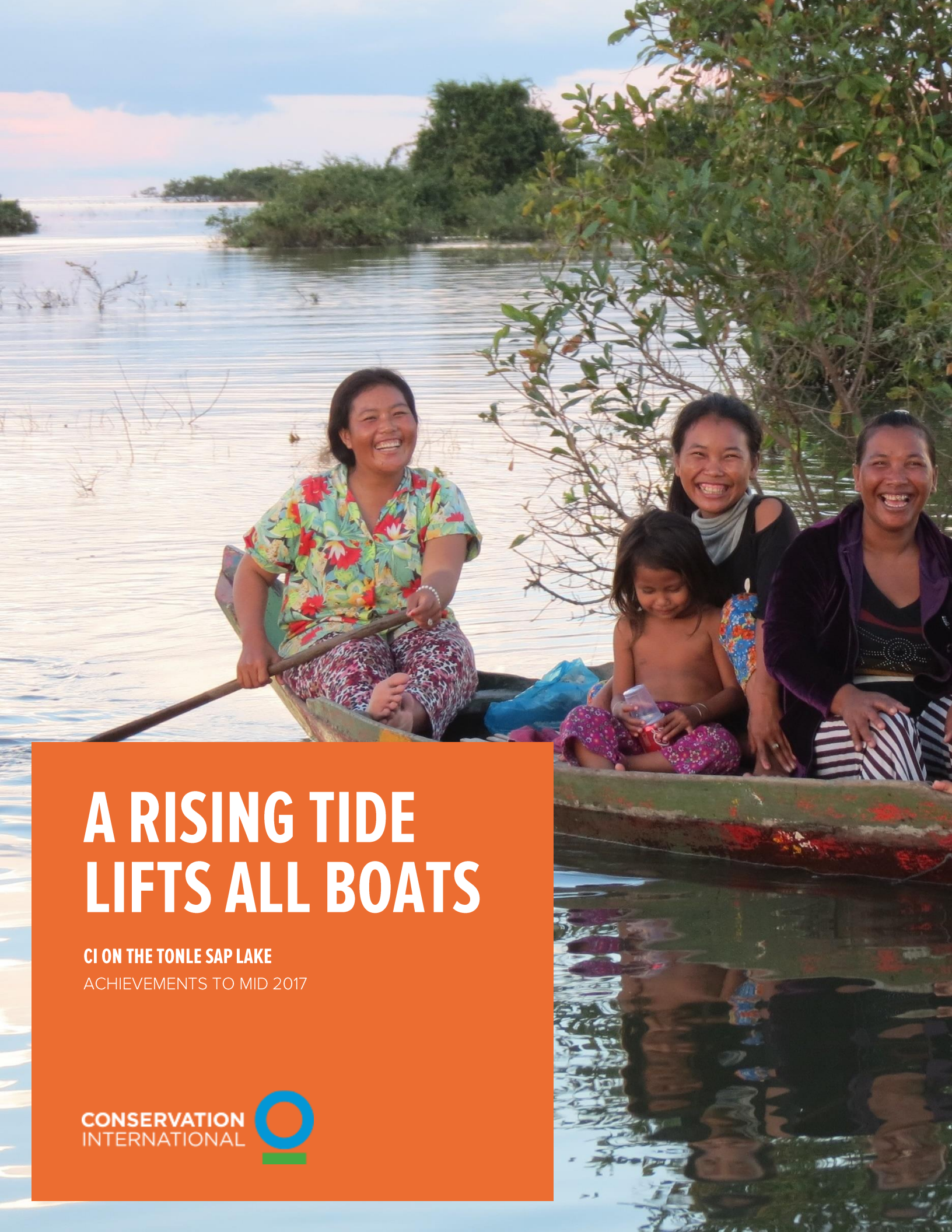

A RISING TIDE LIFTS ALL BOATS

CI ON THE TONLE SAP LAKE

ACHIEVEMENTS TO MID 2017

CONSERVATION INTERNATIONAL

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EXECUTIVE SUMMARY

The Tonle Sap is the largest lake in Southeast Asia and forms the heart of Cambodia. With its unique annual hydrological flood cycle, incredibly prosperous fisheries, and rich biodiversity, the Tonle Sap is a critically important ecosystem for the country. The lake supports livelihoods and food security for more than 95 percent of the area's 3 million inhabitants. However, the Cambodian Government's 'Deep Fisheries Reform' of 2012, a growing population, and the increasingly evident impacts of climate change are resulting in illegal fishing, deforestation and a less and less tenable living environment for wildlife and people alike.

CI started working in Cambodia in 2000, and in 2006 expanded its focus to include the Tonle Sap Lake. Beginning with three floating villages in Pursat province, and then extending to a further three[1], CI began working with communities to find ways to reverse the degradation of their fisheries and forest resources and to improve their livelihoods. CI's work promotes income generating opportunities for communities in Tonle Sap, helps maintain food security, and improves access to clean water for many of Cambodia's poorest people. CI works in partnership with local communities, the Cambodian government, local private sector actors and local non-governmental organizations to create alternatives to harmful practices such as overfishing and destruction of flooded forest habitats.

From November 2011, CI has undertaken a series of activities which has engaged 2000 households from 14 villages, with a total population of 8,000 people, to protect flooded forest and biodiversity, conserve fisheries and improve livelihoods of floating villagers. By June 2017, CI and its Lake partners had delivered the following outputs:

- Approximately 662 villagers directly benefited and 7,338 villagers indirectly benefited from the project;
- About 25,000ha of flooded forest areas were conserved;
- 160ha of flooded forest replanted with a total number of 99,741 seedlings;
- About 6,000ha of fish sanctuary protected;
- 52 fuel-efficient smoke stoves utilized by villagers;
- Continued presence of at least 21 globally threatened species;
- 16 community fisheries committees established;
- 17 women's fish processing groups and two marketing groups organized;
- 16 saving groups formed and
- Establishment of the Fisheries Coordination Team (FCT) as a link between provincial authorities and local fishers.

CI's approach of integrating livelihood improvements with better natural resource management has paid off. Our suite of activities has served to lift levels of household income, environmental awareness, social cohesion and cooperation, gender equity and community confidence simultaneously; so that development in one area has not come at the expense of another. Rather, communities have come to understand the interlinked nature of ecosystems and fishery productivity, forests and climate change mitigation, value chains and livelihoods, sanitation and health, savings and business growth; and with these understandings, have developed the capacities to make more informed decisions about the management of the resources and livelihood opportunities they will leave for their children.

1 (i) O'Akol village, (ii) Kompong Prak village, (iii) Anlung Raing (iv) O'Taprok; (v) Srey Cheok; and (vi) Koh Keak.

THE TONLE SAP LAKE

The Tonle Sap is the largest lake and most concentrated source of freshwater fish in Southeast Asia (ADB 2005). With its unique annual hydrological flood cycle, incredibly prosperous fisheries, and many threatened and endemic species, the Tonle Sap is a critically important ecosystem for the country. Each year during the monsoon, the Mekong River rises and reverses the flow of the Tonle Sap River, flooding the Lake. The Lake increases its surface area more than threefold to over 15,000 sq km, inundating forests and grasslands. This seasonal inundation results in highly fertile fish breeding and feeding grounds. Estimates of the annual fish yield of the Tonle Sap range widely, hampered by a lack of long-term reliable data, and complicated by national interests in hydropower development, which encourages underestimates. Most figures range between 150,000-550,000 tonnes per year, comparable to the annual catch of the entire inland fishery of the USA.

The Lake provides essential food security and livelihoods for one million people living on the Lake itself, and another two million living in the agricultural and rural areas around the Lake. Fish and other aquatic animals contribute 76% of total animal protein intake per person in Cambodia, likely to be closer to 100% in the Tonle Sap area. Fish also supply 28% of total fat and 37% of total iron for Cambodians (IFReDI 2013).

The Tonle Sap's importance however, reaches well beyond the boundaries of Cambodia. Wetland habitat has been rapidly degraded throughout Asia; the Tonle Sap's size, ecological integrity and diversity of habitats make it a critical global asset. Fish that migrate from the Tonle Sap help restock fisheries as far upstream as the People's Republic of China and the many tributaries along the way. The lake also helps to regulate salinity and conserve mangroves in the Mekong Delta by acting as a natural reservoir from which water drains during the dry season.

The Lake is managed by the Cambodian Fisheries Administration (FiA) under the Ministry of Agriculture, Forestry and Fisheries, and the Tonle Sap Authority coordinates ministries' interventions on the lake. Eight separate Fish Sanctuaries are regarded as protected by law across the lake. The Lake is also listed as an UNESCO Man & Biosphere Reserve and contains a RAMSAR site for the conservation of rare water-birds.

Figure 1 The Tonle Sap Lake. Photo: Molly Bergen

THREATS TO THE TONLE SAP

Despite the Lake's biological riches, the people living in floating villages on the Lake are among the poorest in Southeast Asia. According to the Asian Development Bank, 40–60% of floating households on the Tonle Sap live in poverty, with a peak of 80% in some areas. Half of children under the age of five are malnourished and 115 out of every 1,000 children die before the age of five. Malaria, dengue fever, acute respiratory infections, and tuberculosis are endemic and the HIV/AIDS infection rate is the highest in the region (ADB 2005).

Almost all of those living in floating villages are landless. Livelihoods are therefore entirely dependent on the Lake's natural resources – fish, other aquatic animals and forests. Since there is little to no storage available, families balance immediate protein consumption needs with spot market trading or value-added processing. Without access to land, income from fisheries products is essential to buy rice.

Exact population figures are impossible to obtain, but the population is growing, largely as a result of people migrating from other parts of Cambodia and from Vietnam to exploit the Lake's fishing opportunities. The Lake is therefore under unprecedented pressure to provide, and the consequences are evident in a multitude of ways.

- **Deforestation -** The flooded forest is crucial to maintaining the Tonle Sap's fish stocks, comprising over two hundred different species (ADB 2005). However, the flooded forests are being rapidly cleared, primarily to make way for dry-season agriculture, as a source of fuel-wood, and to make illegal fish traps. Further destruction is caused by accidental fires lit by people who fish illegally in the dry season ponds and then cook the fish they catch on-site.
- **Illegal fishing -** In 2012 the Royal Government of Cambodia initiated reforms in the fisheries sector which cancelled concessions to large scale commercial fishers (a policy known as the 'Deep Fisheries Reform'). This had the positive outcome of expanding the fishing grounds available to poor non-commercial fishers; however, it also attracted more people to the area and increased pressure on the fishery overall. Ideally, this change would have been accompanied by increased enforcement in the designated protected areas and closed seasons, however a lack of resources has hampered government efforts to manage the fisheries. It can be the poorest of the poor who are the perpetrators of illegal fishing, although often they do not reap the rewards; those who do not own a boat or their own fishing nets (the means to fish for themselves) are forced to fish illegally for larger operators, fish out of season and use prohibited gear. Fish catches and species diversity are falling as a result.
- **Climate change -** Climate change is expected to bring shorter wet seasons and longer, hotter dry seasons to Cambodia, exacerbating the effects of other human activities on the Lake. The widespread wildfires of 2016 are a taste of what is likely to be a recurrent culmination of these factors. Climate change will also alter the Lake's hydrological cycle through changes in rainfall intensity and duration in upstream Mekong countries such as China and Laos. It is predicted that less of the seasonally flooded forests will flood, and the floods will be shorter; with dire consequences for the forests, biodiversity, and fishery productivity, including the loss of many dry season ponds.
- **Upstream infrastructural development -** An estimated 62% of the Tonle Sap's water comes from the Mekong River (ADB 2005), and there is a strong correlation between water levels at peak flood and fish catch in the Tonle Sap. As such, a number of proposed upstream developments will, if they go ahead, have serious implications for the lake and the people and wildlife that it supports.

At the time of writing there are two mainstream Mekong hydropower dams proposed in Cambodia which are expected to have very serious negative impacts on Cambodia's fish supply. The development of the Stung Treng dam is predicted to reduce yields of fish and other aquatic animals by 6% to 24% (34,000 – 145,000 tonnes). The Sambor dam, if developed, is predicted to reduce yields of fish and other aquatic animals by 16% - 31% (98,000 – 182,000 tonnes) compared to 2011 baseline values, blocking all fish migrations upstream. Other dam developments such as the Lower Sesan 2 dam, under construction, and those operating and proposed in Laos, all have negative impacts on the flood pulse of the Mekong and Tonle Sap systems and on the 'black' fish that rely on seasonal wetlands and the 'white' fish that depend on open migratory routes (IFReDI 2013b).

CI'S ENGAGEMENT ON THE TONLE SAP LAKE

CI started working in Cambodia in 2000 and in 2006, expanded its focus to include the Tonle Sap Lake. Beginning with three floating villages in Pursat province, and then extending to a further three[2], CI began working with communities to find ways to reverse the degradation of their fisheries and forest resources and to improve their livelihoods. CI's work promotes income generating opportunities for communities in Tonle Sap, maintains food security, and improves access to clean water for some of Cambodia's poorest people. CI works in partnership with local communities, the Cambodian government, local private sector actors and local non-governmental organizations to create alternatives to harmful practices such as overfishing and destruction of flooded forest habitats. In 2017, CI began training local NGO Akphivath Neary Khmer Organization (ANKO) to extend CI's model into new geographies.

Beginning from November 2011, CI has worked with 2000 households from 14 villages, with a total population of 8,000 people, to protect flooded forest and biodiversity, conserve fisheries and improve livelihoods of floating villagers. By June 2016, CI and its Lake partners had delivered the following outputs:

- Approximately 662 villagers benefited and 7,338 villagers indirectly from the project;
- 25,000ha of flooded forest areas were conserved;
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- 16 community fisheries committees established;
- 17 women's fish processing groups and two marketing groups organized;
- 16 saving groups formed; and
- Establishment of the Fisheries Coordination Team (FCT) as a link between provincial authorities and local fishers.

The above achievements have been made possible thanks to grants from United Nations Development Program on Cambodian Climate Change Action Trust (CCCA), USAID's HARVEST project, Fondation Ensemble, the MacArthur Foundation, Manna Foundation and the Silicon Valley Community Foundation.

The following sections provide more detail on CI's specific activities and outcomes, achieved from the inception of CI's work on the Lake up to and including June 2017.

[2] (i) O'Akol village, (ii) Kompong Prak village, (iii) Anlung Raing (iv) O'Taprok; (v) Srey Cheok; and (vi) Koh Keak.

Supporting Community Fisheries

After the Deep Fisheries Reform of 2012, the government encouraged local villages to establish Community Fisheries (CFi) managed by Community Fisheries Committees (CFCs). The sub-decree on Community Fisheries Management (SDCFM) describes a CFi as 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 cancelled
(b) manage fisheries resources in sustainable and equitable manner
(c) to increase understanding and recognition of benefits of fisheries resources through participation in protection and management
(d) provide legal framework to establish community fishery and
(e) improve standard of living and reduce poverty.

About 175 community fisheries have been established in 361 of the 1,037 villages situated around Tonle Sap. While a step in the right direction for community-based natural resource management, most CFCs need significant capacity building and support before they are ready for this substantial and complex challenge. CI has engaged with CFCs to help them acquire the understanding, the skill sets and the relationships with government they need to be effective. Specifically we have focused on:

- Building CFC capacities and relationships with government.
- Helping CFCs establish and patrol Community Fishery Zones and Community Conservation Zones such as Dry Season Ponds and Rice Field Fisheries.
- Facilitating CFCs' protection and replanting of the flooded forests.

More detail on each of these activities follows.

Building CFC capacities and relationships with government

Most of the CFCs which have been formally established do not have the skills, the resources or the relationships they require to be effective in their roles as fisheries managers. Even if they patrol their designated areas, they do not have the legal standing to enforce the law, which remains the remit of the Fisheries Administration (FiA). However, the Fisheries Administration is also severely under-resourced, to the point of commonly not having the funds to pay for petrol to act on reports of illegal fishing. This chronic under-resourcing inevitably leads to corruption, which in turn makes CFCs wary of contacting the FiA about illegal activities they encounter – or of patrolling at all - for fear of retribution. The problems of corruption will be largely insurmountable until the Cambodian government begins to properly resource the ground activities of the Fisheries Administration. In the meantime, CI has worked to actively build trust and cooperation between the CFCs and the FiA around their joint missions to protect the fisheries and forests of the lake.

➢ *Achievements and outcomes up to June 2017*

CI has assisted 16 CFCs to develop the Management Plans that are a prerequisite for official recognition from the FiA, and which forms the basis of their organizing and activities as a group, and have worked intensively to up skill the CFC members in the areas they need to perform their own functions. Trainings delivered by CI include GPS use, patrol data collection and organizing via SMART, bookkeeping and financial management, report writing, grant writing and many others. Not only are these skills essential to the performance of their daily activities, but also to the prospects for the CFCs to gain support for their activities in the future, independently of CI. To help with securing financial sustainability, in 2014, CI established trust funds for Kampong Prak CFC and O'Taprok CFC and in 2017, Srey Choek CFC. A deposit of $5000 for each CFC was made in ACLEDA bank, producing an average of $375 annually that the CFCs were able to withdraw and use for their conservation activities. Using these funds, in 2016 the CFCs successfully leveraged a further $120 from voluntary community contributions and $685 from other NGOs to further their work. In a further strategy for securing ongoing finance, the CI helped one CFC design an entrance fee

system to charge non-community members for fishing in the Community Fishery Zone, and if successful, this may be a model other CFCs could adopt.

CI has observed that following our support, the CFCs are continuing to deliver well on their management plans, even after we have reduced our level of support and intervention. Importantly however, the CFCs' new abilities to deliver tangible results to the communities they serve have inspired greater levels of participation from local fishers. The CI team was inspired to see in 2015 community members in Akol all offering voluntary contributions to support the CFC to protect dry season ponds, many offering $5 contributions, packets of dry noodles and rice and sausages to sustain those 'on watch'; without any encouragement from CI. This is unlike anything we would have seen at the beginning of our project. This swell of community support for the CFCs has, in turn, demanded that the FiA take heed of the CFCs and engage meaningfully.

To facilitate this process, CI has held joint meetings between CFCs and the FiA to directly discuss barriers and solutions for working together on protection of the fisheries resources. Through our engagement with the CFCs we have witnessed a marked improvement in the confidence of the CFCs and their willingness to engage the FiA. The CFCs now conduct patrols and confront illegal fishing problems, and there have been several instances where the CFCs have taken it on themselves to initiate meetings with the FiA to discuss issues of illegal activity and seek cooperation and resolution.

To assist the FiA in overcoming financial barriers, CI has provided some operational costs for the FiA rangers to support our target villages in their patrols of two fish sanctuaries spanning about 6000ha. Two FiA/Community Joint Patrol Teams have been established, and are functioning well. The FiA are now responding positively to approaches from the CFCs, and together the CFCs and FiA rangers are delivering results in reducing illegal activities in both the fish sanctuaries (which the community assists FiA to protect) and community fisheries zones (which the FiA assists the community to protect). Fisheries Administration records show that between 2010-2016 these cooperative efforts succeeded in decreasing instances of illegal fishing by half in our target areas. Based on these results, and this growing positive relationship, the FiA has been recommending that inquiring donors invest in CI's target area, indicating that our partner CFCs will continue to develop and strengthen well beyond our own partnership with them. Various other NGOs (IUCN, FACT, and Star Cambodia) have visited our sites to learn from our approach or invited community members to speak in their forums, and we are always happy to help those wishing to replicate our success across the Lake.

At the moment, CI is assisting IUCN to set up community mini-trust fund in IUCN's target areas. IUCN has requested CI's technical support to guide the process.

Establishing and patrolling Community Fishery Zones and Community Conservation Zones such as Dry Season Ponds and Rice Field Fisheries

Establishing and patrolling Community Fishery Zones and Community Conservation Zones is a fundamental function of CFCs, and a critical objective in the effort to raise the incomes of the Lake's poorest people. Community Fishery Zones are areas open to all fishers in the community, and are patrolled to ensure legal fishing techniques are used and that outsiders do not exploit the resource. Community Conservation Zones are no-take areas, reserved to allow fish stocks to recover. Dry Season Ponds and Rice Field Fisheries are two examples of these.

During the dry season, natural 'Dry Season Ponds' are dotted throughout the floodplain surrounding the Lake. They form crucial nurseries for juvenile fish and crucial feeding grounds for a range of other wildlife species. A man-made variant of Dry Season Ponds is the rice field fishery. The concept of rice field fisheries is not a new one – farmers have known for centuries that keeping fish in their rice fields has multiple benefits. Keeping fish in rice fields improves rice yields as the fish both fertilize the paddies and eat many of the insects that are attracted by – and would otherwise attack - the rice. However, actively developing rice field fisheries had not yet been explored by CI's partner CFCs, creating another opportunity to support and nurture local fish stocks.

➢ *Achievements and outcomes up to June 2017*

The CFC Management Plans that CI helped develop outlined plans for demarcating various zones within each CFC's jurisdiction, and for protecting them. As outlined in previous sections, the CFCs have been successful in garnering support for law

enforcement from the FiA. By mid 2017, FiA records showed that our team effort had decreased instances of illegal fishing in the Community Fisheries Zones by as much as 90% from before CI's intervention. Conversely, monitoring of fish catch in the same areas shows that between 2010 and 2015 the minimum catch recorded increased 300% from 2kg to 6kg. This represents the catches of the poorest fishers, providing essential sustenance and income for families in our target villages. We expect that over time the fish populations in this area will continue to recover from previous overfishing and this minimum catch will continue to grow.

Figure 2 Catch monitoring in Kampong Prak Village. Photo: Dong Tangkor

CI also assisted three CFCs with scouting for suitable locations for establishing four Dry Season Ponds, and planning for their protection through the dry season. In 2015, five Dry Season Pond patrol teams were organized and had effectively protected both the ponds through the dry season. Now, in 2017, the improvement was visible to the community who, upon throwing a handful of feed into the dry season ponds, could see the water boiling with fish rushing to the surface; when the monsoon returned, these were the fish that formed the base of the stock for the new season. Last year in the wet season, fishermen reported an increase of fish catch from 5-7kg per day, to 25kg per day, and a fishing peak that was prolonged an extra two weeks from normal.

The abundance of wildlife has also increased noticeably around the Dry Season Ponds since the beginning of their protection, particularly the number of otters and water birds.

Figure 3 Fishing on the Tonle Sap. Photo: Tangkor Dong

In addition to the five CFCs, CI also helped establish one Rice Field Fisheries Conservation group (RFC), and in fact two of the dry season ponds were chosen for their connectivity to surrounding rice fields. As a first step, CI arranged for members of the Tonle Sap CFCs to visit a rice field fisheries refuge in Battambang province to learn from the group's experience of establishing and managing the refuge. CI then worked with the community to identify and choose suitable sites in our target area, in consultation with the Fisheries Administration and village chiefs. The CFC erected fences to keep buffalo out, and methods for blocking fish passage at the right time of year were trialed and agreed on. CI guided the community in conducting a baseline study of the density and diversity of the fish in the ponds, and a baseline of the rice yields in the connected paddy fields (still awaiting follow-up findings). CI then helped the communities to hold elections to select members for the new Rice Field Fisheries Conservation (RFC) Committees, who convened in November 2014, to be responsible for protecting the sites. Despite a total lack of remuneration, the RFC members have shown absolute dedication to their task, and we expect ongoing research to show that the contribution of the rice field fisheries to overall fish stock in the Community Fisheries Zone to be significant.

Protecting and replanting the flooded forests

CI integrates protection of the flooded forests into all our work on the lake. The forests provide critical habitat and nurseries for fish: without flooded forests, fisheries would collapse and food security along with them. Further, the flooded forest of the Tonle Sap is still by far the greatest continuous area of savannah swamp forest and inundated forest in the entire Asian region (ADB 2005). The flooded forests support rich biodiversity, including almost a third of Cambodia's globally threatened fauna. They serve as the nesting grounds for many of the world's endangered water bird species. These include milky storks, spot-billed pelicans,

Figure 4 Intact flooded forest. Photo: Sokrith Heng.

painted storks, lesser adjutants and greater adjutants. The forests are home to two species of otter including the largest known population of the world's rarest otter, the endangered hairy-nosed otter. The forests are also home to fishing cats, silvered langurs, at least four species of freshwater turtles, and Siamese crocodiles, all of which are classified as globally threatened on the IUCN Red List, with several listed as 'Endangered' or 'Critically Endangered'.

A significant proportion of the Tonle Sap's original flooded forest has already been lost to land clearing for agriculture, wood cutting for house construction and firewood, and illegal fishing. For wildlife, this habitat loss is compounded by direct hunting and illegal poisoning, in a bid for extra income from the illegal wildlife trade. When CI first engaged in our target area we discovered many skins from otters, civit cats, leopard cats and other endangered wildlife stored in the houses of villagers.

➢ *Achievements and outcomes up to June 2017*

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 find ways to reduce their wood consumption; to replant previously cleared areas; and to protect the regenerating and remaining stands of flooded forest.

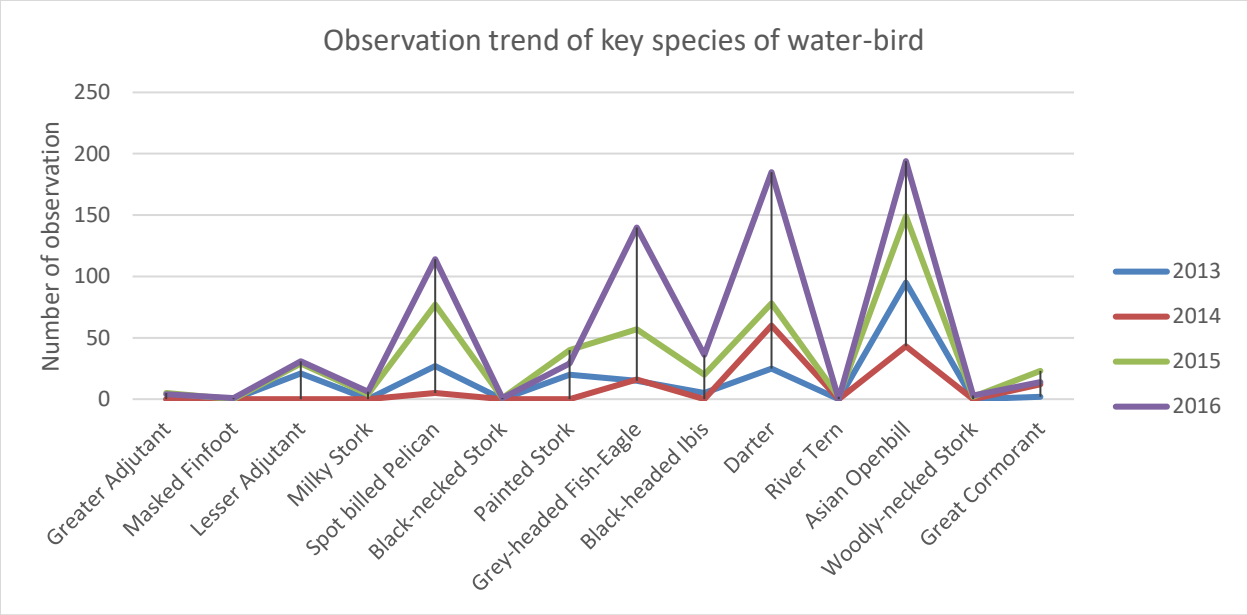
Regular education sessions delivered by CI's Tonle Sap Team have helped communities understand the critical function of the forests in sustaining the fish that the communities base their livelihoods on. These sessions have broached the topic of illegal hunting of wildlife, and made clear to the community 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 Nino 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.

Figure 5. Replanting assessment, Kampong Prak. Photo: Sokrith Heng

CFCs have patrolled the replanted areas and the flooded forest within the Community Fisheries Zones. The patrol teams provide warnings or arrest persons they find cutting wood illegally and FiA rangers assist in making arrests where necessary. Overall the patrol teams have successfully maintained 25,000ha of flooded forest, both primary and replanted. The fact that the Commune Chairman regularly organizes meetings with village chiefs, CFC leaders, and the joint ranger teams to ensure follow-up on the agreed-on protection activities is further pleasing evidence of improved community-government relationships and cooperation.

The three-fold approach to safeguarding the forest is paying off. Both community reports and CI's own monitoring reflect an increase in number of both birds – including pelicans, daters, Asian open-bills, grey-headed fish eagles and painted storks - and mammals in the project area. Our records have confirmed the continued presence of at least 21 globally threatened species in the flooded forest areas protected the CFCs. Chart 1 shows the overall trend in numbers for fourteen water bird species from 2013-2016. It can be seen that all species increased in numbers over the last three years with the exception of River Terns and Masked Finfoots which remained stable.



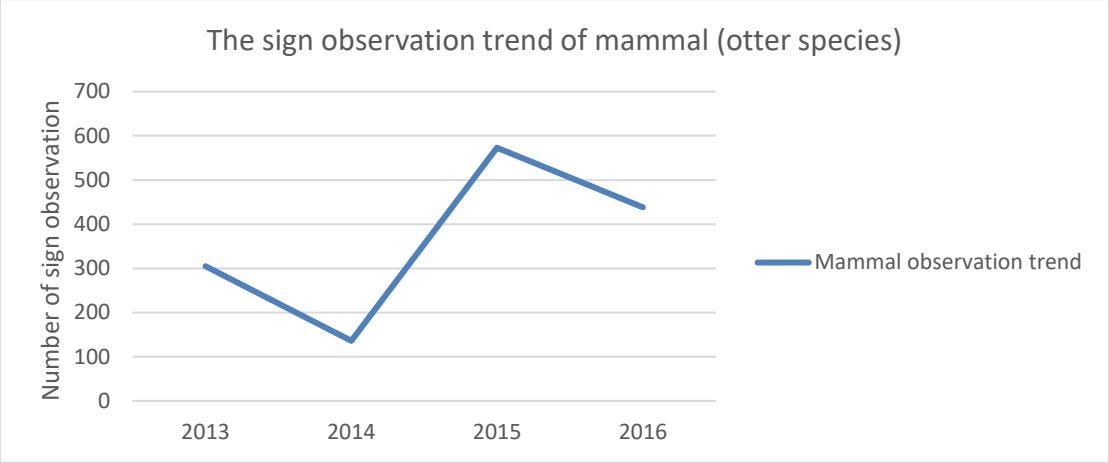
Nationally listed as Critically Endangered, river terns (*sterna aurantia*), were recorded around our replanting sites in November 2015. The current national population is estimated at no more than 100-200 individuals.

Additionally, the Endangered Greater Adjutant and Vulnerable Lesser Adjutant were recorded at CI's project site in April 2016. Spotted-billed pelicans are also increasing in numbers around the site.

Figure 6 Asian Open-bills feeding in CI's target area. Photo: Sokrith Heng

Otters were used as an indicator species for mammal presence in Kampong Prak. The CI team set camera traps in gallery forest trees throughout the year, as well as in scrub and on floating logs during the wet season and around dry season ponds during the dry season. We used the knowledge of local fishers to determine the best spots to set the traps. The team had also learned to distinguish between spraints from the different otter species and could identify the presence of different species based on this. Interviews were carried out with local fishermen and hunters as they often have great knowledge of the wildlife. Photos of the different species were used during the interviews to aide identification of species, however anecdotes alone were not used to add

to otter records. Chart 2, below, shows an overall increase in otter presence in Kampong Prak. The dip in 2014 is explained by a change in survey methodology, and the dip in 2016 by severe drought which resulted in forest fire and habitat loss.



Overall, trends in wildlife presence give us confidence that once the replanted sites have grown up sufficiently, and with ongoing protection, they will continue to be re-populated by some of these important species. Importantly for communities, they will also be providing important fish habitats in the wet seasons, helping shore up livelihoods for fishing households.

Fostering improved livelihoods for women

Women are particularly vulnerable to poverty on the Tonle Sap, and there are a high proportion of female-headed households (ADB 2005). Women have less property rights than men, and less access to credit, paid employment, education, and health services. Khmer tradition does not provide women and girls with many opportunities for self-development or participating in community decision making.

However, fish processing activities make up an important source of income for floating households in Tonle Sap Lake communities, and these activities are managed solely by women. To date, women processing fish have had limited tools, information and capacity at their disposal. Problems have included:

- Inefficient processing technologies, and unhygienic or dangerous methods which present health risks to both producer and consumers.
- A dearth of floating storage facilities, limiting the preservation of processed fish and restricting women's capacity to capitalize on seasonal market price fluctuations.
- Women having no access to market information, and limited capacity to forge commercial relationships with downstream buyers.
- Mutual mistrust, hampering incentives for village-level supply aggregation and hindering women's ability to access larger buyers collectively.
- A lack of access to credit, making it difficult for women to build their businesses.

These constraints have perpetuated the poverty trap and limited the success of women entrepreneurs in floating communities. After discussion with women fish processors it became clear there were a number of ways CI could help the women get more return for their efforts. In particular CI has helped the fish processing women to organize, and improved the knowledge and tools at their disposal (including an innovative new fish smoking stove); and developed a platform for women to begin saving their earnings and supporting each other with collective access to credit.

Establishing collective organizing, and increased earning capacity for women fish processors

One of the legacies of the Khmer Rouge regime was a fragmented society with a disinclination toward collective action and collaboration. At the point of CI's engagement with the target villages, many women were processing fish – but doing so in isolation, each forgoing the potential benefits of economies of scale, and each problem solving and troubleshooting largely on their own. CI saw the many efficiencies that could be gained from collective organizing and embarked on a process to encourage the women to work together.

➢ *Achievements and outcomes to June 2017*

By June 2017, CI had helped its target villages to organize 17 Women's Fish Processing Groups with 194 women members. Each Women's Fish Processing Group has an elected leader and a treasurer, and meets regularly to share their techniques, advice and experiences, and to support each other in an effort to improve their products and their incomes.

Once the groups were established CI undertook assessments of the products the women were producing, their processes, the problems they were encountering with the process, and the end profits from market sales. Based on these needs assessments, CI designed and delivered a training package for each group including:

- **Good hygiene practices:** the CI team helped the groups understand the importance of using clean water, and higher quality white (as opposed to 'black', indicating mixing with dirt) salt for their fish products; the need to adopt standard measures in fish processing such as wearing gloves, masks and hair nets; the necessity for cleaning and maintenance of equipment and of the areas in which food is handled; and the need to using appropriate storage containers and methods. We reinforced this training with regular refreshers to the groups, and practice 'audits' as if from potential buyers. The women's ongoing adherence to GHP practices to date is pleasing and a side benefit has been the extension of their improved cleanliness standards beyond fish processing to household life, improving family health.
- **Business skills and building markets for their products**: focusing on assisting women to address social and cultural norms that have traditionally constrained their participation in business activities and value chains, and including basic financial literacy, record-keeping, credit risk management, marketing, conflict resolution and negotiation. CI also organized and led the women on study tours to Siem Reap and Battambang to observe best practice examples of three different types of processed fish product, where the groups learned not only about other processing techniques and products, but about the key principles of market mechanisms/linkages and their own potential to diversify their products. CI supported several of the Women's Fish Processing Groups to attend trade fairs in Phnom Penh and elsewhere, to display their improved products and seek new customers. These resulted in significant product sales on the Fair days, several new retail contracts and at least one prize, awarded by the Minister of Agriculture, Forestry and Fisheries (MAFF).

Figure 7. Making prahok employing safety standards. Photo: Chanthorn Srorn

Figure 8 Members of a Women's Fish Processing Group at trade fair in Pursat. Photo: Sokrith Heng

The women rightly have a newfound pride in their products and also a new confidence and collective bargaining power to negotiate higher returns for themselves and their families. In June, their products were gaining recognition and support in external markets, and the groups were able to capitalize on these new opportunities by transporting their products to market collectively, saving on fuel costs and having the bulk supply to attract more resellers in the market. Transport costs were cut between 50% and 70%, and at the group level, the selling price of prahok has increased between 14% to 133%, and smoked fish prices have trebled.

The benefits realized by the groups supported by CI motivated other fish processors in the village to move to producing prahok instead of selling raw fish or produce less valuable 'semi-prahok'.

Designing a new fish smoking stove

Smoked fish is a popular 'processed fish' product in Cambodia and one of the main ways women in our target villages were aiming to add value to fish before taking them to market. The traditional open fire smoking stoves are made of bamboo and zinc and cost around USD$50 per unit. They have a life span of one year or less and many are home-made. The women estimate that 0.3m^3, or 23kg, of wood is needed to smoke 50 skewers of fish in the 'old' stoves, meaning an average of 70m^3 of fuel wood each year per stove user. The old stoves take 2-3 hours per batch of fish cooked, which includes regular monitoring every 10 minutes to make sure the fire neither spreads or goes out. Smoke moves freely though family homes, and acute respiratory infection is one of the major causes of childhood mortality on the Lake (ADB 2005). House fires have also occurred as a result of untended stoves.

➢ *Achievements and outcomes up to June 2017*

CI was funded by USAID though the HARVEST program to develop a new fish smoking stove. The new model stove was based on input from women using the traditional stoves. Several new models were trialed and again, based on feedback from the women users, modified for improvements. Key performance indicators included cost, wood consumed, time required, smoke escape, unit weight, and safety.

Once the stove was market ready, the CI team held smoking 'demonstrations' and training sessions with groups of women on the Lake, and after each event numerous women put themselves on the waitlist to buy a new stove. The stove's success is based on the following benefits:

- An improved end product: fish smoked in the new stove fetch a 300% higher price than the traditional stove.
- 50% less fuel-wood use. This means 35m^3 of wood is saved from logging from the flooded forest per year per stove, or 1820m^3 if we count all 52 of the new stoves now in use.
- Estimated 18 days per household saved per year in time and effort spent collecting firewood.
- An estimated 0.84 tonnes of Co2 saved per year per stove, or over 43 tonnes of Co2 per year across all the new stoves now in use. (0.1kg of Co2 emitted per kg of wood burned[3], 11.5kg less wood burned for a single smoking, and an average of two smokings per day for a year).
- 45 minutes less time spent cooking for each batch.
- An enclosed design that reduces smoke inhalation and affords better protection against fire spreading and the ability for women to attend to other tasks while fish are smoking rather than guarding the stove.
- More time for women to pursue other livelihood activities and girls to attend school.
- A foldable and portable design.

Women included in CI's project area received a subsidy from the project funds with the understanding that when the stove reached its end life (estimated 5-6 years), they would need to replace it themselves; an easily achievable goal given increased earnings from smoked fish.

By 2014, the financial, health and environmental benefits of the stove were self-marketing, and CI did not need to facilitate any demonstration workshops beyond the first few. Already 47 households in our target area were using fuel efficient smoke stoves, and more families were on the wait list to purchase one. The design of the stove also continued to evolve, and at the end of 2015 the CI team had found a way to produce it from old, cleaned oil drums, which will reduce the cost of the stove further and eliminate the need for future subsidies.

Establishing Savings Groups

A critical part of women's economic empowerment is not only helping women to earn more money, but to control it. They are ineligible for direct loans from banks who are discouraged by the communities' remote location and lack of land title. Yet, they can easily slip into debt when forced to rely on local money lenders or middlemen who can charge up to 15% interest; a generally unpayable amount, which often forces the taking of further loans.

Saving money is equally difficult, and even when it can be saved, keeping cash at home is not safe and does not generate interest.

CI works with women in its target villages to circumvent these problems by forming women-only 'Savings Groups'. These are small collectives, which focus on pooling savings and providing an opportunity for members to take out small loans.

[3] http://www.carbonindependent.org/sources_home_energy.htm#hhhhh

➢ *Achievements and outcomes up to June 2017*

By June 2017 there were 16 Savings Groups operating in CI's target villages on the Lake. Eight of these had been directly supported by CI (funded by USAID's HARVEST project and other donors), and the ninth formed spontaneously when other women saw the benefits being enjoyed by the members of the CI-initiated groups. In 2017, CI supported ANKO, a local partner NGO, to help women in the Tonle Sap watershed area between the Lake and the Cardamom Mountains, to establish seven new saving groups.

After running information sessions and then extending an open invitation to women in the communities to join a group, CI and ANKO 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 CI and ANKO, 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.

An evaluation at the end of 2015 showed that women are honoring their repayments, and accumulated capital is increasing, leading to a change of perceptions within the community. The attitude toward savings is slowly changing both among group members and other non-group affiliated residents. More people wanted to join the groups following closure of the first cycle and once they witnessed their success. With the increasing number of loans and repayments, trust within groups is slowly building and contribution amounts are increasing, with some members contributing as much as 50,000 KHR per cycle.

The same evaluation found a 70% reduction in the flow of funds to external lending agencies/microfinance institutions, with the members preferring to borrow from the Savings Group instead.

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. On a broader level, training on 'savings' and self-sufficiency are proving to be influential in other areas of the members' daily lives. Members have been receptive to CI's encouragement of them to try saving and recycling other resources such as reusing plastic bottles and keeping kitchen waste for compost for floating gardens, or as feed for the fish.

The benefits and ongoing enthusiasm generated by the groups indicate that there is significant scope to develop many more Savings Groups on the Tonle Sap as CI and ANKO work together to bring opportunities to new communities.

Figure 9. Savings Group sharing the interest. Photo: Chanthorn Srorn.

Investigating locally appropriate aquaculture

CI's initial assessments on the Lake identified that although aquaculture development held the potential to increase the household availability of freshwater fish while mitigating potentially negative impacts on wild fish stocks due to illegal/harmful fishing techniques, there were several problems with the way the community was engaging in aquaculture. CI found that community members were purchasing poor quality fish seed/fingerlings, consuming far more wild fish to feed their aquaculture fish than they needed to, poorly administering medicines and antibiotics, and over-stocking fish cages. These widespread problems meant that villagers were wasting their scant financial resources, polluting the Lake water, and putting extra pressure on the already stressed wild fishery; and still not producing healthy, profitable aquaculture fish.

➢ *Achievements and outcomes to June 2017*

CI conducted a detailed value chain analysis of freshwater aquaculture to identify the constraints and opportunities for actors all along the chain. Once this process was complete, and the community confirmed they wanted to pursue aquaculture, CI facilitated production improvement and market access for target households. Trainings addressed all of the existing problems, ensuring fish farmers knew the best ways to select quality seed, what to feed them at various stages of their life cycles, and how to stock their cages for optimum yields per unit of space. The farmers learned how to monitor water quality and construct their own cages and make their own vegetable and rice-husk based feed for the older and larger fish. The vast majority of participants were women, representing 72 households across CI's target area. CI also worked on improving the communities' understanding of the market, determining what standards they needed to reach as producers, and building relationships with buyers.

By applying their new husbandry techniques and market knowledge, the women were able to double their income from aquaculture in the first year with average earnings rising from $246,12 to $429,97.

Although CI's training had focused on the raising of Pangasius, the majority of community members then decided they would like to try applying their new aquaculture skills to raising Snakehead, a more valuable species. Snakehead aquaculture had been outlawed by the Fisheries Administration because of Snakehead's ravenous appetite for wild fish; 1kg snakehead can eat 5kg of other fish (Cambodia Daily 2005), and this feed cannot be substituted for other vegetable based feed as it can for other species. Due to both the illegality and the impact on the ecology of the lake, CI could not support this request, and suspended our aquaculture activities with the communities. Despite this break in our activities, our preliminary results have shown fantastic

promise for raising livelihoods for women, in particular on the Lake, and we are ready to re-engage in aquaculture when the community shows renewed interest in raising a more sustainable species.

Providing safe drinking water

CI is no longer working on drinking water issues, but includes our program experience of working with this issue in case if may help inform the work of others.

In our preliminary community surveys on livelihoods, needs, and opportunities in the three villages in Pursat province, the village representatives listed a number of urgent issues they would like CI's support to address. One of the issues raised was the lack of clean drinking water. In the dry season, the Lake's water level is low and water becomes stagnant and of poor quality, and therefore most families use wells. In the wet season, families drink and cook with the Lake water. Both water sources contain dangerous levels of pathogens. In early 2012, we found bacteria levels of 1,000-10,000 units of E.coli/100ml of water in our target villages. Just 100 units is considered high risk, and 1,000 units is considered extremely unhealthy, with ramifications ranging from school absences due to illness, to reported increase in infant and child mortality due to recurrent diarrhea. The lack of clean water is compounded by low accessibility and affordability of health care: Lake families generally spend approximately 11% of their household budgets on healthcare, and about 45% of people report being obliged to take loans to cover the cost of health emergencies (ADB 2005). The cost of poor health can be crippling for families, but could largely be avoided with precautionary measures.

However, drinking clean water was simply unaffordable for many families at the beginning of CI's partnership with its target villages. To buy filtered water directly from the market in Kampong Luong village costs from 1.1$USD to 1.25 $USD for 20 liters. CI's investigations found that this was adding up to USD$135 over the course of a single dry season for an average sized household of five to seven members – not even including the considerable transportation cost.

There have been many attempts to commercialize clean water services in the Tonle Sap, including by very large development actors, with little success. Past failures stem from introducing technologies that are both too large and cumbersome for the floating infrastructure, or commercially unsustainable financial models. CI aimed to learn from these past mistakes by focusing on contextually relevant technology and identification of micro-entrepreneurs who were willing and able to lead a successful clean water production and distribution enterprise.

➢ *Achievements and outcomes up to June 2017*

CI researched a number of water cleaning technologies, and trialed two. After an 'ultra-filtration hollow fiber membrane technology' failed to provide reliably clean water, the 'Rabbit' water filter, produced by Hydrologic Social Enterprise, was identified for trial. The Rabbit is a ceramic filter element set in a plastic receptacle tank with a lid and spigot to protect filtered water from recontamination. Small-scale ceramic filtration has a long history, having been used in various forms since antiquity. Hydrologic Social Enterprise claim that household-scale ceramic filtration technology is among the most promising options for treating drinking water at the household level in developing countries. Its use in Cambodia is widespread and growing. Locally produced ceramic pot-style filters have the advantages of being relatively inexpensive, chemical free, low-maintenance, portable, effective, and easy to use. The filters remove microorganisms from water by gravity filtration through porous ceramics, with typical flow rates of 2-3 liters per hour.

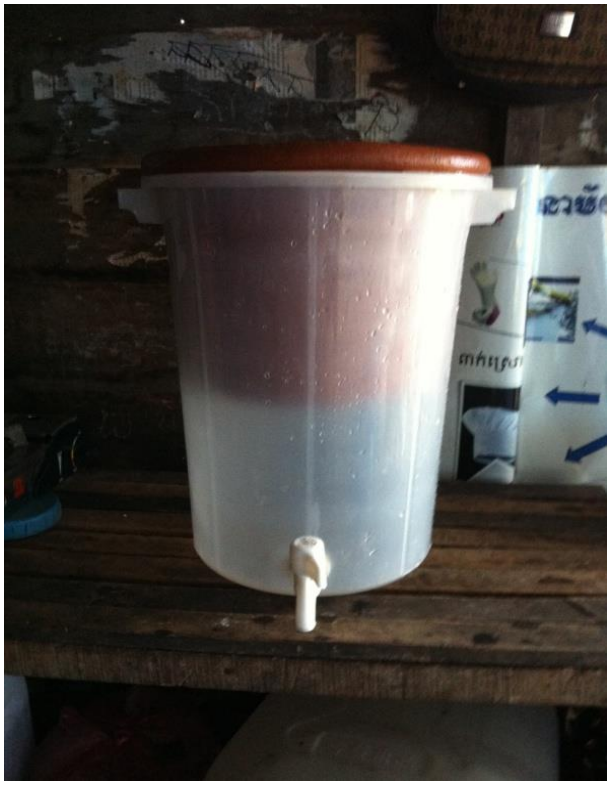


Figure 11 Rabbit water filter. Photo: Sith Kriya

Figure 10 Cleaning the filter. Photo: Sith Kriya

As a pilot, CI provided Rabbit water filters to 11 families in Kampong Prak and Akol villages, and two schools. Households were selected comprised a range of socio-economic statuses, sizes and expected understandings of household hygiene. Guidelines on the maintenance of the filter were provided to the users and checkups on proper use were carried out during the trial period. The testing was undertaken in wet season of June 2014. The 11 sampled households used the filters for one month. Indicators used for the assessment of the water produced included taste, smell, color, number of liters provided and adaptability. Results were that:

- All sample households and schools reported that the Rabbit water filter was easy to use and clean.
- All families confirmed the acceptable taste and smell of the filtered water, and that the water from the Rabbit filter was drinkable without boiling.
- Eight of 11 families confirmed that size of the Rabbit water filter was sufficient for use with five to six members in the family.

- Six families confirmed that the Rabbit filters three liters in an hour which was acceptable to use for both daily drinking and cooking.
- 10 families confirmed they would pay to replace it at the end of its life span.

A Rabbit filter costs $12, making it an affordable option for households. As part of a five-year project funded by Fondation Ensemble, CI provided 124 Rabbit filters to 96 families, at a subsidized rate of 50%. Ironically, other livelihood improvement activities of CI have meant than many of the households who might have bought a filter are now able to purchase bottled water, which alleviates the burden of cleaning a filter. Either way, families are drinking clean water, and the women in CI's target area report improvements in family health and a subsequent reduction in their workloads.

An additional nine Rabbit filters were given to three schools (three to each) entirely subsidized by the project.

There is considerable scope to scale up this effort to reach other communities and share more broadly the benefits of safe, reliable and affordable drinking water. The efficacy and affordability of the filter, and the many critical benefits of drinking clean water make this a very worthwhile investment on the Lake.

Providing environmental education

The health of the local environment has a dramatic effect on the wellbeing of the lake dwellers. The benefits of clean water and robust healthy fisheries are clear. Climate change brings with it more frequent storms with heavy swells and high waves that are liable to topple or sometimes sink floating houses, particularly where the flooded forest has been cleared and can no longer provide storm protection. Towing houses to more sheltered locations and repairing storm damage can account for as much as a third of annual household expenditure (ADB 2005). However low levels of formal education and literacy on the lake mean many lake residents have to rely on their own observations to understand the linkages between human behavior and environmental change. CI has integrated basic environmental education into its engagements on the lake, to help project partners gain the knowledge they need to manage their natural resources for the long term.

- ***Achievements and outcomes up to June 2017***

CI has conducted quarterly 'night shows' focusing on general environmental awareness in all target villages. The educational elements have been interspersed with screening of popular Khmer films, which has drawn large crowds. Focal topics included discussion of climate change vulnerability and adaptation; the importance of the flooded forest both for fish and wildlife and also for storm protection; basic ecosystem structure and function; sanitation; the illegal wildlife trade, and more. These evenings have always been extremely well attended and appreciated by the community.

CI has also trained a number of community members to become educational leads on environmental issues through a 'train the trainer' program delivered by CI staff. Having environmental focal points in the villages helps maintain community awareness throughout the year.

The degree of knowledge obtained and retained by community members is impressive—in follow up sessions the CI team have observed that villagers are now using their own words and stories to illustrate complicated concepts such as rainfall linked to tree cover and changing water flow patterns. These new understandings will be important for feeding into the decisions communities make about natural resource management, both through formal structures such as the CFCs and in their own daily lives. CI believe that the reductions we have seen in flooded forest loss, illegal fishing and wildlife poaching are not only a result of improved law enforcement in our target area, but are also a reflection of the communities' evolved appreciation of the value and the fragility of the unique ecosystems of the Tonle Sap, and the services those ecosystems provide to sustain human life on the lake.

THE FUTURE

CI's work on the Lake has been successful for a number of reasons. One is undoubtedly our integrated approach. While our project plans may appear at first unwieldy - encompassing, as they do, a wide range of activities running simultaneously - this webbed approach is intentional.

CI as an institution believes that addressing the needs of people is a prerequisite for conservation, therefore our conservation efforts have been closely entwined with a range of sustainable livelihood initiatives. Each initiative has been chosen for complementarity and ability to build upon others. Flooded forest and fishery protection leads to improved fish yields; increased fish yields leads to more fish for processing; better returns from improved fish processing generates surplus income for saving and loaning; access to credit allows entrepreneurs to build their businesses, to re-invest in conservation (such as the example of the community members proving their own funds to protect dry season ponds) and to meet all kinds of other family needs. Our focus on women in particular has led to rising family incomes overall: the number of households with zinc roofs (as opposed to leaf) doubled in our target area over the last five years, as did the number of household owning motorboats. Closing the loop in this way paves the way to sustainability.

Sustainability has also been built by our focus on building relationships between the government and communities; the government is actively directing other NGOs to invest in our target communities, in the knowledge that they will be building on a successful model and that the communities have the capacity to take advantage of the opportunities they are offered.

Lastly, we have taken an adaptive management approach; we have learned from our mistakes and those of others, and we have supported communities long enough to allow them time to see the tangible benefits of their efforts, and also to build their self-reliance.

As this model is becoming closer and closer to becoming self-financing, we aim to replicate it in other places of the Lake and the watsrsheds that feed the Lake. We are keen to expand our 'train the trainers' approach, so we can pass on what we have learned and share our model with not only ANKO, but other NGOs so that they can replicate it themselves. In this way we hope to see life on the Tonle Sap for people, fish and wildlife alike improve to a point where future generations can more than survive, they can flourish.

Figure 12 Boats awaiting their next outing. Photo: Virginia Simpson

CI'S TONLE SAP TEAM

Figure 13 CI's Tonle Sap team, 2015.

REFERENCES

Asian Development Bank. (2005). 'The Tonle Sap Basin Strategy'. http://www.adb.org/sites/default/files/institutional-document/33050/files/tonle-sap-basin-strategy.pdf

Cambodia Daily (2005) 'Snakehead Ban in the Works' BY KAY KIMSONG | AUGUST 19, 2005 https://www.cambodiadaily.com/archives/snakehead-ban-in-the-works-49011/

IFReDI (2013a) 'Key Considerations: Food and Nutrition Security Vulnerability to Mainstream Hydropower Dam Development in Cambodia'. Inland Fisheries and Research Development Institute, Ministry of Agriculture, Forestry and Fisheries, Royal Government of Cambodia https://www.oxfam.org.au/wp-content/uploads/2014/02/key-considerations-dams-and-nutrition_english-2.pdf

IFReDI (2013b) 'Food and nutrition security vulnerability to mainstream hydropower dam development in Cambodia'. Synthesis report of the FiA/Danida/WWF/Oxfam project "Food and nutrition security vulnerability to mainstream hydropower dam development in Cambodia".Inland Fisheries Research and Development Institute, Fisheries Administration, Phnom Penh, Cambodia.44 pp. https://www.oxfam.org.au/wp-content/uploads/2014/02/pdf_food-and-nutrition-for-print-2.pdf