeholders from the fishery sector.

Moreover, establishing communication and support networks between CFis enables coordination and cooperation at the local level and potentially reduces dependence on external support. For example, WorldFish facilitated the organization of meetings between multiple CFis within the Stung Treng Ramsar conservation wetlands to discuss joint protection of areas outside their individual management zones. These meetings revolve around reflection on successes and failures, share of contributions and recommendations for the implementation of policies affecting them.

Collaborating with the RGC for large-scale replication

The RGC already counts on a sophisticated legal framework for the protection of fishing resources, biodiversity and forests. Cambodian institutions are well integrated within communities and the governmental structures necessary to allow effective natural resource management are already in place in many key areas. On the other hand, lack of communication, knowledge and funding greatly hinder the implementation of effective management plans at the local level. More efficient collaboration, communication and support of Cambodian institutions would facilitate the implementation of resilience mechanisms nation-wide and allow for large-scale replication of good practice examples.

Recommendations

- Provide training in natural resources management and promote awareness of climate change impact and resilience mechanisms to all community members. Empowering communities to self-organize and access knowledge allows them to focus and develop the resilience mechanisms most appropriate for their specific conditions. The “How To” guides developed under the current MNRM project, documentation developed under the Cambodia’s National Adaptation Programme of Action to Climate Change (NAPA) with support of UNDP and reports published by WorldFish detailing their interventions at fisheries communities are good sources of practical information on resilience mechanisms.

- Increase the funding available to communities to develop resilience mechanisms. Funding for climate change adaptation should be included in commune investment plans and budgets. Climate change adaptation and deployment of resilience mechanisms should be a high priority within government plans. The MNRM projects works on increasing the capacity of CFi to voice this need and raise their concerns to government institutions.

- Create and promote networks that allow the development of synergies between government institutions, NGOs and CFi. Learning from each other and supporting each other organizations and institutions at different levels can help identify good practices, successes and learn lessons from failures to create unified strategies to promote resilience.

- Enhance the natural protection provided by ecosystems by implementing community-led projects to continuously restore and replant degraded areas as well as improving protection of both aquatic and terrestrial conservation areas. Faced with habitat damage and overexploitation of resources, CFi need to take decisive action to protect and enhance the ecosystems they depend on. Guidance on the implementation of re-planting projects and improved awareness and community participation in the direct protection of conservation areas against illegal use are paramount to achieve more resilient ecosystems.


Photo credit: Oliver Langrand

Conclusion

Cambodia's rich, diverse and fragile aquatic ecosystems and the millions of rural Cambodians that depend on them are under threat. The convergent impacts of climate change, large infrastructure development and overexploitation of natural resources could bring ecosystems and livelihoods to the brink of collapse in the near future. But Cambodians are resilient, creative and adaptable; many communities such as those featured in this report are already deploying adaptation mechanisms that will protect them and their natural resources from the threats in the horizon. By strengthening communication, knowledge sharing and the effectiveness of institutional and community networks there is ample hope that Cambodians will overcome the difficulties ahead and preserve their unique natural heritage.

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