A characterization of community fish refuge typologies in rice field fisheries ecosystems

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A CHARACTERIZATION OF COMMUNITY FISH REFUGE TYPOLOGIES IN RICE FIELD FISHERIES ECOSYSTEMS

Authors

Alan Brooks, Miratori Kim, Celine Sieu, Vichet Sean and Vanvuth Try

Citation

This publication should be cited as: Brooks A, Kim M, Sieu C, Sean V and Try V. 2015. A characterization of community fish refuge typologies in rice field fisheries ecosystems. Penang, Malaysia: WorldFish. Handbook: 2015-37.

Acknowledgments

The authors would like to thank the Fisheries Administration for their support in this project. The partner nongovernmental organization—Organization for Women Support (COWS), Aphiwat Neary Khmer Organization (ANKO), Trailblazer Cambodia Organization (TCO), Village Support Group (VSG)—kindly contributed to this report in participating in the assessment of the CFRs and attended a series of workshops to help define the CFR categories.

The United States Agency for International Development (USAID) provided financial support to the Rice Field Fisheries Enhancement Project, enabling the publishing and distribution of this report.

CONTENTS

PREFACE

Published in 1997, the *Ricefield Fisheries Handbook* examines the capture and culture production potential of rice ecosystems in Cambodia. Five categories of rice ecosystems, ranging from upland to lowland deep-water rice fields near natural lakes, were assessed according to land elevation. Rain-fed lowland and irrigated rice ecosystems showed the greatest potential for improving production of aquatic animals either by culture or through better-managed wild capture environments. Deep-water rice was also evaluated as having potential for culture fishery improvements.

In rural Cambodia, fish is a source of food and income to millions of people. However, there has been a real threat to fish populations in natural wetlands due to the degradation of aquatic biodiversity and habitat, illegal fishing, increase of population and demand for fish, and the use of harmful pesticides for agriculture. The Rice Field Fisheries Enhancement Project (RFFEP) seeks to rebuild and protect the fish populations through innovative methods. The project works with communities to sustainably strengthen the rice field fisheries near their villages by improving protected habitats called "community fish refuges".

Building on the earlier handbook, this publication characterizes rice field fisheries that are connected to community fish refuges. Community fish refuges are designated fish conservation areas promoted by the Fisheries Administration of the Royal Cambodian Government. By establishing 1200 community fish refuges throughout the country, the government plans to increase productivity of rice field fisheries.

This technical brief examines the characteristics of rain-fed rice field ecosystems that are connected to community fish refuges in order to further refine descriptive criteria and better understand potential benefits and management strategies.

In order to ensure that effective management approaches are developed for rice field fisheries with community fish refuge agro-ecosystems, four categories have been characterized. The data and information provided in this report are generated from focus group discussions with community fish refuge committee members. A greater understanding of a detailed typology of these rice field fisheries systems will provide a platform for targeted research and enable development planners and communities to better optimize investment for enhancement and management of the resource.

THE IMPORTANCE OF RICE FIELD FISHERIES: AN INTRODUCTION

A rice field is an expanse of agricultural land supporting rice agronomy along with an aquatic ecosystem often diverse in fish species, other aquatic animals and other biota. Embankments, water channels, ditches, canals and sumps (fish traps or refuges) generally characterize the physical structure of the agro-ecosystem and are connected to larger waterways and lakes. Rice field fisheries refer to the harvesting or capture of wild fish and other aquatic animals (mainly snails, snakes, crabs and frogs) from the flooded rice fields and their supporting infrastructure of canals and streams.

In Cambodia, the natural supply of fish and other aquatic animals from rice fields is a very important contribution to household food economies and to the potential nutritional well-being of many rural people. Therefore, maintaining this supply, or even increasing total supply to meet the growing population, captures the attention of government policies and strategies. This section briefly describes the Royal Government of Cambodia's strategic plan for rice field fisheries and highlights their importance to livelihoods and biodiversity.

Royal Government of Cambodia planning

Overall productivity, fish supply and the harvesting of other aquatic animals, maintaining species diversity, and identifying potential opportunities for rice-fish culture are key elements of Royal Government of Cambodia's rice field fisheries planning and policies. The maintenance and development of rice field fisheries is explicitly stated in the National Strategic Development Plan 2009–2013 in item 420.

The Strategic Planning Framework (2010–2019) developed by the Fisheries Administration and approved by the Ministry of Agriculture, Forestry and Fisheries further elaborates on this plan by stating that by the end of 2019, "at least 1200 communes [will] have [a] sustainable and effective fish refuge." Guidelines for the National Strategic Development Plan 2014–2018 recommend continuous support and policy development for improved community fish refuge and rice field fisheries management.

> *Encourage the establishment and improvement of community fisheries and Community Fish Refuges in inland and coastal areas in order to enhance the management of sustainable fisheries resources by empowering local communities.*
>
> **—National Strategic Development Plan 2009–2013, item 420**

Rice field fisheries productivity and importance to livelihoods

Rural households in other countries in Southeast Asia, most notably Thailand and Vietnam, have become less dependent on natural and wild food sources from rice fields as rural economies diversify and flourish, offering alternative livelihood options. However, in Cambodia, rice fields remain an important source of food and protein for the rural population. Although the Cambodian rice sector is rapidly transforming, with large-scale irrigation schemes, more intensive rice production techniques (Agrifood Consulting International and CamConsult 2006; United States Government 2010), and the adoption of new and innovative rice varieties (Mak 2001), the contribution of rice field fisheries to household food security and nutrition will likely remain very important over the next one to two decades. At the same time, overexploitation of natural resources, increased use of agro-chemicals, and construction of hydrological infrastructure reduce fish productivity across the different habitats of the floodplain.

The productivity and value of rice field fisheries to households in rural Cambodia is highlighted in previous studies. Most notably, Gregory and Guttman (2002) estimated that the average amount of fish caught in rice field fisheries

in southeastern Cambodia was more than 380 kilograms (kg) per household per year, contributing to an annual consumption of 37 kg per person. Variations were high, ranging from a maximum of 604 kg with good water supplies to a minimum of 158 kg in areas of poor water availability. Even the lower range is an important contribution of "free" fish to the household.

Shams et al. (2001), conducting a rice field study in Svay Rieng, showed that a majority of the fish (89%) caught were *Clarias*, *Channa* and *Anabas* species, all of which command good market prices in rural, peri-urban and export markets in Cambodia. They showed that over a 9-month period, yields were 585 kg per household or 2 kg per household per day per year. This was close to the mean catch rate outlined in Gregory et al. (1996a) of 681 kg per household per 10 months. These high rates were attributed to the presence of trap ponds, not found in Battambang by Hortle et al. (2008).

A baseline livelihood study (Joffre 2013) commissioned by the RFFEP sampled 640 households from 40 community fish refuges and revealed that the average fish harvest per household was 201 kg per year, 77 kg (38%) of which was sourced from rice fields. An additional 38 kg per household per year of other aquatic animals were caught during the previous year at the time of the study period in November 2012. Further analysis reveals that only 54% of the surveyed households were involved in collection of other aquatic animals, while 99% of the households engaged in fishing and 83% fished in rice fields specifically. According to this study, rice field fisheries contributed 54% of the fish catch that is consumed by households (Joffre 2013).

The RFFEP catch and consumption survey (WorldFish and USAID 2014a) collected 7-day recall data from 400 households six times per year between 2012 and 2014. Analysis to date reveals that households vary their catch and consumption of fish (including other aquatic animals) according to the seasons and that their choice of fishing grounds also changes with the seasons. This is to be expected. The data reveals that 40%–60% of households fish in flooded rice fields during the wet season in the months of July, September and November (months surveyed) significantly more than any other fishing ground.

> *Protect the important natural habitats and biodiversity by establishing Community Fish Refuges and releasing fish in fishing lots and major important water bodies in every commune all over the country.*
>
> **—National Strategic Development Plan 2009–2013, item 420**

During the drier times of year, households frequent three main fishing grounds fairly equally: rice fields, lakes, and streams or canals. Similarly, at the peak of the wet season in July and September (months surveyed), close to 60% of the fish households caught were from rice fields.

The refuge ponds are also highly productive assets for many households. Also known as trap ponds, these are small deep ponds (often 50–100 square meters [m^2] and 2–3 metres deep) dug in rice fields with the aim of catching fish from the rice fields as the water recedes. The trapped fish are commonly harvested in January and February. The RFFEP refers to these ponds as rice field "refuge ponds" because farmers are encouraged to retain some fish for seed stocking brood fish for the following wet season. For households with refuge ponds (trap ponds), yields could be as high as 600 kg per 100 m^2. However, the average for the 132 "refuge ponds" surveyed during the livelihood baseline study for the RFFEP was 35 kg per pond per year, equivalent to 60 kg per 100 m^2 per year. Furthermore, additional unpublished data collated by the project reveals that 80% of refuge ponds yield below 100 kg per 100 m^2 per year. Viseth et al. (2008) surveyed four fish refuge ponds (Takeo, Kampong Speu, Kampot and Prey Veng) through a series of interviews and found an annual catch of fish and other aquatic animals ranging from 86 to 684 kg, with a per capita consumption between 17.4 and 47.8 kg. The resulting economic returns were estimated to be between US$ 2300 and US$ 35,500 for the 2006–2007 season.

Photo Credit: Rice Field Fisheries Enhancement Project

Rice field refuge pond in Lboeuk Keteyuos Community Fish Refuge (Siem Reap Province).

Hortle et al. (2008), studying the value of rice field fisheries in Battambang, reported that the mean yield was 119 kg per hectare (ha) per season (+/- 25 kg with a 95% confidence limit) for a value of US$ 102/ha (+/- US$ 23). This is an underestimate, as fishers make additional catches with illegal gear and unmonitored dry season catches. By comparison, gross income from rice production at the time was US$ 150 per hectare per single crop season. Studying 291 households located near one community fish refuge in each of five provinces, Thuok (2009) reported significant increases in fish catch, consumption and income when comparing respondents' data before and after establishment of community fish refuges. Overall income from all occupations doubled from US$ 442.10 per year before the formation of community fish refuges to US$ 924.59 per year after the formation of community fish refuges.

The contribution of fisheries to income is highly dependent on household location and access to fishing grounds. Of the 640 respondents surveyed in November 2012 for the RFFEP within the zone of influence of 40 community fish refuges, fisheries contributed 15% of households' total income on average. However, for households with access to rice field refuge ponds (10% of total surveyed), flooded forests and the Tonle Sap Lake, the average contribution to household income significantly increased to 60% of total income (Joffre 2013). It is also worth noting that this study highlighted the importance of rice field fisheries as a source of income, with 42% of all fish sold harvested from the rice field.

Researchers have also assessed yields per unit area, or habitat productivity, from which the data has been used as a crude method to estimate total productivity of fish from rice fields in Cambodia. Ahmed et al. (1998) used figures ranging from 25 to 61 kg per hectare per year to estimate the annual production of Cambodia's rice field fisheries. Multiplied by the 1.8 million hectares of potential Cambodian rice fields, they reached an annual production of 45,000–110,000 tons, amounting to 15%–25% of Cambodia's total annual fish catch. For purposes of gross estimates, 50–100 kg per household per year is often used for an estimated 2 million hectares of seasonal wetlands and rice fields, representing a total supply of 100,000–200,000 metric tons of "free" nutritious food to many of the rural resource-poor (Gregory and Guttman 2002). More recently, Hortle (2007) reported rice field fisheries yields from eight surveys and studies in Cambodia ranging from 42 to 165 kg per hectare per year.

The baseline livelihood study for the RFFEP combined rice cultivation area data with fish catch data to estimate annual yields of fish to be 87 kg per hectare per year from 640 households across four provinces (Joffre 2013). In a separate study by Un et al. (2014), using secondary source data to estimate habitat productivity, rain-fed rice field productivity was estimated to be

109 kg per hectare per year, while flooded rice field productivity was estimated at 121 kg per hectare per year (but with significant variations from minimum to maximum recorded). Using this average estimated fish production multiplied by the total estimated area in Cambodia of 3.2 million hectares for rain-fed rice fields and 0.37 million hectares for flooded rice fields, the review concluded that the rice field habitat could produce 395,635 metric tons of fish per year, which is significantly higher than the 108,500 metric tons of estimated production in 2009 (FiA 2010b).

The discrepancy may be explained by the Fisheries Administration using the lower multiplier for rice fields only (e.g. Ahmed et al. 1998) and reporting a separate category known as "Family Fisheries" for catches from wetland areas (streams, ditches and small lakes) associated with rice fields. One category uses yield per unit area, while the other uses yield or catch per household. It may be better to combine both as "rice field fisheries," including all habitat types of the rice field fishery environment and calculating yield on the basis of catch per household from all habitat types.

Clearly, additional and more refined productivity data is required to account for differences across rice field fisheries ecosystems in the country for more accurate estimates. Characterizing different categories of rice field ecosystems with community fish refuges is one step to achieving more useful estimates for future analysis of variation.

Biodiversity

In a study that harvested all aquatic animals from rice fields in Battambang, Hortle et al. (2008) reported 35 species of aquatic animals. Fish made up 77% of the total catch weight, with "black fish species"[1] comprising 88% of fish weight. Most species of this catch were carnivores. The key species found in this study were *Channa striata* (chevron snakehead), *Macrognathus siamensis* (peacock eel), *Anabas testudineus* (climbing perch), *Clarias batrachus* (walking catfish), *Trichogastor trichopterus* (three-spot gourami) and *Monoterus albus* (swamp eel). Shams and Hong (1998) also list 35 species caught from rice fields in a study conducted in Kampong Thom Province.

The RFFEP biological monitoring (WorldFish 2014) surveyed fish and other aquatic animal catch in weight and number using gill nets, hook long lines and fyke traps across 40 community fish refuges. Across all categories of community fish refuges, a range of 42–77 fish species were found, with numbers of fish species, genera, and families all being highest during November of both survey years (2012 and 2013). Here, however, "gray fish species"[2] made up the largest portion, over half of fish caught on each occasion. *Cyprinidae* (carps and barbs) and *Ambassidae* (glass perches) were the two dominating fish families among all fish caught in the four categories of community fish refuges and across all occasions. Two other fish families were among the top five species caught on almost every occasion: *Bagridae* (bagrid catfish) for all categories and *Osphronemidae* (gouramies) for three out of four categories.

Rice-fish culture

Rice-fish culture primarily refers to the deliberate stocking of specific fish species into the rice field environment in order to raise a fish or crustacean crop for consumption and/or sale (Halwart and Gupta 2004). In addition to the wild aquatic resources that travel into flooded rice fields with rain or irrigation water, fish are stocked concurrently or in rotation with rice (WorldFish 2012) to enhance the aquatic agro-ecosystem productivity. Notably, this is a temporary and seasonal agro-ecosystem, and production can be highly variable depending on wet season flooding. Integrating fish crops into rice field ecosystems has a long history and can provide extra income, furnish additional food supplies and reduce dependency on livestock husbandry (Halwart and Gupta 2004), but its potential depends on many factors beyond seasonal variability. In Cambodia, fisheries contribute to the employment, livelihoods, and food and nutrition security of the resource-poor, as well as to national gross domestic product (SPF 2010). While rice-fish culture currently faces challenges such as overfishing and ecosystem change due to climate change and damming for hydropower, there are opportunities for improvement in Cambodia's vast and diverse rice-fish ecosystems (SPF 2010). These opportunities chiefly involve improving natural resource management, improving postharvest handling of fish, and growing rice field fisheries sustainably through mapping conservation areas (SPF 2010).

TYPES AND INFRASTRUCTURE OF RICE FIELD FISHERIES ECOSYSTEMS

The *Ricefield Fisheries Handbook* (Gregory 1997) describes the five types of rice field fisheries systems: upland rain-fed, lowland rain-fed, irrigated (dry season), recession rice and deep-water rice. The highest potential for capture and culture fisheries was identified in the middle-elevation systems: lowland rain-fed and irrigated rice fields. These ecosystems are characterized by plentiful and manageable water in an average year. Wild fish and other aquatic animals are abundant and accessible in these areas compared to other rice field ecosystems. The highest potential for intervention was identified in culture fishery for all systems at different times of the year and in capture fishery in rain-fed lowland ecosystems during both wet and dry seasons. Many of the designated community fish refuges are located in between the upland and lowland areas—that is, the "middle zone" between true upland rice fields and flooded deep-water rice-growing areas.

This section addresses the basic features of the ecosystem common to all categories associated with community fish refuges. Essentially, the rice field fisheries systems are made up of three domains: community fish refuges, rice fields, and the connecting channels (rivers, creeks and canals). All three domains are considered habitats for fish and other aquatic animals as described by Doi and Viseth (2005): (i) the community fish refuge, a natural or artificial fish pond of a certain size and shape that serves as the initial spawning grounds for brood stock and as a conservation area during the dry season; (ii) several inlet-outlet canals for fish migration out of and into the ponds; and (iii) the surrounding rain-fed rice fields.

There are additional features and considerable variations in the descriptions of these domains. For example, a community fish refuge can be a designated conservation area within a larger water body, and deep rice field refuge ponds are often dug in the rice fields in order to aggregate fish during receding waters across the wetlands and rice fields.

An illustrated schematic (Figure 1) shows fish migrations and the most important features of the ecosystem. The three domains of rice field fisheries ecosystems with community fish refuges are further described in the following subsections.

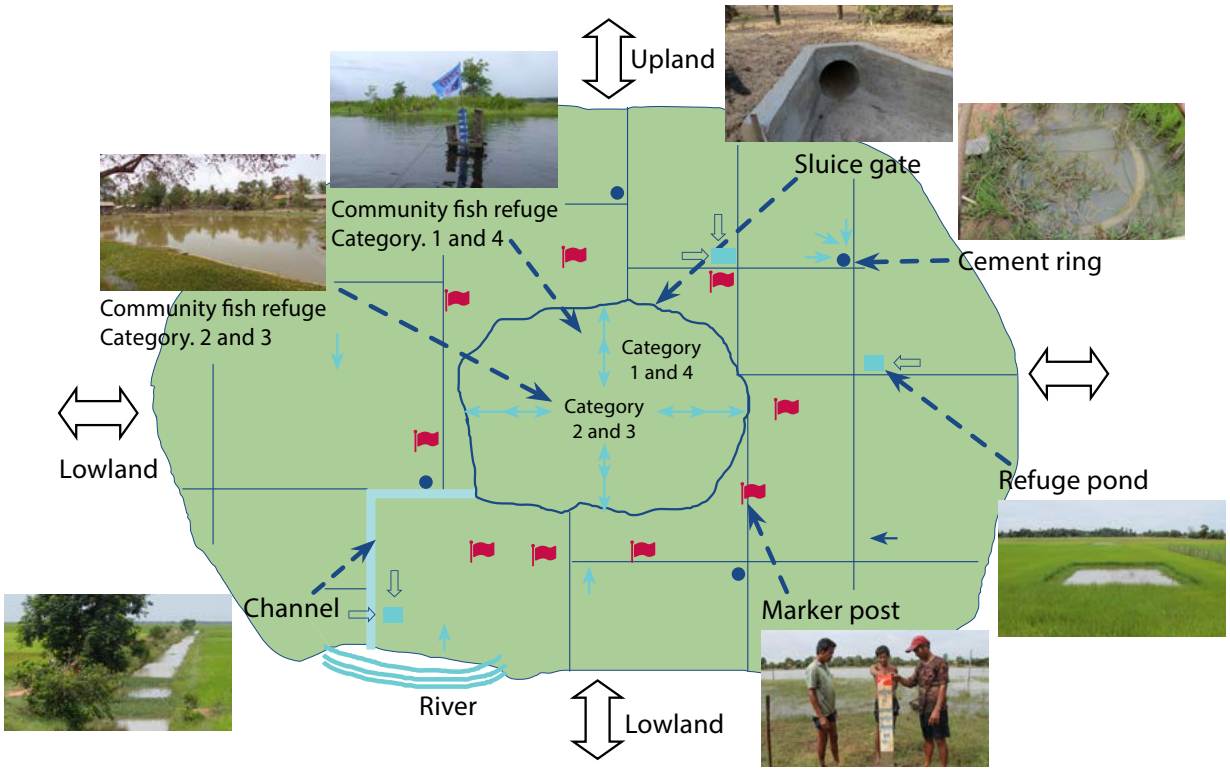


Figure 1. Rice field fisheries ecosystem and fish migration pathways.

The community fish refuge

A community fish refuge is an area of water designated to conserve aquatic fauna, mainly fish. The Fisheries Administration established the community fish refuge concept as a national policy in 2005 principally in order to increase fish yields of the surrounding rice fields, as well as to preserve the biodiversity of fish and other aquatic animals of the wetlands and Tonle Sap floodplain. Community fish refuges provide dry season refuges (Shankar et al. 2004; Joffre et al. 2012) for black fish species as well as providing a focal point to encourage community-based fisheries management (Magoulick and Kobza 2003; Joffre et al. 2012). However, unpublished work from the RFFEP reveals that white[3] and gray fish remain resident in the community fish refuge conservation area, most likely trapped from accessing their migratory routes.

The community fish refuge by definition must be a perennial volume of water—artificial or natural—that never dries up during the dry season. It may be a designated area within a larger water body or it may be an entire community pond. For the latter, the pond becomes disconnected from the floodplain during the dry season. These areas are strictly "no fishing" all year round and are managed directly by local community members with technical assistance from Fisheries Administration staff (TWGF 2006 *In* Thouk 2009). In these conservation areas, brood fish are ideally taken care of by the community for the following year and intended for escape to the surrounding rice fields (Thouk 2009).

Community fish refuges and the surrounding water bodies are in almost all cases multiple-use water resources. The community pond types are also designated and managed water storage areas for irrigating rain-fed rice-growing areas during the early monsoon season and for watering vegetable gardens, and in some instances, they are used as a potable water source for the local community. Fishing occurs in areas around community fish refuges that are demarcated within the large water bodies. In these reservoir types, the water volume that can be used for irrigation purposes may vary substantially, especially when a mini-drought occurs during early monsoon season. The multifunctional nature of different types of designated areas within community fish refuges has to be considered when making decisions on habitat improvement and community fish refuge management.

The channel

The channel's prime function is to facilitate fish movement to and from the refuges. Channels may be up to 300 meters (m) long or may be just a few meters connecting the community fish refuge pond to the rice fields. In some cases, particularly in long, complex channel networks draining upland reservoirs, the main canal channels may be large, dividing into smaller feeder channels to the rice fields. Conversely, other pond-type community fish refuges may only be connected to the rice fields via a culvert or sluice with no channel. For most of these community fish refuges, enforcing a 100-m no-take zone in the rice fields around the refuge is important in order to allow fish to radiate for an assumed improved equitable distribution across a wider rice field area and to facilitate propagation of the species. Channels are not always artificial structures, and interconnecting culverts may connect to small natural streams or rivers. (See Figure 7.)

The rice field

Rice fields are irrigated or flooded fields where rice is grown. They can be categorized as upland, lowland, irrigated, recession or deep-water. Once the rice fields become inundated with about 25–50 centimeters (cm) of water and especially after the rice transplanting, fish use the rice fields as breeding, spawning, foraging and growing-out habitats (Thouk 2009). This habitat then becomes a fishing ground for rural farmers (Gregory 1997). The area of rice fields connected to community fish refuges via channels, culverts, streams or sluices can range from 181 to 5946 ha in the wet season and 0 to 2000 ha in the dry season. Some community fish refuges are not connected to the rice fields at all in the dry season. Average rice field connectivity across all 40 inventoried community fish refuges was 1767 ha per refuge in the wet season and 111 ha per refuge in the dry season. Almost all rice fields around community fish refuges are planted early in the rainy season with medium- or long-term-maturity rice varieties, while short-term rice varieties are cultivated in the dry season. Most farmers of rice fields located in the lowland broadcast in the wet season and transplant rice in the dry season. Most of the upland areas are cultivated using more transplanting methods and less broadcasting.

CHARACTERIZATION OF RICE FIELD FISHERIES WITH COMMUNITY FISH REFUGE CATEGORIES

Formulating categories

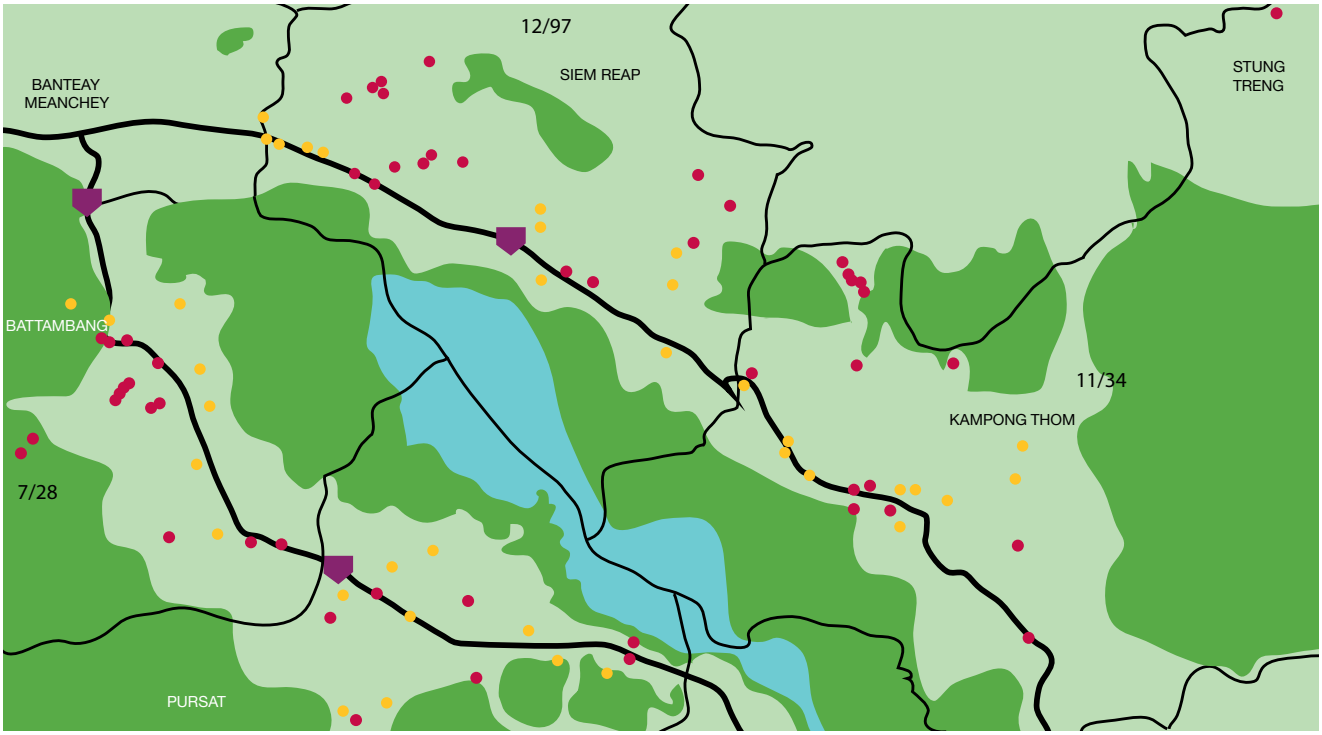
To facilitate the development of more focused management guidelines, the RFFEP selected and inventoried 40 out of the 179 Fisheries Administration-designated community fish refuges in Siem Reap, Battambang, Kampong Thom and Pursat provinces (Figure 2). The RFFEP then characterized categories of rice field fisheries ecosystems to determine intervention strategies to increase productivity and biodiversity of the ecosystem.

The initial inventory revealed two distinct types of community fish refuges: (i) community ponds set in agricultural land and (ii) designated conservation areas within a larger water body, either a reservoir or a natural lake. Rice fields that either flooded regularly or were not prone to flooding at all often surrounded the community pond types. Among the second type, community fish refuges located in reservoirs tended to be in more upland areas and subject to drawdown for irrigation purposes, while lowland community fish refuges in lakes within the floodplain were affected by the seasonal flood pulse.

To improve research outcomes and ultimately develop more specific and beneficial management approaches for each category, the two types of refuges were further subdivided to make four categories, which were numbered broadly by elevation: Category 1 represents community fish refuges in upland reservoirs; Category 2 represents community fish refuges that are community ponds not prone to flooding (usually outside the Tonle Sap Lake road boundaries delineated by Highways 5 and 6, shown in Figure 2); Category 3 represents community fish refuges that are community ponds prone to flooding (typically inside the road boundaries); and Category 4 represents community fish refuges within the floodplain of the lake.

Key descriptive characteristics differentiating categories

Broad descriptions to briefly summarize distinctive physical features of the four categories are shown in Figure 3. These descriptions are based on six key characteristics that are discussed in more detail in this section.



● Community fish refuges not selected by the RFFEP ● Community fish refuges selected by the RFFEP

Figure 2. Map of selected community fish refuge locations for the RFFEP inventory.

Category 1: Irrigation reservoir • reservoir usually upland • large water body with conservation area within • water control structures • long ditches and channels to rice fields • variable and rapidly changing water volumes • water in rice fields controlled • irrigated dry season rice • increased use of pesticides	 I. Kuch Noub Community Fish Refuge in Pursat
Category 2: Community pond without flooding • community pond with water control structures • usually does not flood • often shallow and parts dry out • short connections to rice field by channels	 II. Lboeuk Keteyuos Community Fish Refuge in Siem Reap
Category 3: Community pond with flooding • community pond with water control structures • usually floods • often shallow and parts dry out • short connections to rice fields by channels	 III. Trapaing Thlok Meanchey Community Fish Refuge in Kampong Thom
Category 4: Within large water body • natural depression forming large water body, usually with pulsing and extensive flooding areas • relatively small community fish refuge compared to total area of water body • widespread and diffuse connection to the rice fields • deep-water rice and fields vulnerable to flooding • some recession rice	 IV. Boeng Rolum Community Fish Refuge in Kampong Thom

Figure 3. Summary of main physical features and distinctions across community fish refuge categories.

AGRO-ECOLOGICAL ZONE

The Tonle Sap floodplain is one of four major agro-ecological zones in Cambodia (Figure 4). Along with the Mekong plains zone (Nang et al. 2014), it is characterized by flooded or inundated forests during the wet season as the Tonle Sap Lake expands and by relatively nutrient-rich soils and fish production from flooded rice fields (Forestry Administration and DANIDA 2003).

This zone is a multifunctional agro-ecosystem, with different rice cropping systems adapted to different water depths, shrub and grass land for grazing, and fishing in recession ponds and rice fields (Diepart 2007). It encompasses both productive agricultural and fisheries land (Figure 5) and may be further subdivided into five categories according to elevation (Figure 6). These subdivisions are an important feature in determining community fish refuge category types.

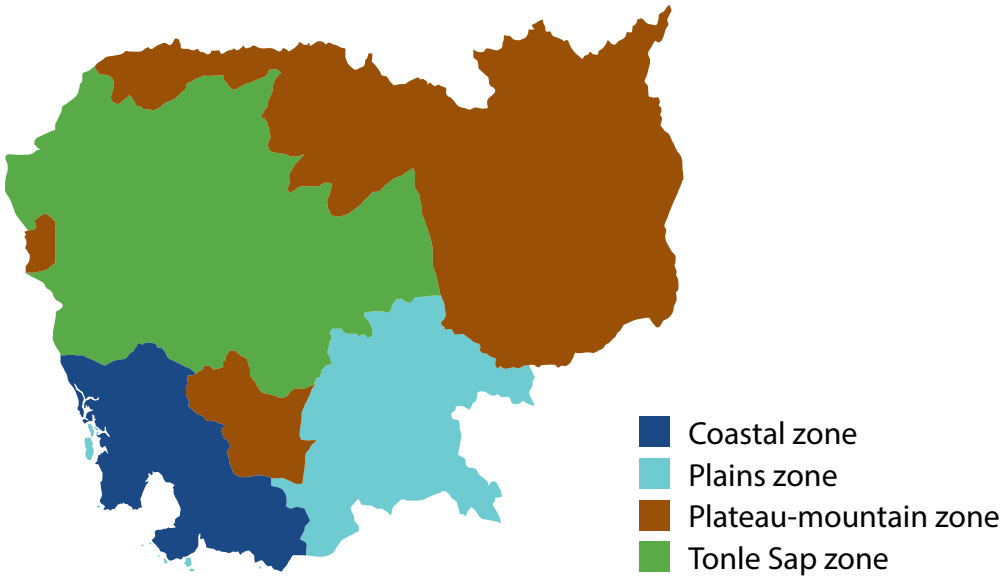


Figure 4. Four major agro-ecological zones in Cambodia (Ministry of Environment of Cambodia and UNDP Cambodia 2011).

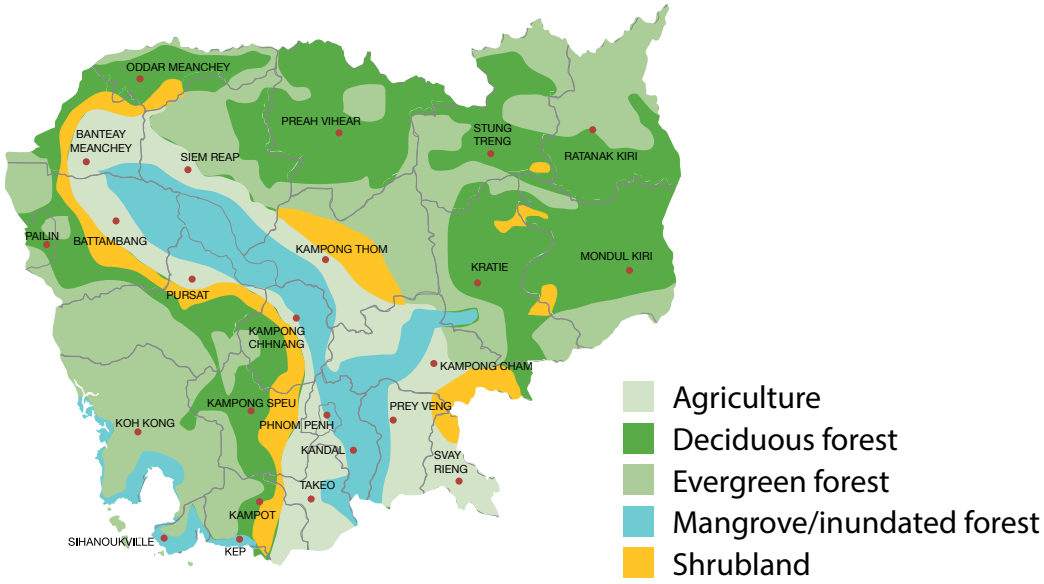


Figure 5. Agriculture around the Tonle Sap floodplains (Forestry Administration and DANIDA 2003).

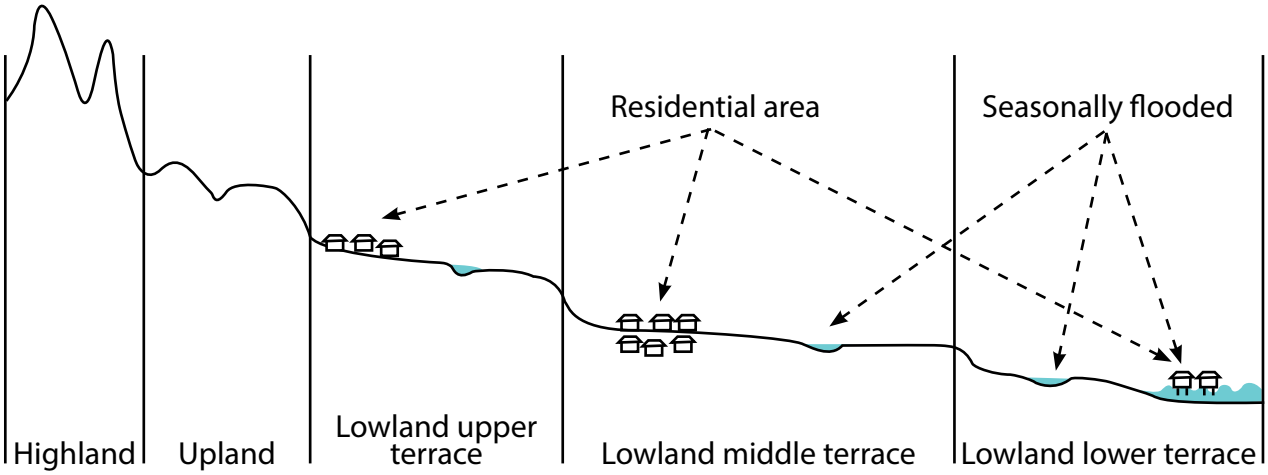


Figure 6. Floodplain agro-ecological zone divided according to elevation (CGIAR 2008).

Category 1 community fish refuges are usually situated in upland areas and range from 12 to 45 kilometers (km) in distance from the Tonle Sap Lake, with an average distance from the lake of 32 km. Specific to this category is a water catchment that surrounds higher elevations. This impacts fish migration and species assemblage resident in the system. Rice farming is rain-fed and irrigated (one or two crops per year), mainly carried out on small household-owned plots, although larger rice-growing schemes also exist (e.g. Ang Chork Community Fish Refuge in Battambang). In this zone, the rice types are early- and medium-maturing varieties, with less than half of community fish refuges planting late-maturity varieties. Rice is broadcast in the wet season like in all other categories, but a greater proportion of community fish refuges transplant in the dry season compared to other categories.

Category 2 community fish refuges are situated in the higher areas of lowland rain-fed rice systems. They are often located outside of Highways 5 and 6, which encircle the Tonle Sap Lake (Figure 2). The distance from the Tonle Sap Lake to Category 2 community fish refuges ranges from 15 to 72 km, with an average of 36 km. Wet season rice cultivation is most common within this agro-ecological zone.

Category 3 community fish refuges are in a similar agro-ecological zone to Category 2 refuges, but they are closer to the Tonle Sap floodplain; distance from the Tonle Sap Lake to Category 3 community fish refuges ranges from 9 to 44 km, with an average distance of 33 km. This zone usually falls between the Tonle Sap basin and Highways 5 and 6 (Figure 2). It is connected to the Tonle Sap Lake or Mekong system and spreads from lowland to floodplain agro-ecological zones. The closer proximity to the floodplain means that community fish refuges in this zone are prone to frequent flooding. This zone is rain-fed, and dry season rice is cultivated. Rice types are medium-maturity or early-maturity varieties, with fewer deep-water rice varieties being used. Broadcasting techniques are used in all community fish refuges in this category, but farmers in less than half of the refuges transplant rice in the dry season. In this category, more late-maturity rice varieties are planted compared to other categories, with farmers in 90% of community fish refuge locations planting late-maturity rice.

Category 4 community fish refuges fall in an area ranging from 25 to 72 km from the Tonle Sap Lake. Community fish refuges in this agro-ecological zone are on average situated farther from the lake compared to other categories (52 km), but are at the lowest elevation. The cultivation of rice paddy fields (not recession rice) is still possible during the wet season. Community fish refuges in this zone are within larger water bodies that may be within or connected to the Tonle Sap floodplain.

WATER BODIES AND COMMUNITY FISH REFUGES

As mentioned previously, a community fish refuge is a perennial volume of water, either artificial or natural. It may be a designated area within a larger water body or an entire community pond, and it never dries up completely during the dry season. The large water bodies containing community fish refuges can be reservoirs, lakes or flooded areas. The RFFEP collected data on the size of community fish refuges and large water bodies, as well as on water depth, transparency and quality. Selected criteria are presented (Table 1) and discussed in order to highlight differences between categories.

Based on the 40 community fish refuges inventoried across four Tonle Sap provinces by the RFFEP in 2012, community fish refuge sizes vary substantially, ranging from 0.15 to 10 ha in the dry season and 0.16–16.32 ha in the wet season. Some community fish refuges are within larger water bodies which themselves may range in total size from 0.20 to 180 ha in the dry season or 0.4–1750 ha in the wet season. For independent community fish refuges (usually community ponds), the size range may be from 0.15 to 2.5 ha in the dry season or 0.16–3.50 ha in the wet season. For community fish refuges within larger bodies of water, depths range between 1.3 and 7 m in the dry season or 3–9 m in the wet season. Independent community fish refuge depths range from 1.2 to 10 m in the dry season or 2–12 m in the wet season.

Except for Damnak Kranh Community Fish Refuge in Pursat, in which the entire water body is the community fish refuge in the wet season, all Category 1 community fish refuges are a part of a larger water body. These large water bodies are often large upland reservoirs (e.g. Kuch Noub Community Fish Refuge in Pursat) used for storing water, mainly to supplement early rains for rice field irrigation and/or to provide water for dry season crops.

The community fish refuge is often located in the deeper part of the large water body and is least likely to drain dry during drawdown for irrigation. Similarly, Category 4 community fish refuges are all located within a large water body and are often located in the deepest part. These large water bodies may be natural lakes (e.g. Boeng Thea in Kampong Thom) or flooded lowland areas in the floodplain. In both Category 1 and 4 community fish refuges, the community fish refuge is a relatively small demarcated area in relation to the size of the large water body. (See Table 1.) In contrast to the pond-like features of Categories 2 and 3, community fish refuges in Category 4 may comprise a flooded forest area and are abundant in floating vegetation, with many submerged dead tree stumps and branches.

	Average area of community fish refuge (ha)		Average depth of community fish refuge (m)		Average transparency (cm)		Average area of large water body (ha)		Average depth of large water body (m)	
	wet season	dry season	wet season	dry season	wet season	dry season	wet season	dry season	wet season	dry season
Category 1	8.09	4.44	5.50	3.09	59.86	31.14	245.85	43.73	4.92	2.43
Category 2	1.20	0.94	4.96	3.37	49.50	26.39	n/a	n/a	n/a	n/a
Category 3	1.26	0.56	4.55	2.30	57.70	16.90	n/a	n/a	n/a	n/a
Category 4	3.28	2.98	4.89	2.29	56.78	21.61	267.58	37.65	4.89	2.29

Table 1. Large water body and community fish refuge characteristics across categories.

Category 2 and 3 community fish refuges are different from refuges in Category 1 and 4 in that they are not located within a larger water body (with the exception of Boeng Chheutrav [Pursat] in Category 2 and Boeng Tramper [Pursat] in Category 3). Community fish refuge ponds are a multipurpose resource. These ponds are commonly utilized as community ponds, often accessed for irrigation of rice and vegetable plots, or for domestic purposes such as washing and bathing cows and buffalos. At one community fish refuge location, Lboeuk Keteyuos in Siem Reap Province, the water is used by a local clinic and also as a potable supply for the community.

However, there is an important difference between Category 2 and 3 community fish refuges. Community fish refuges in Category 2 almost never flood, and refuges in Category 3 are characterized by wide fluctuations in volume and depth, peaking in October or November at 4.55 m in depth and declining on average by 50% to their lowest level in April or May at 2.30 m. Moreover, community fish refuges in Category 3 are prone to flooding during above-average rainfall and flooding years, flooding about once every other year according to local memory. They are small natural lakes or artificially dug ponds, retaining water all year round.

Through the seasons, the water transparency within community fish refuges may fluctuate. This is a result of increasing mineral turbidity, and in some cases, low transparency is due to high plankton density. In general, the transparency of the water tends to be greater in categories with a higher elevation (1 and 2) during the dry season. Water transparency also tends to be greater in the wet season compared to the dry season, but no apparent differences exist between categories. Ensuring an ideal water transparency of green water measured to a depth of 30–40 cm using a Secchi disk is a management strategy used to increase fish productivity. Community fish refuges with brown colored water high in suspended silt loading cannot support high densities of plankton for the planktivorous fish species commonly found in rice field aquatic ecosystems.

Harvesting fish from the Rice Field Fisheries Enhancement Project refuge pond.

CHANNELS AND RICE FIELDS

Community fish refuges are connected to surrounding rice fields through channels and streams, providing passage for migrating fish (Figure 7). The length, function and construction of these channels vary. The project collected data regarding channel length (i.e. distance of the channel connecting the community fish refuge to the rice fields), construction material (earthen or concrete), and the number of rice field refuge ponds and rice field refuge rings found in rice fields connected to community fish refuges.

Figure 7. Rice fields (top left), channels (top right, bottom left), connecting culvert (bottom right).

In general, variation in the length of the channels for community fish refuges located within larger water bodies (Categories 1 and 4) is very high, ranging from no channel to 300 m long. Out of seven community fish refuges inventoried as Category 1, three have a direct connection with no channel. The channels' lengths for the pond refuges (Categories 2 and 3) are much more consistent, with short channels not exceeding 25 m for the 24 community fish refuges inventoried (Table 2). Since fish migrate to the rice fields through these channels, the length creates an opportunity for unregulated over-fishing if not well managed. Therefore, Categories 1 and 4, with long channels, may require more focused attention for better regulation of fishing in channels.

In Category 1 community fish refuges, the initial channels may be earthen or concrete lined and can be quite wide. These channels feed into junctions known as "culvert boxes," where water is directed according to need to the main irrigation channels. Smaller off-take channels (similar to those seen in Figure 7) beginning at the end of larger irrigation channels then irrigate the rice fields. Fish migrate to the rice fields largely by water gates during the peak flooding period.

However, water gates can limit certain types of fish species from accessing the rice paddies. These gates are also the exit point for stored and excess water, and water may be released from storage during the mini-droughts of early monsoon season to irrigate dry rice fields. This is a time when there are fewer wild fish inhabiting the surrounding wetlands, which means the demand for fish may be high, resulting in additional fishing pressure if not controlled.

In Category 2 community fish refuges, fish migrate primarily through earthen inlet or outlet channels or through culverts. In one case, a spillway overflows directly into the nearest rice field, from which fish migrate to other fields, mostly via smaller channels. According to community fish refuge committee decisions, the no-take zone for fishing may range from 50 to 100 m around the community fish refuge water body.

In Category 3 community fish refuges, fish migrate by open channels, by concrete pipes or sometimes across the entire rice field when the community fish refuge is completely flooded, a defining characteristic of this category. According to community fish refuge committee decisions, the range of the no-take zone for fishing is the same as in Category 2, from 50 to 100 m around the community fish refuge water body.

For Category 4 community fish refuges, the types of connections between community fish refuges and surrounding water bodies to rice fields can be either culvert-type or have no channel at all due to seasonal inundation and flooding around the shoreline of the larger water body.

	Channel length (m)[4]	Average area of rice fields connected to community fish refuge (ha)		Average number of trap ponds in rice fields[5]	Average number of cement rings in rice fields[6]
		Wet season	Dry season		
Category 1 (n=7)	0–300	2,006.6	42.1	21	8
Category 2 (n=14)	0–25	1,305.7	6.4	57	3
Category 3 (n=10)	0–13	2,063.4	316.4	33	2
Category 4 (n=9)	0–25	1,968.9	100.1	20	3

Table 2. Channel and rice field characteristics across categories.

Category 2 community fish refuges have the smallest average area of connected rice fields compared to the other three categories, but have the largest average number of rice field refuge ponds. (See Table 2.) Category 1 community fish refuges have the most cement rings on average, while Category 3 community fish refuges have the fewest.

The period of connectivity to the surrounding rice fields is greatest during the wet season, typically between July and October. However, this depends on the year, as some years can experience droughts in this time, reducing the connectivity.

Photo Credit: Rice Field Fisheries Enhancement Project

Kuch Noub Community Fish Refuge (Pursat) irrigation scheme, where smaller off-take channels begin at end of main irrigation channel (left); spillway and no-take zone at Entark Koma Community Fish Refuge in Kampong Thom Province (right).

FISHERY RESOURCES

Fishery resources can be understood as the amount of fish and other aquatic animals households catch, consume or sell, as well as how productive the rice fields and connecting channels and streams are in terms of fish catch. In order to understand community fishery resources across community fish refuge categories, the RFFEP surveyed households to better understand their own catch and consumption of fish from rice field fisheries, as well as their access and ability to fish throughout the dry and wet seasons. In this section, "all fishing grounds" refers to rice fields (including rice field refuge ponds), channels and streams.

During the inventory of community fish refuges, focus group discussions with community fish refuge committee members revealed that in general, respondents in Categories 1 and 4 (where the community fish refuges are within larger water bodies) perceive that a greater portion of the fish they eat comes from the rice fields (including rice field refuge ponds) as opposed to other sources (channels, streams or markets) than do respondents in Categories 2 and 3 (where the community fish refuges are pond-like). Estimates also show that catches in all fishing grounds per household in Category 4 may be 50% more than in other categories.

Given that Categories 1 and 4 are characterized by community fish refuges located within larger bodies of water, the average number of months fishers catch fish is higher than in Categories 2 or 3, where the community fish refuges are pond-like. In Categories 1 and 4, the average number of months households can fish is 9 and 10 respectively, compared to around 6 months for Categories 2 and 3.

The importance of community fish refuge rice field fisheries for fish catch generally ranked higher for Categories 1 and 4 than for Categories 2 and 3. Most respondents in Categories 1 and 4 ranked community fish refugerice field fisheries' importance as "quite" to "extremely" important as a fish supply for the community. (See Table 3.) The importance of fishing grounds can also be demonstrated by the number of households fishing: Categories 2 and 4 show similar numbers, which are significantly higher than the average number of households fishing on all grounds in either Category 1 or 3. (See Table 4.) This is discussed further in the section accompanying Table 4.

Fish migration and species are also slightly different for each category. For Category 1 community fish refuges, since the water connectivity from rice fields to the community fish refuge and water body may be established early in the monsoon season, fish migration is also early in the season compared to other categories. However, migration from the community fish refuge upstream is hampered by the water structures in place. (This does not happen in other categories.) These factors may have implications for management strategies of fish stocks in the water body and community fish refuge, as well as for harvesting from the rice fields. Although there is strictly no fishing within the community fish refuge, fishing is permitted within the water body surrounding the community fish refuge. This may also call for different management strategies compared to categories in which the entire water body is the community fish refuge.

	Average approximate fish eaten from rice field fisheries compared to other (%)	Average estimated fish catch from rice field (kg) per household per year	Average number of fishing months per year	Importance of community fish refuge rice field fisheries[7]
Category 1	64	172	9	4.4
Category 2	46	115	6	3.9
Category 3	46	143	6	3.7
Category 4	62	200	10	4.7

Table 3. Fishery resources across categories.

According to ongoing biological studies, the dominant species (over half of fish caught) across all community fish refuge categories are gray fish, followed by black fish. Very few white fish species were present at the community fish refuges. The presence of black fish species increased during the months of November and February, but was still significantly less than gray fish species.

Finally, the ecosystem of Category 4 community fish refuges is home to a wider range of species, comprised of all the fish types and abundant other aquatic animals such as frogs, shrimp, crab and water birds.

Photo Credit: Rice Field Fisheries Enhancement Project

Digging channel connecting community fish refuge to rice field.

MANAGEMENT

Sustainably improving the management, productivity and habitats of community fish refuges and surrounding rice field ecosystems is one of the main aims of the RFFEP. Structural improvements and changes such as building canals to link community fish refuges to rice fields, deepening parts of community fish refuge ponds, installing cement rings in rice fields for fish conservation, constructing spillways to control flow to rice fields, removing excess vegetation, and preventing illegal fishing are all part of achieving this aim. In order to assess if and how these changes were being implemented, this project asked respondents in community fish refuge communities to reflect on ongoing management activities.

In Category 1 and 4 community fish refuges, fishery resources are protected as part of a conservation area (the community fish refuge) in only part of a larger body of water. In Category 1 community fish refuges, the most important task for the management committees is the effective management of water distribution to the rice fields. Therefore, management of the fish is often treated as of lesser importance. The farmer water user committees and community fish refuge management committee work together to ensure sufficient water is distributed without draining the reservoir to a critical level, which would harm the fish resident in the community fish refuge. The committees also try to control fishing in the culvert boxes and channels so that brood fish can access the rice fields. At larger, more picturesque reservoirs, the location may be managed for ecotourism (e.g. Obosmkak Community Fish Refuge in Kampong Thom).

In Category 4 community fish refuges, signboard or marker poles mark protected areas. This demarcation is an important management task. Fishers can fish legally outside these conservation areas for the whole year as long as the water levels do not decrease to a critical level. Managing illegal fishing from February to May is important and is done regularly by the community fish refuge committees because the risk of illegal fishing during the dry season is higher.

In Category 2 and 3 community fish refuges, management committees are responsible for the entire water body, as the community fish refuges are entire ponds. This is defined as fishery-restricted management. The whole water body is therefore the conservation area managed by the community and relevant authorities and is a main fish refuge source.

In 2015, respondents were asked to assess the effectiveness of community fish refuge management committees and plans, and to report on how much illegal fishing might be taking place. In general, the majority of community fish refuges in each category indicated that a management plan had been agreed upon and that many actions and tasks had been implemented (and in Category 3, this was a clear majority at 80%). However, almost half of community fish refuges in Category 1 indicated that although a management plan had been agreed to, it was being poorly implemented. Also, very few community fish refuges indicated that most or all actions and tasks had been implemented. In terms of meeting times, community fish refuges in Category 3 met most regularly, with 60% holding meetings one or two times per month and 40% holding meetings three or four times per year, perhaps contributing to why these community fish refuges most commonly indicated that many actions and tasks had been implemented. The project intentionally selected community fish refuges with functional community fish refuge committees in order to achieve better success of best practice habitat improvement and management.

Around half of the community fish refuges in Categories 2, 3 and 4 noted that all illegal fishing in community fish refuges had stopped but that there was still some illegal fishing in channels. However, only 29% of community fish refuges in Category 1 noted this same trend, while over half indicated that some new rules and guidelines were being followed but illegal fishing in the refuge continues. In general, most community fish refuges across categories felt that there was still some illegal fishing happening; this was taking place either out of sight and at night, or by children and the resource-poor. Only three community fish refuges (two from Category 2 and one from Category 3) felt that no illegal fishing was happening at all.

ZONE OF INFLUENCE AND FISHERS

The zone of influence may be defined as the zone within which the benefits from the community fish refuge and the incremental benefits from interventions to improve productivity of the refuge and surrounding rice fields are realized. Boundaries are determined loosely by the connectivity to the community fish refuge during normal years. In some years of atypical flooding, no boundary exists, since connectivity is widespread. The project assessed the area of rice fields with connectivity to community fish refuges, as well as households and fishers within the zone of influence.

As discussed above in relation to channels and rice fields, the main difference between Categories 1 and 4 and Categories 2 and 3 is that the rice field areas within Categories 1 and 4 are distant from the community fish refuges and may be less influenced by any intervention to improve the refuge.

The average number of households within a community fish refuge's zone of influence (shown in the table as households benefiting) was greatest in Categories 1 (1307) and 4 (1042), while the average number of households benefiting for Categories 2 and 3 was much less (961 and 896 respectively). Notably, although Category 2 community fish refuges were on average connected to the smallest area of rice fields (1306 ha in the wet season; see Table 2), they had the third highest number of households benefiting and the second highest number in terms of the average estimate of households benefiting who were also fishing from inside the zone of influence. Categories 1 and 3 showed the highest estimated average numbers of households fishing from outside the zone of influence (111 and 80 respectively).

	Average number of households benefiting [8]	% and average number of households benefit fishing[9]		Average number of estimated households fishing from outside[10]
		%	Number	
Category 1	1,307	91	1,192	111
Category 2	961	89	853	26
Category 3	896	68	612	80
Category 4	1,042	74	769	56

Table 4. Zone of influence households and fishers across categories.

SUMMARY

In Cambodia the wetland rice field areas remain an important "free" food source of fish and other aquatic animals for many rural people. Appropriate management of water bodies, channels and rice fields for sustainable harvest of aquatic fauna and flora can be best achieved by gaining a better understanding of the physical and biological characteristics of these systems. Working closely with 40 rice field systems with designated community fish refuges, four categories have been identified and their characteristics described.

Table 5 summarizes the main differentiating features and characteristics of the four community fish refuge categories. The unique characteristics of each community fish refuge category are important to consider when pursuing improvements to management plans, rice field fisheries productivity and household livelihoods. For example, although two categories are similar due to the community fish refuges being embedded within a larger water body (usually the deepest part), a Category 1 refuge is a reservoir, often in an upland area, whereas a Category 4 refuge is a depression forming a natural lake. The reservoir category would be managed differently because of its frequent drawdown for irrigation, long channels connecting to rice fields, and distance and reduced connectivity to the biodiverse-rich Tonle Sap Lake, potentially leading to a different species assemblage and abundance. Similarly, the mid-elevation community pond categories (2 and 3) may be managed differently since Category 3 tends to flood more frequently than Category 2. For example, less or no investment in stocking or establishing eutrophic water would be appropriate for Category 3. However, it is important to note that there will be overlap for many criteria, as shown in Table 5.

This technical brief describes the characteristics for four categories using selected criteria determined during the implementation of the RFFEP. A sequel to this brief to be published by the project will describe interventions to improve management and overall biological productivity of the rice field fisheries system with specific focus on the habitat enhancement and management of the four categories of community fish refuges.

The information provided by these two documents is intended to improve investment strategies for developing these systems and overall impact of any future investment to improve over 1000 designated community fish refuges in rice field areas. Determining the best return on investment in terms of productivity and livelihood benefit, including gains in nutritional well-being, will encourage scaling of this approach. Ensuring sustainability following any scale-out will involve improved community-led self-governance, local fundraising, and less or no reliance on public sector funding of fish stocking.

	Category 1 – Upland reservoir	Category 2 – Pond not prone to flooding	Category 3 – Pond prone to flooding	Category 4 – Natural lake
Agro-ecological zone	Upland areas Rain-fed or irrigated	Higher areas of lowlands	High areas of lowland to floodplains	Higher areas of lowlands
	Rice Broadcast wet season, transplant dry season Early- and medium-maturity rice	Rain-fed rice Wet season rice cultivation and broadcasting	Rain-fed rice Dry season rice cultivation, less transplanting in dry season More late-maturity rice	Rain-fed rice Lowlands Deep water rice and some recession rice
Water body and community fish refuge	Community fish refuge within larger water body (upland reservoirs) Greater water transparency	Community fish refuge community pond No flooding Greater water transparency	Community fish refuge community pond Prone to flooding	Community fish refuge within larger water bodies (natural lake or flooded area of lowland)
Channels and rice fields	Sometimes long connecting channels Fish migration via water gates; may be hampered by water structures	Shorter connecting channels Smallest area of connected rice fields Most trap ponds Fish migrate via inlet and outlet channels or culverts	Shorter connecting channels Fish migrate via open channels, concrete pipes or entire flooded rice field	Varied connections can be either culvert-type or no channel at all due to seasonal inundation and flooding around the shoreline of the larger water body and paths for fish migration
Fishery resources	Greater portion of fish eaten from rice fields Average fishing months: 9	Smaller portion of fish eaten from rice fields Average fishing months: 6	Smaller portion of fish eaten from rice fields Average fishing months: 6	Greater portion of fish eaten from rice fields Average fishing months: 10 Wide range of species
Management	Most illegal fishing still taking place Management plan agreed to but poorly implemented Good opportunity to promote tourism	Management committees responsible for entire body of water Few illegal fishing activities still taking place	Management committees responsible for entire body of water Committees meet most regularly Management plan agreed to and many tasks and actions implemented Some illegal fishing still taking place	Protected areas marked by sign board or marker poles Some illegal fishing still taking place
Zone of influence	Highest overall number of households benefiting Highest percentage of households fishing Highest estimates of fishers from outside Second highest connected rice field	Number of households benefiting lower than Categories 1 and 4 Second highest percentage of households benefit fishing Lowest estimates of fishers from outside Lowest connected rice field	Lowest overall number of households benefiting Lowest percentage of households benefit fishing Second highest estimates of fishers from outside Highest connected rice field	Second highest overall number of households benefiting Second highest percentage of households benefit fishing Third highest estimates of fishers from outside Third highest connected rice field

Table 5. Summary of community fish refuge characteristics by category.

NOTES

Fish conservation areas are places in the rice field fisheries system where people are prohibited from fishing in order to preserve the different fish species and other aquatic animals. The conservation area includes the community fish refuge and rice fields around the refuge, with a distance ranging between 50 m and 200 m from the refuge.

The purpose of this document is to describe the community fish refuge and rice field fisheries system and the typology of community fish refuge and rice field fisheries locations, describing potentially different categories of community fish refuges. More detailed information across a wide range of physico-chemical and biological criteria is provided in subsequent project documentation.

[1] Black fish are usually of a black color and are permanent residents of the floodplain.

[2] Gray fish migrate along the main river tributaries onto the floodplain.

[3] White fish migrate long distances along the main stems of rivers, and their reproductive strategies depend upon the annual hydrological cycles.

[4] Channel length is the distance from the community fish refuge to the surrounding rice fields.

[5] Average number of rice field refuge ponds (trap ponds) and rice field refuge rings (cement rings) refers to the average number found within the community fish refuge designated study area.

[6] Average number of rice field refuge ponds (trap ponds) and rice field refuge rings (cement rings) refers to the average number found within the community fish refuge designated study area.

[7] Importance of rice field fisheries and community fish refuge for fish supply as perceived by community members present:
- Seasonal bonus but not that important for food source
- Some seasonal importance
- Not very important
- Quite important
- Extremely important

[8] Number of households situated within the community fish refuge's zone of influence.

[9] Households who benefit from the zone of influence and who engage in fishing activities.

[10] Estimated number of households from outside the community fish refuge zone of influence who fish within the refuge's zone of influence.

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ANNEX: LIST OF COMMUNITY FISH REFUGE NAMES AND LOCATIONS BY CATEGORY

No.	Community fish refuge	Village	Commune	District	Province
1	Ang Chork	Chork Thum	Kor Koh	Moung Russei	Battambang
2	Damnak Kranh	Ansor Kdam	Sna Ansa	Krakor	Pursat
3	Kuch Noub	Kralanh	Kbal Trach	Krakor	Pursat
4	Tumnub Kandole	Dub Thnaot	Pongro Leu	Chikreng	Siem Reap
5	Tumnub Mkak	Mkak	Kork Thlork Leu	Chikreng	Siem Reap
6	Tumnub Rumdeng	Rumdeng	Khnar Pur	Sotr Nikum	Siem Reap
7	Obosmkak	Trapaing Bosmkak	Trapaing Russey	Kampong Svay	Kampong Thom

Category 1. Community fish refuges in reservoir for irrigation.

No.	Community fish refuge	Village	Commune	District	Province
1	Anlous Dong	Prey Prom	Robors Meangkul	Moung Russei	Battambang
2	Sla Slak	Sla Slak	Anlong Run	Thmor Koul	Battambang
3	Boeng Chheutrav	Santrei	Santrei	Phnom Kravanh	Pursat
4	Boeng Romlech	Prolay Romdeng	Romlech	Bakan	Pursat
5	Aren	Aren	Snam Preah	Bakan	Pursat
6	Boeng Kantuot	Trapaing Kantout	Boeng Kantout	Krakor	Pursat
7	Kork Lhong	Lhong	Sranal	Kralanh	Siem Reap
8	Lboeuk Keteyuos	Keteyuos	Prey Chruok	Puok	Siem Reap
9	Trapaing Thlong	Thnal	Chansar	Sotr Nikum	Siem Reap
10	Trapaing Veng	Trapaing Veng	Spean Thnaot	Chikreng	Siem Reap
11	Krasaing Rithy	Krasaing Khor	Sankor	Kampong Svay	Kampong Thom
12	Preah Neang Korl	Preah Neang Korl	Chamna Krom	Stoung	Kampong Thom
13	Entark Komar	Entark Komar	Kampong Svay	Kampong Svay	Kampong Thom
14	Trapaing Neang Noy	Trapaing Neang Noy	Chamna Krom	Stoung	Kampong Thom

Category 2. Community fish refuges in community pond within agricultural land not prone to flood.

No.	Community fish refuge	Village	Commune	District	Province
1	Boeng Krong	Kach Rotes	Kampong Preang	Sangke	Battambang
2	Boeng Daiphtaul	Sdey Loeu	Prek Loung	Ek Phnom	Battambang
3	Boeng Prang	Andong Trach	Kampong Preah	Sangke	Battambang
4	Boeng Tramper	Tramper	Snam Preah	Bakan	Pursat
5	Pur Sdey	Sranal	Sranal	Kralanh	Siem Reap
6	Othom Sranal	Sranal	Sranal	Kralanh	Siem Reap
7	Trapaing Kuy	San Tey	Dan Run	Sotr Nikum	Siem Reap
8	Bakong	Bakong	Tbeng	Kampong Svay	Kampong Thom
9	Boeng Kamhengsa	Krasaing	Trapaing Russey	Kampong Svay	Kampong Thom
10	Trapaing Thlok Meanchey	Prey Khla	Prolay	Stoung	Kampong Thom

Category 3. Community fish refuges within agricultural land prone to flood.

No.	Community fish refuge	Village	Commune	District	Province
1	Otaky	Otaky	Otaky	Thmor Koul	Battambang
2	Boeng Tramses	Tramses	Boeng Batkandol	Bakan	Pursat
3	Boeng Kampeng	Osrav	Pro Ngil	Phnom Kravanh	Pursat
4	Boeng Preah Ponley	Pteah Rung	Pteah Rung	Phnom Kravanh	Pursat
5	Boeng Thmor Koul	Phnom Touch	Ta An	Kralanh	Siem Reap
6	Otamoan	Okralanh	Kralanh	Kralanh	Siem Reap
7	Boeng Thea	Prasat	Trapaing Russey	Kampong Svay	Kampong Thom
8	Boeng Rolum	Kok Srok	Taing Krasao	Prasat Sambo	Kampong Thom
9	Boeng Prahauch	Char	Sambo	Prasat Sambo	Kampong Thom

Category 4. Demarcated community fish refuge areas in larger water body.

This publication should be cited as:
Brooks A, Kim M, Sieu C, Sean V and Try V. 2015. A characterization of community fish refuge typologies in rice field fisheries ecosystems. Penang, Malaysia: WorldFish. Handbook: 2015-37.

Contact Details:
WorldFish, PO Box 500 GPO,
10670 Penang, MALAYSIA
www.worldfishcenter.org

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