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The Role of Community Fish Refuges (CFRs) in Promoting the Integration of Water, Land, and Aquatic Food Systems

A Case Study of the CFRs in the Mekong Delta and the Tonle Sap Lake

Mak Sithirith and Chhaing Marong

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List of acronyms and abbreviations

AMD	Asian Mega Deltas
CFi	Community Fishery
CFR	Community Fish Refuge
DP	Development Partner
DTWG	District Technical Working Group
FiA	Fishery Administration
FiAC	Fisheries Administration Cantonment
FWUC	Farmer Water User Community
FGD	Focus Group Discussion
JICA	Japan International Cooperation Agency
KII	Key Informant Interview
MR	Mekong River
NGO	Non-Governmental Organisation
PDAFF	Provincial Department of Agriculture, Forestry and Fisheries
PDWRAM	Provincial Department of Water Resources and Meteorology
SPWBs	Semi-Permanent Water Bodies
TKIS	Taing Krasaing Irrigation System
TSL	Tonle Sap Lake
VIS	Vaiko Irrigation System

Executive summary

Cambodia's inland fisheries play a vital role in national food security, rural livelihoods, and nutrition, contributing an estimated 8–12 percent of gross domestic product and providing the primary source of animal protein for the majority of the population. Within this system, rice-field fisheries alone account for roughly 30 percent of inland fish production, underscoring the importance of integrated aquatic–agricultural landscapes. However, these fisheries are increasingly threatened by hydrological alteration in the Mekong–Tonle Sap system, climate change, habitat degradation, irrigation expansion, and competing water uses. Declining flood extent and duration, combined with overfishing and pollution, have reduced fish abundance and heightened vulnerability among floodplain-dependent communities. In response, the Government of Cambodia has promoted community fish refuges (CFRs) as a core community-based fisheries management intervention. By 2023, nearly 900 CFRs had been established nationwide, reflecting their central role in fisheries governance reform and decentralisation.

This study examines the role of CFRs in promoting the integration of water, land, and aquatic food systems, with particular emphasis on their function as landscape-level connectors linking rivers, floodplains, irrigation systems, and rice fields. Moving beyond a narrow focus on fish conservation, the study conceptualises CFRs as multi-use, community-governed socio-ecological systems that contribute simultaneously to fisheries productivity, agricultural water management, and local food and nutrition security. The research addresses three overarching questions: how different governance models influence CFR effectiveness and scalability; how CFRs can be demonstrated as landscape models for integrated resource management; and how integrated governance differs from conventional, sector-specific approaches.

The study draws on six CFR case studies located in Prey Veng Province in the Mekong Delta and Kampong Thom Province in the Tonle Sap floodplain. These sites were selected to capture variation in hydrological conditions, institutional arrangements, and livelihood contexts, including CFRs connected to large lakes (Boeng Sneh and Boeng Ream) and to irrigation systems such as the Taing Krasaing Irrigation System (TKIS). A mixed-methods approach was employed, combining secondary data review, key informant interviews, focus group discussions, and participatory mapping. Analysis focused on CFR physical characteristics, hydrological and ecological connectivity, institutional recognition, management structures, community participation, and links with district-level governance mechanisms such as District Technical Working Groups (DTWGs).

Findings demonstrate that CFRs play a critical ecological role in sustaining fisheries productivity by providing dry-season refuges, wet-season spawning and nursery habitats, and migration nodes that reconnect fish populations with rice fields and floodplains during annual floods. Based on physical and hydrological characteristics, three broad CFR typologies are identified. Perennial and deep refuges retain water year-round and offer high resilience to drought, supporting broodstock survival and biodiversity conservation. Seasonally expanding floodplain refuges experience dramatic wet-season expansion, providing highly productive spawning and feeding grounds but limited dry-season protection. Ephemeral refuges, which dry out completely in the dry season, nonetheless play an important role during floods by supporting short-term fish recruitment, nutrient cycling, and landscape-scale productivity. Together, these CFR types contribute complementary ecological functions that sustain the broader Mekong–Tonle Sap floodplain system.

Beyond ecology, the study highlights the governance significance of CFRs. All studied CFRs are formally recognised at commune and Fisheries Administration Cantonment levels, and

most are recognised by district administrations and provincial technical departments. This multi-level recognition provides legal legitimacy and technical support, although the absence of formal endorsement by provincial governments limits access to long-term public financing. CFR management committees are generally functional and locally legitimate, but governance capacity varies. Strengths include strong community participation, proximity of villages to CFRs, and high dependence on fisheries for livelihoods in several sites. Weaknesses include irregular committee re-elections, uneven documentation, limited financial sustainability, and variable inclusion of women in leadership roles.

A key finding is that CFRs are most effective when embedded within integrated governance arrangements. In sites where CFR committee members also participate in Farmer Water User Communities and engage with DTWGs, water allocation decisions for irrigation are better aligned with fish conservation needs. Such overlap reduces sectoral conflicts, improves coordination during dry seasons, and enables CFRs to function as shared reservoirs that support both fisheries and agriculture. In contrast, CFRs managed in isolation under conventional governance approaches are more vulnerable to over-abstraction, weak enforcement, and declining effectiveness under climate stress.

Overall, the study demonstrates that CFRs are not merely localised conservation interventions but are viable landscape models for integrating water, land, and aquatic food systems at the district level. Scaling up their impact requires strengthening integrated governance mechanisms, formalising links with district and provincial planning, improving gender inclusion and leadership renewal, and investing in hydrological connectivity and habitat maintenance. When supported by inclusive institutions and cross-sector coordination, CFRs offer a practical pathway to enhance food security, climate resilience, and sustainable livelihoods across Cambodia's floodplain and delta regions.

1. Background

Cambodia's fisheries sector contributes significantly to the livelihoods, trade, and food security of the nation and accounts for around 8–12 percent of the country's GDP (Freed et al. 2020). Fish is the major source of animal protein in Cambodia and provides important micronutrients and vitamins. Many rural families rely on fishing for both income and food. The rice-field fishery has contributed about 30 percent of the total inland fishery production and food security (Freed et al. 2020). However, these fisheries are increasingly threatened by habitat loss, overfishing, pollution and climate change. In response to these pressures, the Government of Cambodia has promoted fisheries management at the local level. In doing so, Fishery Administration (FiA) has implemented the CFRs within Rice Field Fisheries (RFFs) to protect fish stocks, increase productivity, and strengthen local food systems. In 2007, the Prime Minister also declared that the promotion of CFRs at the district and commune levels, "one commune one CFR," should be discussed so that these areas can be kept as state property and fish releasing activities can be organised in those areas. At present, there are 893 CFRs in 24 Provinces (FiA 2023).

CFRs are communal, village-based water bodies—natural or human-made—located within or adjacent to rice paddies and managed collectively by local communities. Typically surrounded by dikes or weirs to retain water, CFRs are governed by community-established management committees that set rules, coordinate activities, and ensure compliance. Fish colonise CFRs through natural seasonal migration during floods or through periodic stocking, often using locally sourced wild fish in accordance with community-agreed guidelines. During the dry season, CFRs function as refuges that sustain fish populations when surrounding rice fields and channels dry up. When floodwaters return, fish disperse naturally into rice fields and floodplains, contributing to stock recovery and improved availability for local fishers.

Beyond fisheries production, CFRs deliver a range of ecosystem and livelihood benefits, including improved aquatic habitats, enhanced biodiversity, increased production of fish and other aquatic foods, and strengthened food and nutrition security. These outcomes are supported by active community governance, which typically includes habitat restoration, regulation of fishing access and timing, maintenance of infrastructure, monitoring, and conflict resolution. In many cases, CFR management committees also coordinate awareness-raising and link fisheries management to broader livelihood and climate resilience strategies at the village level. Given these multiple functions, CFRs operate as multi-use, community-governed socio-ecological systems, rather than as single-purpose conservation interventions. Their effectiveness depends not only on ecological design and stocking practices, but also on sustained community participation, locally legitimate rules, and coordination with other village institutions managing water, agriculture, and natural resources.

WorldFish has worked with FiA to support the establishment and management of the CFR in Cambodia over the last 20 years, particularly around the Tonle Sap Lake (TSL). In 2022, WorldFish, together with its partners, implemented the research programme on food and nutrition security in the Mekong Delta Region in Cambodia. The research programme examines food system governance across different natural resources sectors, from centralised to community-based natural resources management, including CFRs, community fisheries (CFis) and farmer water user communities (FWUCs), and develops an innovative model to promote the integrated decentralised governance system to manage water, land, and natural resources at the district level. To assess CFR's performance in this context, the study will look into five characteristics of CFR's effective governance mechanisms: 1) organisational management, 2) planning and implementation, 3) resources mobilisation, 4) networking and communication,

and 5) representation and participation. These governance practices are essential for ensuring fishery productivity, enhancing livelihoods, and promoting nutritional well-being within communities. In addition, the study will examine the integrated governance mechanisms at the landscape or ecosystem level, such as the Boeng Sneh and Boeng Ream Lakes, that CFRs play in improving water governance, fish and aquatic production, agricultural productivity, livelihoods, and food security. It will contribute to the governance of water, land, and natural resources at the district level, as promoted by the CGIAR's Asian Mega Delt (AMD).

Integrated governance refers to modern-day commons; this reflects the idea that CFRs, as multiple-use systems, are common goods that have not traditionally been managed as common-pool resources for fish conservation, but, in a contemporary context, they require collective management to ensure sustainability (Soruco et al. 2025). Conventional governance describes a traditional approach in which CFRs are established and managed solely by committee members, without broader support or resources (Ou et al. 2024).

In line with the above, this study focuses on the CFR to:

1. Assess alternative scaling pathways for CFRs in terms of effectiveness and readiness;
2. Compare CFR's performance under an integrated governance approach versus a conventional governance approach; and
3. Demonstrate CFR as a landscape model for the integration of land, water, and aquatic food systems.

To achieve the research objectives outlined above, this study seeks to answer three main research questions:

1. How can the governance models, such as an integrated and conventional one, be a pathway for CFRs to be scaled up in terms of impact areas, specifically, rural livelihoods and climate change adaptation?
2. How CFRs can be demonstrated as a landscape model for integrating land, water, and aquatic food systems. How is integrated governance different from conventional governance?

2. Conceptual framework: CFR system for integration of water, rice fields and aquatic systems

Seasonal reversal of flows between the Mekong River (MR) and the TSL generates a flood pulse that drives floodplain productivity. During the wet season, floodwaters inundate terrestrial habitats, transferring biomass and sediments into aquatic systems and mobilising large amounts of organic and inorganic matter. As water levels recede in the dry season, stored water, nutrients, and suspended materials return to the lake, while floodplains dry and are recolonised by terrestrial organisms. Aquatic species migrate or adopt drought-adaptive strategies, and isolated floodplain pools develop distinct ecological characteristics. This cyclical flood–drought dynamic underpins the exceptional productivity of the Tonle Sap lake–floodplain ecosystem (Lambert 2006, 2013).

The productivity of the TSL is shaped by reverse flow, water volume, inundation extent, and the duration of flooding. TSL productivity arises from both the permanent lake and its floodplains, with floodplain productivity largely driven by lateral inundation that supports flood-dependent fish species such as blackfish and snakehead (Sithirith 2024). Seasonal flooding connects the lake to surrounding floodplains and thousands of hectares of rice fields, extending the flood

pulse over approximately six months and sustaining fisheries and other natural resources (Joffre et al. 2012). Reductions in reverse flow or water volume limit floodplain inundation, leading to declines in fisheries productivity and associated ecosystem services (Zalinge 2003), underscoring the central role of the flood pulse in supporting local livelihoods and economic well-being.

The damming of the river system causes disruption or discontinuity in river flows, the biotic and abiotic patterns, and processes of the river-floodplain systems. The connectivity between the river channels and their floodplains has been changing, affecting major interactive pathways and reducing river-floodplain productivity. Fragmentation of connectivity by dams is apparent in the downstream area, where linkages are most diverse and where the strength of interactions is greatest. Dams and water infrastructure built on the river reduce the naturally low levels of biodiversity, including fisheries (Stanford and Ward 1983).

Declining water flows to the TSL have been attributed to upstream hydropower development on the MR, including dams built in China (Kallio and Kummu 2021; Lambert 2013; Lauri et al. 2012), although other studies emphasise climate change as a primary driver of reduced flows (Wang et al. 2020). These changes increase climate vulnerability, defined by the IPCC (2014) as the propensity of systems or communities to be adversely affected. Vulnerability is shaped by exposure to climatic and hydrological change, sensitivity to its impacts, and adaptive capacity. Exposure depends on geographic location, magnitude, frequency, and duration of climatic events; sensitivity reflects the characteristics of communities or systems, including infrastructure and management practices; and adaptive capacity refers to the ability to respond and adjust through knowledge, participation, institutional support, and investment. Together, these factors determine how hydrological change affects ecosystems and livelihoods dependent on the TSL.

Joffre et al. (2012) have presented the CFRs as an innovation to restore water and improve rice field fisheries. Fishery Administration (FiA) has then embarked on an ambitious programme to promote the development of CFRs in what is called "one commune one CFR." Indeed, CFRs contribute to increased water security, fisheries production, rice farming and household food security (Joffre et al. 2012). The annual and seasonal water regimes from the CFR system around TSL and the Mekong floodplain contribute to sustaining the flood pulse of the TSL, its floodplain, and the rice field ecosystem. More than that, CFRs offer a useful strategy to address the changing flood pulse, improve connectivity between the lake and the floodplain and rice fields, and enhance fisheries productivity and biodiversity in the Tonle Sap system (Fiorella et al. 2019). Floodplain and rice fields around the TSL and the MR are submerged by the flood pulse during the wet season and exposed to dry land during the dry season. The flood pulse induces ecosystem processes and services that can sustain aquatic biodiversity and fisheries (Freed et al. 2020). Strengthening management and motivating management investment in CFRs are essential for improving connectivity between lakes, floodplains, and rice fields (Fiorella et al. 2019).

CFRs were established in Cambodia in response to widespread declines in inland fisheries linked to overfishing, loss of floodplain habitats, irrigation expansion, and increasing hydrological variability in the Mekong–Tonle Sap system. As seasonal wetlands, rice fields, and natural pools dried during the dry season, fish broodstock and juveniles became highly vulnerable to overharvesting, leading to reduced recruitment and declining catches. CFRs were introduced as a community-based management approach to protect fish during critical dry-season periods by retaining water in natural or man-made ponds within agricultural landscapes. By conserving

brood stock and allowing fish populations to recover, CFRs enhance fish availability when floodwaters return, and connectivity is restored. Beyond ecological objectives, CFRs were also designed to support food and nutrition security, diversify rural livelihoods, and strengthen community participation in fisheries governance following Cambodia's fisheries decentralisation reforms in the early 2000s (Hortle 2007; Joffre et al. 2012; FiA 2016; WorldFish 2018).

The CFR innovative system involves the rehabilitation of waterways, channels, streams, and reservoirs, and connects water bodies and lakes, including permanent and semi-permanent water bodies, to the rice fields. Some studies on CFRs were undertaken, focusing on fish productivity and its construction (Tilley et al. 2024; Ignowski et al. 2023). These mechanisms further enable community-led adaptive management, in which community members respond to changing environmental conditions and adjust their management strategies through the use of CFR systems to protect water bodies and river systems, addressing changing hydrological flows and climate change in TSL and the Mekong (Fiorella et al. 2019). The implementation of the CFR itself increases fishery and rice farming productivity of the floodplains and the surrounding rice fields. CFRs play important roles in forestalling declines in water quality or resolving water use in variable or bad years in the Tonle Sap (Fiorella et al. 2019). The CFRs improve the rice field fisheries and food security for rural households (Freed et al. 2020).

3. Methodology

3.1. Location and the studied CFRs

The studies of CFRs were conducted in the project sites of WorldFish and IWMI in Prey Veng and Kampong Thom. The two provinces were selected to represent the diversity of geographical, socio-economic, and livelihood dimensions. Kampong Thom is situated in the TSL, while Prey Veng is in the Mekong Delta. Four CFRs were selected for the study in agreement with WorldFish—two CFRs in Prey Veng, namely Boeng Loeu and Ang O'Ktom; and two in Kampong Thom, namely Boeng Ream and Boeng Banteay. However, when the fieldwork was conducted, the selected CFRs did not provide the information and data the study needed, for instance, CFR Ang O'Ktom. For these reasons, the study team selected two additional CFRs that have connections with Boeng Sneh and Boeng Ream, and the irrigation systems. The Boeng Sangke Chrum in Prey Veng has connection with the Boeng Sneh by the irrigation canal, and Boeng Sbov Ambaeng has connection with the Boeng Ream by the irrigation canal. These CFR systems have connections with the Boeng Sneh and Boeng Ream, and they are surrounded by rice fields.

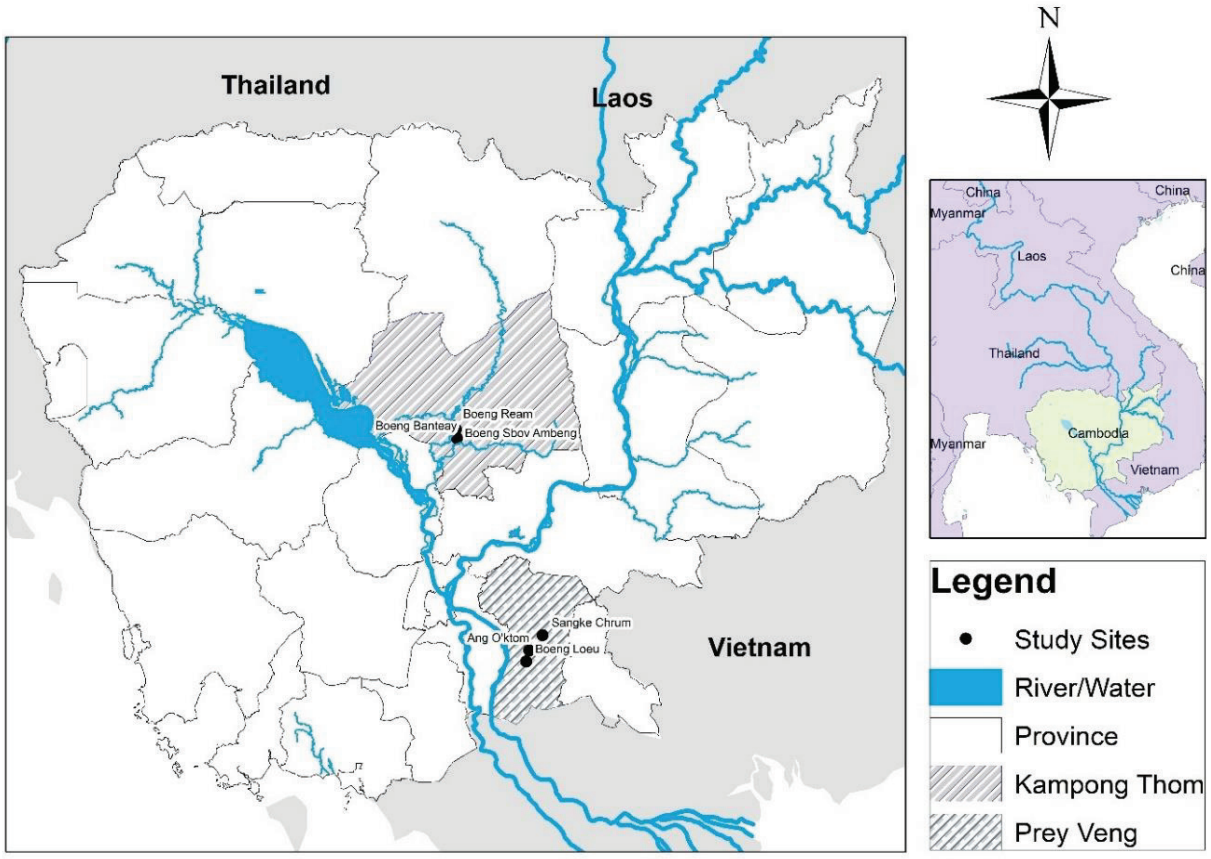
Thus, six CFRs in these provinces were selected to study integrated, decentralised good system governance, utilising the CFR system to link water, land, irrigation, and fisheries, and for scaling. The selection of CFRs was based on suggestions from WorldFish and IWMI, and the DTWGs were established to manage water, fisheries, land, and natural resources at the district level. It is especially in Prey Veng that the selected CFRs exhibit similar hydrological connectivity; there were supporting actors, such as the European Union, that entered the area. In Kampong Thom, on the other hand, the selected CFRs included one that has been integrating a governance model and has water flow connectivity. Moreover, with these existing sites, the data collection process was expected to be smoother in terms of communication and fieldwork coordination.

In Prey Veng, the study selected three CFRs for the studies: (1) Boeng Loeu; (2) Ang O'Ktom and Boeng Sangke Chrum. These three CFRs have been chosen because they are comparable in terms of ecological conditions, including flood timing, water levels during the dry season,

and community rule and enforcement. They are connected to Boeng Sneh Lake (BSL). The BSL is located in three districts—Ba Phnom, Peam Ro, and Svay Antor. This freshwater lake is hydrologically connected to the MR. It is surrounded by 44 villages across 7 communes in four districts, offering a rich and diverse landscape. Within the BSL, four CFis, two FWUCs, one community-based ecotourism (CBET) and a number of CFRs were established to manage water, fisheries, and biodiversity. These features make BSL an ideal location for achieving the research objective, which aims to demonstrate CFRs as a landscape model for integrating land, water, and aquatic food systems.

In Kampong Thom, the study will select three CFRs in Santuk District for detailed study, namely Boeng Ream, Boeng Sbov Ambaeng, and Boeng Banteay. The Boeng Ream CFR is a small waterbody located in the Tonle Sap's floodplain. The Boeng Ream is also a fish refuge area, connected to the Tang Krasaing Irrigation Scheme (TKIS), which was developed in 2015. Boeng Ream Lake plays a dual role in supporting both rice cultivation and fisheries. The Boeng Banteay CFR was established in 2020 and is located in a larger water area in Santuk district, with water connectivity to the irrigation system similar to that of the Boeng Ream. During the dry season, it covers approximately 0.70 ha and expands to 32 ha during the rainy season. The CFR is managed by 14 CFR committee members, including 7 women and 7 men. The CFR serves a population of 3,583 residents, including 1,751 males and 1,832 females, who are directly or indirectly connected to its management and benefits. The Boeng Sbov Ambaeng is another CFR located in Santuk District. It is also connected to the TKIS, and it is established by three villages in Kakoh Commune, Santuk District.

Figure 1: Map of the study areas



Source: Adapted and modified by authors.

Table 1: Key characteristics of the studied CFRs

Province	CFR name	Commune	District	Key hydrological characteristics	Connectivity evidence
Prey Veng	Sangke Chrum	Teok Thla	Svay Antor	Seasonal water depth 1.5–3 m; canal built by JICA; rice fields and irrigation channels feed water in and out	Water flows through irrigation canals and rice fields, linking the CFR to broader floodplain systems that drain toward Boeng Sneh Lake
Prey Veng	Ang O'Ktom	(FGD location: Aoukthum)	Prey Veng	Rain-fed + inflow from rice fields + small tributary channels; farmers pump water out for irrigation	Water extracted and discharged through interconnected canals and farm drainage, contributing to and drawing from the Boeng Sneh hydrological regime; shortages and fish loss reported when excessive pumping occurs
Prey Veng	Boeng Loeu	Cherng Phnom	Ba Phnom	36 ha wet-season area; connected to river; two water gates; supplied by irrigation system from Andoung Village	Strong hydrological linkage to the river system draining into Boeng Sneh basin; continuous water exchange supports both irrigation and fisheries across landscape
Kampong Thom	Boeng Ream	Kakoh	Santuk	2 ha dry-season area, expanding to 12 ha in wet season; canals connect the CFR to the irrigation system	Direct water channels allow fish migration and water exchange with irrigation and rice fields; part of district-wide wetland system linked to Tonle Sap tributaries and other CFRs
Kampong Thom	Sbov Ambaeng	Kakoh	Santuk	2 ha, depth 4 m; canals in/out linking to irrigation; rich in broodstock	Seasonal flows move water from rivers and floodplains into CFR; dry-season refuge function connects it to Boeng Ream and wider Santuk wetland system
Kampong Thom	Boeng Banteay	Taing Krasaing	Santuk	32 ha dry; fully submerged in wet; canals regulate inflow/outflow	Fish migrate out during wet season and return in dry season; irrigation canals connect to Boeng Ream and larger Stung Sen–Stung Slab water networks feeding Santuk landscapes

Source: Field data compilation, 2025

3.2. Data collection

The study collected both primary and secondary data. Secondary data for the studied CFRs were collected from WorldFish archives and other sources. These data include the sizes of CFRs, water levels in both wet and dry seasons, the dates of establishments, the governance structure, the planning, the implementation of the CFR plans, the fish species, and its yields.

The primary data were collected through key informant interviews (KIIs) and focus group discussions (FGDs). The questions were designed for KIIs in consultation with WorldFish, and the KIIs were conducted with village chiefs, CFR committee members, elderly people, commune administrators and CFR members, the Provincial Department of Agriculture at the subnational level, FiA at the national level, and key relevant government officials/institutions.

The FGDs were conducted in each CFR with 7-9 participants, most of whom are CFR members and committee members. In addressing the CFR governance, the FGDs focused on organisational management, planning and implementation, resource mobilisation, networking and communication, and representation and participation. In addressing integrated governance of land, water, and natural resources, the FGDs focused on the connectivity of CFRs with the rice fields, irrigation systems, and water governance for fisheries, rice farming, and livelihoods. The questions focused on the management of water that sustains fisheries, agriculture, irrigation systems, and livelihoods, and on the roles of CFR committee members, FWUC members, and CFis in working together to benefit all members of the communities. At the same time, we also discussed scalability and potential pathways for integrated governance of land, water, and natural resources at the district level, should it be successful. To do so, each FGD took less than two hours to discuss 6-8 thematic areas. The thematic questions were prepared in conjunction with WorldFish, IWMI, and concerned stakeholders.

Moreover, the primary data collection, such as KIIs and FGDs interviews, ensured the collection of relevant information to analyse and demonstrate that CFR is the landscape model for integrating land, water, and aquatic food systems. Our method and questionnaires encompassed components such as drawing maps, semi-structured questionnaires that included geographical CFRs, livelihoods and incomes information generated from CFRs.

3.3. Data analysis and reporting

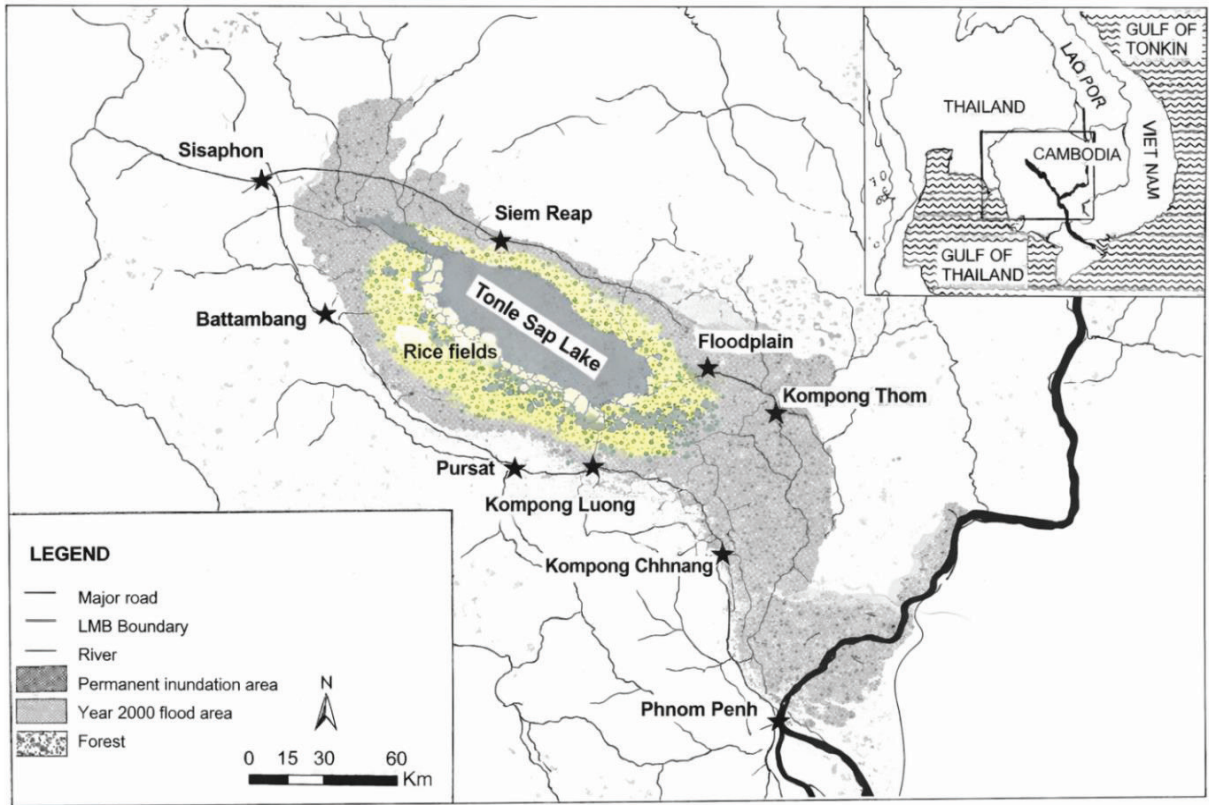
Data collected was analysed using Excel spreadsheets, with qualitative approaches used to interpret the findings. Moreover, through FGD interviews, the analysis aimed to generate CFRs and rice field maps based on participants' perceptions. The study employs the conceptual approach/theoretical framework to guide data analysis and reporting.

4. Results

4.1. River, floodplain, and rice field ecosystems

The flood pulse shapes the Mekong and TSL systems into three ecosystems—the permanent waterbody, the floodplain, and the rice field ecosystems. These ecosystems are connected by the flows, volumes and inundations, which make the lake highly productive. It also supports the livelihoods of different communities in different ecosystems.

Figure 2: The waterbody, the floodplain and the rice field system



Source: Adapted and modified by authors.

4.1.1. Permanent waterbodies

During the wet season, water flows from the MR to the TSL, inundating the floodplain and rice fields. Rainfall in the watershed areas flows into the sub-river systems and tributaries of the Mekong and TSL, submerging rice fields, then entering the floodplains and waterbodies such as Boeng Ream, Boeng Ambaeng Sbov, Boeng Banteay, Boeng Sneh, Boeng Sangke Chrum, and Ang O'Ktom. During the dry season, water receded from the rice fields and the floodplain to the MR and TSL, and the size of these Boengs shrank. The Boeng system has been divided into water bodies, floodplains, and rice field ecosystems. Some semi-permanent water bodies (SPWBs) are created in the floodplain and rice field ecosystem, where water level may fluctuate, and are connected to the rice field ecosystem through streams and channels. The SPWBs provide water and a dry-season habitat for many fish species and biodiversity, such as Boeng Ream and Boeng Sneh. These are small water bodies in or adjacent to a rice field; seasonally connected to rice fields and permanent waterbodies during the flood period; may be conserved, dry up, or be pumped dry during the dry season. SPWBs are being established into the CFRs.

Some 331 CFRs, including Boeng Ream, Boeng Banteay, and Boeng Sbov Ambaengs, are established in six provinces around TSL (FiA 2023). Some other CFRs are established in the Mekong Delta. It is an area of water designated to conserve aquatic fauna, mainly fish. It aims to increase fish yields in the surrounding rice fields and to preserve the biodiversity of fish and other aquatic animals in the wetlands and Tonle Sap floodplain. CFRs provide dry-season refuges (Shankar et al. 2004; Joffre et al. 2012) for blackfish species and serve as focal points to encourage community-based fisheries management (Magoulick and Kobza 2003; Joffre et al. 2012).

4.1.2. Floodplains

The river and the lake system are surrounded by floodplains. The flood pulse shapes the floodplain between the wet and dry seasons. In the wet season, water from the MR floods the floodplains and TSL by the lateral overflow of the MR's water. In the dry season, from November onward, the water recedes from TSL and the floodplains in the MR, leaving the floodplain on the dry land. The areas that are flooded during the wet season and dry out during the dry season are referred to as floodplain.

The floodplain is underwatered for about 4-5 months of the year and dry lands for the remaining months of the year. The increased inundation and presence of water in the floodplain area for half the year increases the level of productivity of the floodplains. However, the inundation varies within and between years, depending on the flows and volumes of water from the MR to TSL. Thus, the connection between the flowing aquatic system and its floodplain zones divides the floodplain zone into different areas, comprising the flooded forest area, the SPWBs, and shrub lands. Fishing has remained prevalent in the SPWBs in the floodplain. Thus, the SPWBs have been utilised to organise CFRs, with variations in size between wet and dry seasons.

4.1.3. Rice fields

The TSL, MR and floodplain are surrounded by rice fields. The rice field ecosystem comprises various interconnected habitats, such as channels, streams, ponds, and reservoirs, connected to the rice fields themselves. These are connected by the flood pulse, the flow, the lateral flows, and the inundation (Shams 2007). The stream and channels are waterways that connect water bodies/lakes and rice fields during flood periods, including irrigation and drainage channels and natural streams that may contain some water year-round. It provides migration routes for fish between permanent water bodies and flooded areas, and some also provide refuge in the dry season. As for the rice field, it is seasonally connected to permanent waterbodies during flood periods and serves as a habitat for fish production and feeding during the flood season. Between the rice field and the floodplains are semi-permanent waterbodies whose water levels may fluctuate, connected to the rice field ecosystem through streams and channels. It aims to increase fish yields in the surrounding rice fields and to preserve the biodiversity of fish and other aquatic animals in the wetlands and Tonle Sap floodplain.

4.2. Physical dimensions of CFRs

CFRs play a crucial role in maintaining aquatic biodiversity, supporting seasonal fish breeding, and sustaining local livelihoods. Their hydrological dynamics—particularly the differences in size, length, width, and depth between the dry and rainy seasons—reflect ecological resilience and the degree of flood connectivity within the broader wetland landscape. The six surveyed CFRs—Boeng Ream, Boeng Banteay, Sbov Ambaeng, Boeng Loeu, Ang O'Ktom, and Sangke Chrum—exhibit highly diverse physical characteristics, as summarised in Table 2 and illustrated in Figure 2.

Table 2: Physical dimensions of CFRs

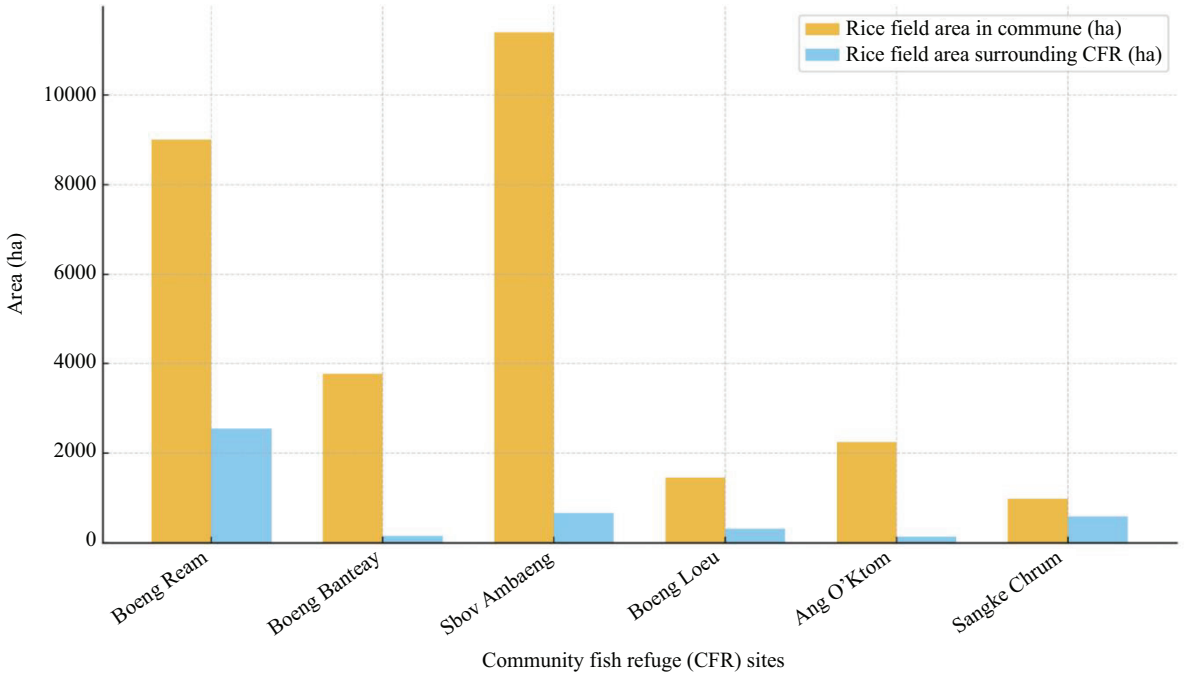
CFR name	Dry size (ha)	Dry length (m)	Dry width (m)	Dry depth (m)	Rainy size (ha)	Rainy length (m)	Rainy width (m)	Rainy depth (m)
Boeng Ream	2	200	100	3	12	400	300	10
Boeng Banteay	0.7	100	70	2	32	1,000	320	4
Sbov Ambaeng	0.5	100	50	4	0.5	100	50	5
Boeng Loeu	10	1,000	900	2	25	2,000	1,200	4
Ang O'Ktom	n.a	n.a	n.a	n.a	4	200	200	4
Sangke Chrum	0.64	80	80	1	15.63	125	125	3

Source: Field data compilation, 2025.

Rice farming forms the economic and ecological backbone of rural communities where CFRs are established. The spatial distribution of rice fields within the communes, particularly those surrounding the CFRs, determines the level of hydrological interaction, nutrient exchange, and competition for water between agricultural production and aquatic conservation systems. The six communes—Boeng Ream, Boeng Banteay, Sbov Ambaeng, Boeng Loeu, Ang O'Ktom, and Sangke Chrum—present distinct profiles in terms of rice cultivation area and its proximity to community-managed aquatic resources.

Across the six communes, total rice field areas range from less than 1,000 ha in Sangke Chrum to over 11,000 ha in Sbov Ambaeng, reflecting substantial variation in land use intensity and agro-ecological capacity. Similarly, rice field areas immediately surrounding the CFRs—representing the hydrologically connected and management-sensitive zones—vary significantly, from 133.5 ha (Ang O'Ktom) to 2,551 ha (Boeng Ream). These differences reveal not only contrasts in commune-level agricultural productivity but also varying degrees of agricultural pressure and water demand on the fish refuge ecosystems.

Figure 3: Rice field areas in the communes and around CFRs



Source: Authors, 2025.

The data reveal clear seasonal transformations in the CFRs' spatial and hydrological conditions. Most CFRs show dramatic expansion in area and depth during the rainy season, as floodwaters recharge the systems and reconnect them to surrounding floodplains and rice fields. Conversely, during the dry season, all study CFRs contract substantially, with some drying up completely, for instance, the Ang O'Ktom. These dynamics determine the ecological role of each CFR—whether as a permanent waterbody, a flood-dependent spawning area, or a seasonal wetland habitat.

Boeng Ream

Boeng Ream maintains a stable core water body throughout the year. In the dry season, it covers about 2.0 ha, measuring 200 m × 100 m with an average depth of 3.0 m. In the rainy season, it expands sixfold to 12 ha, doubling its length and tripling its width (400 m × 300 m), with a significantly increased depth of 10 m. This expansion indicates a high water-retention capacity and strong flood inflows, making it both a perennial refuge and a breeding ground during the monsoon. The deep rainy-season pool ensures the persistence of aquatic life even during extended droughts.

Boeng Ream has one of the largest rice field areas among the six sites, totalling approximately 9,000 ha. This expansive cultivation area indicates a well-developed agrarian system, likely supported by irrigation canals and favourable topography. Surrounding the CFR, about 2,551 ha of rice fields are located within the immediate catchment zone. The large agricultural footprint around Boeng Ream implies strong hydrological linkages—both beneficial and potentially adverse. Runoff from rice fields may supply nutrient inflows that enhance aquatic productivity but could also increase sedimentation and pesticide residues entering the CFR. Effective land-use planning and buffer vegetation management are therefore crucial in this commune.

Boeng Banteay

Boeng Banteay is the most dynamically expanding CFR in the area. Its dry-season area of 0.7 ha grows to 32.0 ha during the rainy season, an increase of more than forty-five times. The refuge's length expands from 100 m to 1,000 m, and width from 70 m to 320 m, with depth increasing from 2.0 m to 4.0 m. This striking transformation highlights Boeng Banteay as a floodplain-type system highly responsive to seasonal rainfall. It functions as a temporary refuge and spawning habitat, ideal for fish reproduction but prone to drying and sedimentation during dry months. Management should therefore emphasise flood connectivity, sediment control, and maintenance of dry-season residual pools.

Boeng Banteay CFR designates a semi-permanent wetland area as a protected fish refuge within the floodplain landscape of Santuk District, Kampong Thom. The CFR is centred on a permanent core waterbody that remains inundated during most dry seasons and serves as the primary sanctuary for fish survival. During the dry season, this core refuge covers approximately 0.70 ha, with an average depth of about 2 m, and is fully protected from fishing activities. In the rainy season, floodwaters expand the refuge area to around 32 ha, reconnecting the permanent pool with surrounding floodplains, channels, and rice fields. These seasonally inundated sections provide critical spawning, feeding, and migration habitats, although they may partially dry out later in the year. The refuge is located in a low-lying wetland area with limited adjacent rice cultivation, which helps reduce agricultural pressure while maintaining hydrological connectivity essential for fish recruitment and biodiversity conservation

Photo 1: The Boeng Banteay CFR, Kampong Thom

Source: Photo by authors, 9 October 2025.

Boeng Banteay features 3,781 ha of rice fields across the commune, but only 150 ha are located in close proximity to the CFR. This comparatively small surrounding area suggests that the fish refuge is somewhat isolated from major rice farming zones, possibly located in a lower-lying or less cultivated wetland pocket. The separation between main rice fields and the CFR could help reduce agricultural runoff impacts, though it also limits the extent of nutrient exchange and seasonal inflow from cultivated lands. This configuration supports water quality stability but may reduce organic nutrient enrichment, which is beneficial to fish productivity. Dry-season vegetable production around—but not within—the Boeng Banteay CFR is ecologically compatible, nutritionally beneficial, and livelihood-enhancing. If integrated into CFR management plans and district-level water governance, it can strengthen food security while maintaining the refuge's core conservation function.

Sbov Ambaeng

Sbov Ambaeng exhibits minimal seasonal fluctuation. The dry-season size of 0.5 ha remains almost identical in the rainy season (0.5 ha), although depth increases slightly from 4.0 m to 5.0 m. Its length and width remain constant (100 m × 50 m). This indicates a permanent or semi-permanent pond with limited floodplain connection. While its small surface area restricts expansion, the consistent depth makes it a reliable dry-season refuge, supporting broodstock survival and small-scale aquaculture functions. Its ecological stability compensates for limited spatial variability.

Sbov Ambaeng hosts the largest commune-level rice field area, amounting to 11,408.64 ha, of which 663 ha directly surround the CFR. This scale positions the commune as a key rice-

producing zone, with substantial interaction between agricultural and aquatic ecosystems. Given the significant land area under rice cultivation, the surrounding 663 ha likely exert high pressure on the CFR through water abstraction and agrochemical inputs. However, the proportional balance between the total commune area and the immediate surrounding zone suggests potential for integrated management, where both fisheries and agriculture can co-exist through controlled water allocation and sustainable fertiliser use.

Photo 2: The Sbov Ambaeng CFR, Kampong Thom

Source: Photo by authors, 8 October 2025.

The Sbov Ambaeng CFR functions as a dual-purpose system, serving as both a fish refuge and a water storage facility supporting irrigated rice cultivation during the dry season. Unlike more flood-dependent CFRs, Sbov Ambaeng maintains a semi-permanent waterbody throughout the year, with relatively stable surface area and depth across seasons. Its reliability is largely attributed to direct access to water from the irrigation canal connected to the TKIS, which enables controlled inflow during periods of low rainfall and declining floodplain water levels. This hydraulic connection allows the CFR to secure water availability for adjacent rice fields while simultaneously sustaining sufficient water depth to function as a dry-season fish refuge, supporting broodstock survival and local biodiversity. Importantly, governance arrangements reinforce this integrated function. Members of the Sbov Ambaeng CFR Committee are also active members of local Water User Groups, enabling coordination between irrigation scheduling and fish conservation objectives. This overlapping membership reduces sectoral conflicts, aligns water abstraction decisions with refuge protection rules, and strengthens collective management across fisheries and agriculture. As a result, Sbov Ambaeng exemplifies a multi-use common,

where irrigation infrastructure and community-based fisheries management are institutionally and hydrologically integrated to enhance livelihood resilience during the dry season.

Boeng Loeu

Boeng Loeu is the largest and most stable refuge. It maintains an extensive 10.0 ha area during the dry season, with dimensions 1,000 m × 900 m and a depth of 2.0 m. In the rainy season, it expands moderately to 25.0 ha, with 2,000 m × 1,200 m dimensions and 4.0 m depth. The moderate expansion ratio (2.5 times) indicates a well-balanced hydrological regime, typical of a perennial natural lake. It serves as a core aquatic habitat for biodiversity conservation and fisheries replenishment. Its size and depth ensure water stability and continuous fish habitat throughout the year.

Boeng Loeu has a relatively small commune-level rice field area of 1,456.1 ha, yet 321 ha of this area lie adjacent to the CFR—equivalent to more than 20 percent of its total rice land. This high proportion indicates a close spatial coupling between the rice production landscape and the aquatic system. The CFR likely plays a dual role in fish conservation and irrigation regulation, receiving and releasing water seasonally. Because of its large water surface (up to 25 ha during the rainy season) and proximity to cultivated land, Boeng Loeu's refuge could function as both an ecological buffer and a hydrological reservoir. However, proximity to farmland also raises challenges, including risks of water over-abstraction, sedimentation, and agrochemical runoff, underscoring the need for strong integrated water–fisheries governance.

Ang O'Ktom

Ang O'Ktom displays the strongest seasonality among all CFRs. During the dry season, it has no measurable area or depth, indicating complete desiccation. When the rainy season begins, it rapidly fills, forming a 4.0 ha pool of 200 m × 200 m with 4.0 m depth. This pattern classifies Ang O'Ktom as an ephemeral or seasonal refuge, functioning primarily during monsoon months. Despite its temporary nature, such refuges are ecologically significant, providing short-term breeding and feeding grounds for migratory fish and replenishing aquatic biomass during floods.

Ang O'Ktom's rice cultivation area totals 2,250.98 ha, of which 133.5 ha are situated around the CFR. This modest surrounding area reflects the seasonal and ephemeral nature of the refuge, which appears only during the rainy season.

Ang O'Ktom CFR differs markedly from other CFRs in terms of water storage, dry-season refuge function, and irrigation support. Ang O'Ktom CFR has very limited water storage capacity, as it typically dries out completely during the dry season. Field data indicate that the refuge has no permanent water body in dry months, with water only accumulating during the rainy season when floodwaters temporarily inundate the area (approximately 4 ha in the wet season). As a result, Ang O'Ktom functions primarily as a seasonal fish habitat, supporting spawning, feeding, and fish migration during the wet season, but it does not provide a reliable dry-season fish refuge for broodstock survival.

Because the CFR lacks retained water during the dry season, its role in irrigation for rice farming is minimal. Unlike CFRs connected to irrigation canals, Ang O'Ktom cannot regulate or release water for dry-season rice cultivation. Rice farming in the surrounding area, therefore, depends mainly on rainfall and broader floodplain hydrology rather than on the CFR itself. This limits Ang O'Ktom's multifunctionality but highlights its ecological importance as a

flood-dependent refuge, emphasising the need to protect seasonal inundation pathways and prevent drainage or over-pumping that would further weaken its ecological role.

Photo 3: The Ang O'Ktom CFR, Prey Veng

Source: Photo by authors, 2 October 2025.

Sangke Chrum Commune

Sangke Chrum represents a moderately expanding shallow system. In the dry season, it measures 0.64 ha (80 m × 80 m) with a depth of 1.0 m. During the rainy season, it expands twenty-fivefold to 15.63 ha (125 m × 125 m) with 3.0 m depth. Although less extensive than Boeng Banteay or Boeng Loeu, Sangke Chrum's broad expansion supports juvenile fish rearing and nutrient cycling during floods. Its shallow profile, however, makes it susceptible to evaporation and siltation during prolonged dry periods.

Sangke Chrum has the smallest commune-wide rice field area, at 989.18 ha, yet a relatively large proportion (589 ha) surrounds the CFR. This indicates that rice fields dominate the landscape immediately adjacent to the refuge, possibly in low-lying floodplain zones. Such proximity creates strong water-sharing interactions: during floods, rice fields may drain into the CFR, while in dry periods, farmers may extract water from it for irrigation. Consequently, this commune requires tight coordination between fish refuge management and agricultural water governance to ensure sustainable use of shared resources.

Sangke Chrum CFR retains a small but permanent waterbody during the dry season, covering about 0.64 ha with an average depth of around 1 m, allowing it to function as a reliable dry-season fish refuge. During the rainy season, the refuge expands substantially (to more than 15 ha), as floodwaters from the wider Boeng Sneh floodplain reconnect the CFR with surrounding

wetlands, channels, and rice fields. This seasonal expansion supports fish spawning, feeding, and migration, while the retained dry-season pool provides critical habitat for broodstock survival.

Photo 4: The Sangke Chrum CFR, Prey Veng

Source: Photo by authors, 3 October 2025.

Hydrologically, Sangke Chrum CFR is closely connected to Boeng Sneh Lake and the local irrigation and drainage network, enabling bidirectional water exchange. These connections allow the CFR to receive floodwaters during the wet season and maintain residual water during dry months, even as surrounding areas dry out. While its role as a large-scale irrigation reservoir is limited, the CFR contributes indirectly to water regulation and buffering, stabilising local water availability and reducing ecological stress during dry periods. Conservation outcomes are strengthened by active community management and frequent patrolling, making Sangke Chrum a strong example of a small but well-connected refuge that supports both fisheries conservation and hydrological resilience within the Boeng Sneh landscape

The CFRs exhibit three broad ecological categories:

1. Perennial and deep refuges (Boeng Loeu, Boeng Ream, Sbov Ambaeng)

Boeng Loeu, Boeng Ream, and Sbov Ambaeng CFRs function as perennial and deep-water refuges, maintaining substantial water volumes during both the dry and rainy seasons. These sites retain permanent core waterbodies even during prolonged dry seasons, making them critical sanctuaries for fish survival as surrounding floodplains and rice fields dry out. Their depths—ranging from approximately 3 m in Boeng Ream during the dry season to up to 10 m in the rainy season, and 4–5 m in Sbov Ambaeng, with Boeng Loeu maintaining 2–4 m depth

across seasons—provide strong ecological resilience against drought, elevated temperatures, and seasonal hydrological stress.

The presence of deep, stable water enables these CFRs to support broodstock survival, biodiversity conservation, and year-round habitat availability, particularly for black fish species that rely on permanent refuges during the dry season. In addition, their capacity to store water allows them to act as hydrological buffers, moderating local water availability and strengthening connectivity between irrigation systems, floodplains, and rice-field ecosystems. As a result, these perennial CFRs represent the most robust refuge type within the studied sites, underpinning both fisheries sustainability and broader landscape resilience

2. Seasonally expanding floodplain refuges (Boeng Banteay, Sangke Chrum)

Boeng Banteay and Sangke Chrum CFRs represent seasonally expanding floodplain refuges, characterised by pronounced hydrological variability between wet and dry seasons. During the rainy season, these refuges expand dramatically as floodwaters from surrounding floodplains, natural channels, and connected water bodies inundate low-lying areas. Boeng Banteay, for example, expands from a dry-season core of approximately 0.7 ha to about 32 ha in the wet season, while Sangke Chrum increases from around 0.64 ha to more than 15 ha. This seasonal expansion transforms both CFRs into extensive breeding, feeding, and nursery grounds, supporting fish spawning, juvenile growth, and nutrient exchange during peak flooding.

In contrast, during the dry season, these refuges contract sharply, retaining only small residual pools or shallow water areas. Their limited depth and storage capacity mean they provide weaker dry-season refugia compared to perennial CFRs, making fish populations more dependent on timely flood onset and connectivity to larger water bodies. Hydrologically, both CFRs rely heavily on rainfall, surface runoff, and floodplain inflows, rather than controlled irrigation supplies, which increases their vulnerability to shortened flood seasons and changing rainfall patterns. Nonetheless, their seasonal dynamics play a crucial ecological role by linking floodplains, rice fields, and larger lakes, thereby sustaining fisheries productivity at the landscape scale.

3. Ephemeral refuges (Ang O'Ktom)

Ang O'Ktom CFR represents an ephemeral refuge type, characterised by the absence of a permanent waterbody and complete drying during the dry season. Field data indicate that Ang O'Ktom holds no retained water in dry months, with the refuge only forming during the rainy season when floodwaters temporarily inundate the site, expanding to roughly 4 ha. As a result, it does not function as a dry-season fish refuge and cannot support broodstock survival once floodwaters recede.

Despite this limitation, Ang O'Ktom plays an important seasonal ecological role within the floodplain system. During the wet season, temporary inundation transforms the area into a highly productive habitat that supports fish spawning, juvenile rearing, and feeding. Floodwaters deliver sediments and organic matter, enhancing nutrient availability and dispersing productivity into adjacent floodplains and rice fields as waters recede. This pulse-driven productivity contributes to wider fisheries yields, even though the refuge itself does not persist year-round. Consequently, Ang O'Ktom's ecological value lies not in water storage or dry-season refuge, but in its role as a short-lived but critical node in flood-season connectivity, nutrient cycling, and fish recruitment within the broader landscape.

Table 3: Comparison of perennial, seasonal, and ephemeral CFRs

Criteria	Perennial Refuges (Boeng Loeu, Boeng Ream, Sbov Ambaeng)	Seasonal Refuges (Boeng Banteay, Sangke Chrum)	Ephemeral Refuges (Ang O'Ktom)
Dry-season water presence	Permanent water retained year-round	Small residual pools only	No water retained
Water depth	Deep (≈3–10 m), stable across seasons	Shallow (≈1–4 m), fluctuating	Very shallow; only present during floods
Seasonal expansion	Moderate expansion in the rainy season	Very large expansion during the rainy season	Appears only during the rainy season
Fish refuge function (dry season)	Strong: supports broodstock survival and biodiversity	Limited: weak dry-season refuge	None
Fish reproduction and feeding (wet season)	Moderate to high	Very high (key spawning and nursery areas)	High but short-lived
Hydrological reliance	Combination of floodwaters and irrigation connectivity	Mainly rainfall, floodplain inflows, and surface runoff	Entirely flood-dependent
Role in irrigation	Strong: water storage and regulation for rice farming	Limited and indirect	None
Ecological contribution	Long-term biodiversity conservation and system stability	Landscape connectivity and productivity	Short-term productivity and nutrient dispersal
Vulnerability to drought & climate change	Low (high resilience)	Medium to high	Very high
Management priority	Protect depth, regulate abstraction, integrate irrigation	Maintain flood connectivity and prevent drainage	Preserve flood pathways and prevent land conversion

Source: Field data compilation, 2025.

Across all sites, the largest spatial expansion is observed in Boeng Banteay (from 0.7 to 32 ha), while Boeng Ream shows the deepest recorded water column (10 m) during the wet season. Conversely, Sbov Ambaeng displays remarkable hydrological stability, indicating resilience but limited breeding area. These variations illustrate how geomorphology, soil texture, and catchment characteristics determine each CFR's ecological function.

The comparative data reveal clear patterns of land–water interaction:

- *High agricultural intensity communes: Sbov Ambaeng* and *Boeng Ream* exhibit extensive rice field areas and significant overlaps with CFR catchments, making them priority sites for integrated water management and pollution control.
- *Moderate agricultural linkage: Boeng Loeu* and *Sangke Chrum* maintain a balanced relationship between rice fields and aquatic zones, supporting both productivity and ecological stability.
- *Low agricultural proximity***:** *Boeng Banteay* and *Ang O'Ktom* show limited rice field adjacency, reducing runoff risks but also limiting nutrient inputs and hydrological recharge.

Overall, the rice fields surrounding the CFRs account for 5–30 percent of the total rice area in each commune, representing zones of direct ecological interaction. These zones play an essential role in regulating sediment, nutrient, and water flow between farmlands and aquatic habitats.

The spatial diversity of CFRs ensures ecological continuity across the floodplain landscape. Perennial systems safeguard biodiversity year-round, seasonal systems boost productivity during floods, and ephemeral systems enhance species dispersion. Integrated management should therefore combine:

- Protection of perennial pools through vegetation and buffer zones;
- Hydrological restoration and connectivity enhancement for seasonal and ephemeral CFRs; and
- Sediment and nutrient management to maintain depth and water quality.

This balanced approach can strengthen community-based fisheries management and climate resilience across Cambodia's rural landscapes. The distribution of rice fields in and around the CFRs underscores the need for integrated land–water planning at the commune level. Areas like Boeng Ream and Sbov Ambaeng require vegetative buffer zones and community-based water governance to mitigate agricultural impacts, whereas smaller systems like Ang O'Ktom and Sangke Chrum benefit from enhanced flood retention and soil–water conservation practices. By aligning agricultural zoning, irrigation scheduling, and fish refuge protection, communes can optimise both rice productivity and aquatic biodiversity—achieving the dual goals of food security and environmental sustainability.

4.3. Institutional recognition and year of establishment of CFRs

Institutional recognition of CFRs represents a critical step in formalising community-based fisheries management. Recognition at multiple administrative levels—commune, district, FiAC, Provincial Department of Agriculture, Forestry and Fisheries (PDAFF), and provincial government—ensures legal legitimacy, policy support, and resource allocation for conservation and livelihood programmes. The table below summarises the year of recognition and the institutions that have acknowledged each CFR.

Table 4: Institutional recognition of CFRs

CFR name	Year of recognition	Recognised by the commune	Recognised by the district	Recognised by FiAC	Recognised by PDAFF	Recognised by the provincial government
Boeng Ream	2021	✓	✓	✓	✓	✕
Boeng Banteay	2020	✓	✓	✓	✓	✕
Sbov Ambaeng	2020	✓	✓	✓	✓	✕
Boeng Loeu	2006	✓	✕	✓	✓	✕
Ang O'Ktom	2015	✓	✓	✓	✕	✕
Sangke Chrum	2008	✓	✓	✓	✓	✕

Note: "✓" = Recognised; "✕" = Not recognised.
Source: Field data compilation, 2025.

The establishment of CFRs in the study areas spans nearly two decades, from 2006 to 2021, reflecting the progressive institutionalisation of community-based fisheries initiatives across Cambodia:

- The earliest recognition occurred in 2006 with *Boeng Loeu*, marking one of the pioneering community-led conservation sites under early Fisheries Administration (FiA) programmes.
- The latest recognition occurred in 2021, when *Boeng Ream* was officially acknowledged at multiple government levels, highlighting the continued expansion of the CFR network under the current national fisheries reform agenda.

A concentration of recognition in 2020 (Boeng Banteay and Sbov Ambaeng) demonstrates the surge of institutional attention toward inland fisheries governance and local conservation partnerships during this period.

All six CFRs (100 percent) have been officially recognised by their respective commune councils. This universal recognition indicates that the CFR concept has been fully integrated at the commune level, aligning with the decentralisation framework under Cambodia's Sub-National Democratic Development (SNDD) policy.

At this level, commune councils play a vital role in legitimising community management committees, facilitating participatory planning, and including CFR areas in Commune Development Plans (CDPs) and Commune Investment Plans (CIPs). Commune endorsement provides a foundation for community mobilisation, rule enforcement, and integration with local development priorities.

Five of the six CFRs (83 percent) — all except *Boeng Loeu* — have been recognised by their respective district administrations. District recognition signifies administrative endorsement of the CFR boundaries, management committees, and operational guidelines, often following technical recommendations from FiAC and PDAFF. This level of recognition strengthens coordination between commune councils, agricultural offices, and law enforcement agencies, especially in regulating illegal fishing activities and managing seasonal water use conflicts.

All CFRs (100 percent) have received recognition from the FiAC, reaffirming their status within the formal fisheries governance structure. FiAC's involvement ensures that community management practices comply with the Fisheries Law (2006) and Sub-Decree on Community Fisheries (2007). FiAC also provides technical assistance on habitat restoration, fish monitoring, and conservation zoning. This universal recognition underscores the strategic role of FiAC as the primary technical authority supporting CFR establishment and sustainability.

Five CFRs—*Boeng Ream*, *Boeng Banteay*, *Sbov Ambaeng*, *Boeng Loeu*, and *Sangke Chrum* — have been officially recognised by the PDAFF, while Ang O'Ktom has not yet received provincial-level acknowledgement. Recognition by PDAFF carries significant institutional weight, as it links community initiatives to broader provincial agricultural and fisheries programmes, enabling access to budgetary support and extension services. The absence of PDAFF recognition on one site reflects administrative delays or pending documentation rather than lack of performance.

None of the six CFRs have yet been formally endorsed by the provincial governments, as indicated by the "0" entries across all sites. Provincial recognition remains relatively rare in Cambodia's CFR system, often reserved for sites of exceptional ecological or socio-economic significance, such as large wetlands or pilot conservation areas. Nonetheless, integration into provincial-level environmental or fisheries planning frameworks could enhance long-term funding and inter-sectoral coordination.

Table 5: Comparative summary and institutional significance

Level of recognition	Number of CFRs recognised	Percentage
Commune	6	100%
District	5	83%
FiAC	6	100%
PDAFF	5	83%
Provincial government	0	0%

Source: Field data compilation, 2025.

Overall, the data show that FiAC and commune-level recognition are universal, forming the core institutional base for all CFRs. District and PDAFF recognitions remain strong but not yet complete, while provincial-level endorsement remains the next frontier for formal integration into regional planning frameworks.

The pattern of recognition reveals a robust multi-level governance structure in which bottom-up community participation meets top-down technical validation. Commune and district recognition ensure administrative and political support, while FiAC and PDAFF provide regulatory and technical frameworks.

For future policy strengthening:

- Provincial endorsement mechanisms should be formalised to secure budget allocations.
- Annual inter-institutional reviews could enhance coordination and accountability.
- Documentation and registration systems at the PDAFF level should be standardised to expedite the formalisation of new CFRs.

This multi-tiered recognition system not only legitimises local stewardship of fish refuges but also anchors them within Cambodia's evolving model of decentralised natural resource governance.

4.4. Membership and community involvement in CFRs

The sustainability of CFRs depends not only on their physical and ecological characteristics but also on the social participation and community governance structures surrounding them. Each CFR is managed by a group of villages whose residents collectively oversee management, enforcement, and conservation activities. The strength of these community organisations can be assessed through the number of participating villages, total and gender-disaggregated population, the number of fishing households or members, and their proportion within the total population. The following table summarises these aspects for the six CFRs studied.

Across the six studied CFRs, the total population of associated villages ranges from 1,747 to 6,215, with an average of approximately 3,245 per CFR. Female populations represent 51 percent of the total, indicating balanced demographic structures across sites. The number of villages affiliated with each CFR ranges from 2 to 4, and the average distance between villages and CFRs is less than 1.25 km, suggesting close physical and social proximity. This proximity facilitates regular access, participation in management, and enforcement activities by community members.

Boeng Ream CFR engages four villages located within 1.3 km of the refuge. With a total population of 6,215 people, including 49 percent of women, it is the largest community among all CFR sites. A total of 1,483 households are directly involved in fishing activities, representing about 19 percent of the commune's population. The fishing population (number of individuals actively engaged in fishing or fish-related livelihoods) reaches 1,186 persons, highlighting Boeng Ream as both a socially dense and economically fishery-dependent community. Such a high participation rate underscores the importance of the CFR not only for biodiversity conservation but also as a primary livelihood safety net, particularly during lean agricultural periods.

Table 6: Population, villages, and membership in CFRs

CFR name	No. of villages	Distance from villages to CFR (km)	Total population	Female population	% Female population	Number of fishing households	Fishing population (no. of people)	% of Population engaged in fishing
Boeng Ream	4	1.3	6,215	3,054	49	1,483	1,186	19
Boeng Banteay	3	2.5	3,583	1,832	51	682	273	8
Sbov Ambaeng	3	2	3,459	1,759	51	932	652	19
Boeng Loeu	2	0.7	2,706	1,433	53	643	193	7
Ang O'Ktom	3	0.5	1,747	970	56	472	378	22
Sangke Chrum	3	0.5	1,761	906	51	577	404	23
Total	**18**	**7.5**	**19471**	**9954**	**51**	**4789**	**3086**	**16**
Average	**3**	**1.25**	**3245**	**1659**	**51**	**798**	**514**	**16**

Source: Field data compilation, 2025.

Boeng Banteay comprises three villages located approximately 2.5 km from the refuge — the greatest distance among the six sites. The total population is 3,583, including 51 percent of females. Out of these, 682 households are engaged in fishing, representing 8 percent of the population, with about 273 active fishers. This relatively lower engagement in fishing suggests that Boeng Banteay's residents rely more heavily on agriculture or wage labour, with fishing serving as a supplementary livelihood. The longer distance from the refuge may also limit daily fishing access and monitoring involvement, pointing to the need for improved community access infrastructure and management outreach.

Sbov Ambaeng CFR involves three nearby villages within a 2 km radius, totalling 3,459 inhabitants, of whom 51 percent are female. Approximately 932 households (19 percent of the population) depend on fishing, with a fishing population of 652 people. This high level of involvement demonstrates a strong cultural and economic connection to aquatic resources. The proximity of the villages and high membership rate suggest strong local governance capacity and potential for co-management arrangements supported by commune councils and FiAC.

Boeng Loeu consists of two villages within 0.7 km of the CFR—the smallest village cluster but among the earliest established CFRs (recognised in 2006). The total population is 2,706, with 53 percent of women. Some 643 households are involved in fishing, accounting for 7 percent of the total population, and 193 individuals are engaged directly in fishery activities. Although fishing dependency is low compared to other sites, Boeng Loeu's longer institutional history and strong governance structure make it a model of sustainable management, where diversification into agriculture and aquaculture complements community conservation efforts.

Ang O'Ktom includes three villages located only 0.5 km from the refuge, with a total population of 1,747 people, including 56 percent of females. Despite its small population, 472 households (22 percent) depend on fishing, involving 378 individuals as active fishers. This indicates an intensively fishing-oriented livelihood system, with strong daily reliance on aquatic resources for food and income. The close physical proximity of villages supports active management and high attendance in CFR-related meetings and enforcement patrols.

Sangke Chrum also comprises three villages, located 0.5 km from the CFR, with a total population of 1,761, of whom 51 percent are female. The community has 577 fishing households, representing 23 percent of the population, and about 404 individuals directly involved in fishing. Its moderate size and balanced gender composition create favourable conditions for inclusive participation and gender-sensitive management, often facilitated through commune-level committees and women's groups.

Across the six CFRs, several key trends emerge:

- Fishing dependence is highest in *Boeng Ream*, *Ang O'Ktom*, and *Sbov Ambaeng*.
- Population density and village proximity strongly influence participation levels: closer villages tend to have higher membership and engagement rates.
- Female participation potential is significant, with nearly half the population female, underscoring the opportunity to strengthen women's roles in fish processing, marketing, and CFR decision-making.

The data illustrates how social structure and spatial proximity shape the strength and inclusiveness of CFR management. CFRs with high fishing populations (e.g., Boeng Ream and Sbov Ambaeng) require robust governance systems to regulate resource use, while smaller but highly engaged communities may serve as models of local participation. For sustainable management:

- Encourage women's involvement in CFR committees;
- Strengthen linkages between nearby villages through joint patrols and awareness activities; and
- Promote livelihood diversification for communities with high fishing dependence to reduce pressure on fish stocks.

4.5. Management and institutional structure of CFRs

Effective management of CFRs depends on well-functioning CBOs that plan, make decisions, enforce, and coordinate with government agencies. Each CFR is administered by a CFR management committee, which oversees conservation measures, regulates fishing activities, and ensures compliance with national fisheries law. The committee structure typically reflects the principles of participatory governance, with representation from local households, fishers, women's groups, and commune councils.

Table 7: Establishment and composition of CFR committees

CFR name	CFR committee established	Year established	Total committee members	Female committee members	Committee functional status	Year of last functioning/ election	Plan to re-establish	Recent re-election	Year of last election
Boeng Ream	Yes	2021	7	2	Functional	Still functional	No	Yes	2021
Boeng Banteay	Yes	2016	14	7	Functional	Still functional	Yes	No	No idea
Sbov Ambaeng	Yes	2016	9	3	Functional	Still functional	Yes	No	No idea
Boeng Loeu	Yes	2006	11	0	Functional	Still functional	Yes	No	No idea
Ang O'Ktom	Yes	2015	9	3	Not functional	2018	Yes	No	No idea
Sangke Chrum	Yes	2008	9	1	Functional	Still functional	Yes	No	No idea
Total			**59**	**16**					
Average			**10**	**3**					

Source: Field data compilation, 2025.

4.5.1. The CFR management committee

All six CFRs in the surveyed communes have formally established CFR management committees, providing a recognised mechanism for local stewardship and accountability. Each committee was formed through community elections and consultations jointly facilitated by the commune council and the FiAC, ensuring that committee members are locally legitimate and broadly representative of community interests. This participatory formation process strengthens local ownership, compliance with refuge rules, and coordination with commune-level development planning.

At the national level, the FiA plays a central enabling role in the CFR system. FiA sets standardised guidelines governing CFR establishment, management roles, and regulations; provides technical guidance and capacity support to FiACs on CFR formation and operation; and maintains and updates the national CFR database. Through this multi-level governance arrangement—linking national policy, provincial technical oversight, and community-based management—the CFR system achieves both local legitimacy and institutional coherence, supporting effective fish conservation and sustainable resource governance across the surveyed communes.

All study CFRs are managed by the CFR management committees, confirming the presence of institutional mechanisms for local fisheries management. The establishment years range from 2006 (Boeng Loeu) to 2021 (Boeng Ream), illustrating an ongoing expansion of community fisheries initiatives in Cambodia over the past two decades.

- Early-established committees, such as Boeng Loeu (2006) and Sangke Chrum (2008), were part of the first generation of CFRs introduced under the Fisheries Administration's Community Fisheries Policy Framework (2005–2010).
- Mid-generation committees, such as Boeng Banteay (2016), Sbov Ambaeng (2016), and Ang O'Ktom (2015), reflect consolidation during the second phase of fisheries reform, emphasising local participation and co-management.
- Newer committees, such as Boeng Ream (2021), represent the latest wave of community establishment under integrated programmes combining fish conservation, agriculture, and water resource management.

The total number of committee members varies across sites, reflecting local population size and administrative preferences:

- The largest committee is Boeng Banteay with 14 members, followed by Boeng Loeu with 11 members. The Boeng Loeu CFR committee election process was organised with support from the Provincial FiAC, the district governor, the commune council, village leaders, and international organisations such as WorldFish. The CFR Committee was officially established in 2020 and consists of a president, vice president, finance officer, and members. Of the nine committee members, four are women, reflecting efforts toward gender inclusivity.
- The remaining CFRs—Boeng Ream, Sbov Ambaeng, Ang O'Ktom, and Sangke Chrum—have committees of 7 to 9 members, consistent with the standard guidelines under the Sub-Decree on Community Fisheries (2007), with an average of ten CFR members per committee.

- Ang O'Ktom CFR Committee was formed through an election process. The committee consists of five members, including two women. Farmers in the area also use water from Ang O'Ktom for cultivation purposes.

Gender inclusion within the committees also varies substantially:

- *Boeng Banteay* demonstrates the highest female participation with 7 women members, achieving a 50 percent gender ratio.
- Sbov Ambaeng and Ang O'Ktom include three women each, while *Boeng Ream* has two female members.
- Boeng Loeu has no female representation, while Sangke Chrum includes one female member.

Overall, women constitute approximately 27 percent of all committee members across the six CFRs. Although this represents progress toward inclusive management, further efforts are needed to enhance women's leadership roles in decision-making, planning and enforcement activities.

Five of the six committees are currently active and functional, while Ang O'Ktom is no longer operational, having ceased activities in 2018. The other committees, particularly those of Boeng Ream, Boeng Banteay, Sbov Ambaeng, Boeng Loeu, and Sangke Chrum, remain "still functional" according to local reports.

The long-standing functionality of committees such as Boeng Loeu (since 2006) and Sangke Chrum (since 2008) reflects strong institutional resilience. In these communities, committee members continue to manage daily operations, including enforcement of fishing bans within refuge zones; coordination with FiAC on monitoring and seed release; management of water access and seasonal closure periods; and community mobilisation for habitat restoration and awareness activities.

4.5.2. Election and leadership

Committee leadership and membership are expected to be renewed every three to five years through community elections, in line with FiA guidelines. However, the data show that regular re-elections are not consistently practised.

- Only Boeng Ream reported a recent re-election (2021) coinciding with the committee's formation year.
- The remaining CFRs—Boeng Banteay, Sbov Ambaeng, Boeng Loeu, Ang O'Ktom, and Sangke Chrum—have no clear records of recent elections, indicating leadership continuity without formal re-endorsement.
- Most communities responded "no idea" when asked about the year of the last election, suggesting weak documentation and lack of structured renewal processes.
- This irregularity highlights the need for capacity building and governance strengthening to institutionalise democratic practices within CFR management.

Where committees have weakened or become inactive—such as Ang O'Ktom—there are plans to re-establish management structures. Likewise, several active CFRs, including Boeng Banteay, Sbov Ambaeng, Boeng Loeu, and Sangke Chrum, have expressed intentions to reconstitute or

refresh committees in upcoming years to ensure broader participation and gender balance. The establishment of new committees or re-elections typically involves:

1. Community consultation meetings facilitated by FiAC and commune councils;
2. Nomination and endorsement by villagers and fishing households;
3. Formal approval from the Fisheries Administration Cantonment and commune council; and
4. Public posting of the new committee structure at the commune office.

Table 8: The comparative observations of the CFR committees

Indicator	Highest observed	Lowest observed	Observations
Committee size	14 members (Boeng Banteay)	7 members (Boeng Ream)	Larger committees often correlate with more populous communes.
Female participation	7 members (Boeng Banteay)	0 (Boeng Loeu)	Gender inclusion remains uneven.
Functionality	5 functional CFR, 1 inactive CFR	N/A—	83% of CFRs maintain operational committees.
Recent elections	Boeng Ream (2021)	None reported elsewhere	Re-election practices remain inconsistent.

Source: Field data compilation, 2025.

The assessment shows that while all CFRs possess formal management structures, their governance maturity varies. To sustain long-term effectiveness, several recommendations emerge:

- Institutional strengthening through regular re-elections, record keeping, and leadership training.
- Gender mainstreaming, ensuring at least 30–40 percent female participation in future committees.
- Legal reinforcement via registration renewal under the Fisheries Administration and commune authorities.
- Capacity-building programmes to improve coordination between CFRs, FWUCs, and commune councils for integrated resource management.

Overall, the CFR committees represent a vital institutional foundation for the co-management of community fisheries. Their establishment between 2006 and 2021 reflects both the evolution of local fisheries' governance and the continued relevance of community participation in sustaining aquatic ecosystems. Strengthening their structure, inclusivity, and democratic renewal processes will be key to ensuring the long-term viability and accountability of Cambodia's CFR system.

4.6. Management and management plans of CFRs

4.6.1. The management plans for CFRs

A core component of Community Fish Refuge (CFR) sustainability is the existence and implementation of CFR Management Plans, which guide local conservation activities, habitat restoration, and community monitoring. The management plan serves as a framework for

aligning community priorities with national fisheries policy objectives under the Fisheries Law (2006) and the Sub-Decree on Community Fisheries (2007). The following assessment summarises the status of management plans, their level of implementation, and the main purposes and activities of the plans for six CFRs: Boeng Ream, Boeng Banteay, Sbov Ambaeng, Boeng Loeu, Ang O'Ktom, and Sangke Chrum.

Table 9: Management plans and purposes of CFRs

CFR name	Existence of management plan (past 3 years)	Plan implemented	Community awareness of plan and purpose	Purpose 1	Purpose 2	Purpose 3
Boeng Ream	Yes	Implemented	Yes	Rehabilitation	Repairing fish passages	Setting up patrolling team
Boeng Banteay	Yes	Implemented	Yes	Construction	Constructing fences around conservation area	Building guarding post
Sbov Ambaeng	Yes	Implemented	Yes	Planting trees	Installing signboards	Rehabilitation of CFR habitat
Boeng Loeu	Yes	Implemented	Yes	Pole installation	Fish release	Installing solar panels
Ang O'Ktom	Yes	Implemented	Yes	Building canals	No	No
Sangke Chrum	Yes	Not implemented	Yes	Rehabilitation of CFR habitat	Building fish passage	No

Source: Field data compilation, 2025.

All six CFRs reported having a formal management plan over the past three years. This demonstrates that local CFR management systems have achieved a reasonable level of planning maturity. Furthermore, all communities confirmed their awareness of the plan's purpose, showing that the management process is both participatory and inclusive.

These management plans were generally developed in collaboration with the FiAC, commune councils, and local stakeholders, using participatory approaches such as community consultations, mapping of fish habitats, and prioritisation of rehabilitation needs.

Five of the six CFRs—Boeng Ream, Boeng Banteay, Sbov Ambaeng, Boeng Loeu, and Ang O'Ktom—reported that their management plans were implemented, while only Sangke Chrum indicated that its plan was not yet implemented due to funding constraints.

The high rate of implementation (83 percent) demonstrates both community commitment and the effectiveness of decentralised fisheries governance. Implementation typically included small-scale infrastructure projects (e.g., fencing, guard posts, canals) and ecological interventions (e.g., fish releases, vegetation planting). The unimplemented plan in Sangke Chrum reflects the challenge of limited financial and technical support, even where community willingness is strong.

4.6.2. Purposes of CFR management plans

The purposes identified across the six CFRs reveal consistent themes focused on habitat rehabilitation, infrastructure improvement, and community surveillance. These purposes can be categorised into three major domains:

(a) Ecological rehabilitation

This is the most frequently cited purpose, appearing in four CFRs (Boeng Ream, Sbov Ambaeng, Boeng Loeu, and Sangke Chrum). Activities under this objective include:

- Habitat restoration through vegetation planting and silt removal.
- Rehabilitation of fish passages to restore aquatic connectivity.
- Tree planting along refuge boundaries to stabilise soil and provide shade; and
- Fish stocking and releases to increase aquatic biodiversity.

These interventions directly support the ecological integrity of the refuge, ensuring breeding and feeding habitats are maintained for native fish species.

(b) Infrastructure development and protection

The second key objective involves the physical protection of refuge zones. *Boeng Banteay* and *Boeng Ream* emphasised construction-based purposes:

- Building fences and guarding posts around conservation areas to prevent encroachment.
- Repairing or constructing fish passages to regulate water exchange; and
- Installing solar-powered lighting and poles (Boeng Loeu) to support night-time patrolling and fish monitoring.

Such infrastructure improvements strengthen the physical demarcation of CFRs and enhance the ability of communities to monitor and enforce conservation rules.

(c) Community organisation and enforcement

The third cluster of purposes focuses on social organisation, capacity building, and surveillance. *Boeng Ream* highlighted the establishment of patrolling teams, while several others (Sbov Ambaeng, Boeng Banteay, Boeng Loeu) integrated signboards, awareness campaigns, or cooperative monitoring measures into their management plans. These activities contribute to community empowerment by fostering collective responsibility, transparency, and rule enforcement within the CFR governance framework.

Across the six studied CFRs, a diverse set of restoration, protection, and habitat-enhancement activities has been implemented to strengthen ecological functions and sustain community fisheries, beginning with Boeng Ream, where the community undertook large-scale excavation of a 25-acre fish pond, rehabilitated a 600-metre access road to ensure year-round mobility, and deployed brush parks as critical fish habitats, accompanied by the release of 5,100 fingerlings over the last three years; Boeng Banteay, by contrast, concentrated on improving physical infrastructure through the construction of access roads, erection of protective fencing, and establishment of a guarding post to secure the CFR, although it did not undertake fish releases; while Sbov Ambaeng prioritized rehabilitation of degraded areas and installed four boundary poles to formalize protection, receiving 3,090 fingerlings despite not directly releasing fish itself, and Boeng Loeu advanced both ecological and governance outcomes by installing poles and signboards for demarcation, releasing fingerlings, planting trees to stabilize the landscape, and maintaining 60 kg of broodstock as part of ongoing conservation efforts. Further illustrating variations in local priorities, Ang O'Ktom focused mainly on structural improvements through the installation of a culvert but undertook no additional ecological interventions, whereas Sangke Chrum engaged in rehabilitation work

and deepened the CFR basin to improve dry-season water retention while also undertaking fish releases, demonstrating how communities combine infrastructure upgrading, ecological restoration, and habitat protection in different configurations depending on local needs, resource availability, and the maturity of their CFR management practices.

Table 10: The activities of the CFR management plans

Name of CFRs	Activity 1	Activity 2	Activity 3	Fish release in the last 3 years	Brood stock (kg)	No. of fingerlings
Boeng Ream	Digging the fishponds for 25 acres	Rehabilitating the access road of 600m	Deploying the brush park	Yes		5,100
Boeng Banteay	Built the access roads	2 fences	Building the guard post	No		
Sbov Ambaeng	Rehabilitation	Installing 4 poles	None	No		3,090
Boeng Loeu	Installing the poles and signboards	releasing fish fingerlings	Planting tree	Yes	60	
Ang O'Ktom	Installing the culvert	none	None	No		
Sangke Chrum	Rehabilitation	Deepening the CFR	None	Yes		

Source: Field data compilation, 2025.

The Boeng Loeu CFR has developed a management plan that includes the following actions: preserving fish habitats by installing shelters and planting trees, constructing a patrol house and conducting regular weekly patrols in collaboration with monks and police, releasing fish species into the refuge, and recording income and expenses annually and installing a solar power system.

4.6.3. The patrolling team

The level of community patrolling effort across the six studied CFRs shows significant variation in team size, gender participation, and frequency of monthly patrolling activities. Boeng Banteay and Sbov Ambaeng demonstrate the strongest organisational capacity, each maintaining relatively large patrolling teams, averaging 10 and 9 members respectively, with two female members participating in each site. These two CFRs also conduct regular patrols—10 times per month in Boeng Banteay and 14 times in Sbov Ambaeng—reflecting well-structured community engagement and a consistent commitment to protecting aquatic resources. Sangke Chrum, despite having only two members, stands out for its exceptionally high patrolling frequency of 30 patrols per month, indicating a highly active surveillance system carried out by a compact yet dedicated team.

Boeng Ream and Boeng Loeu both maintain smaller teams, with averages of three members each and no female participation reported. However, Boeng Ream conducts a comparatively high 17 patrols per month, suggesting that even small groups can sustain a strong conservation presence when local leadership and motivation are strong. Boeng Loeu conducts three patrols per month, indicating a lower but still routine level of activity aligned with its team size. In contrast, Ang O'Ktom reported no active patrolling team, no female members, and no patrolling

activities during the reporting period, highlighting a gap in community-based enforcement capacity.

Overall, the average across all CFRs shows five patrolling members, one female member, and twelve patrols per month, demonstrating moderate engagement but also revealing substantial differences in local governance capacity and gender inclusion across sites.

Table 11: The patrolling team and its members

Row labels	Average of No. of members of the patrolling team	Average of No. of female members	Average of No. of patrolling activity/month
Ang O'Ktom	0	0	0
Boeng Banteay	10	2	10
Boeng Loeu	3	0	3
Boeng Ream	3	0	17
Sangke Chrum	2	0	30
Sbov Ambaeng	9	2	14
Grand total	**5**	**1**	**12**

Source: Field data compilation, 2025.

Boeng Ream's management plan (2021) was successfully implemented, emphasising rehabilitation, repair of fish passages, and establishment of patrolling teams. The plan reflects a strong commitment to combining ecological restoration with community enforcement, creating a model of integrated co-management.

The Boeng Banteay CFR management plan (2016) focused on constructing fences around the conservation zone and building a guard post. These actions addressed recurring problems of illegal fishing and livestock intrusion. The physical protection of the site demonstrates an understanding that structural boundaries are crucial for effective conservation.

Sbov Ambaeng's plan prioritised tree planting, installation of signboards, and habitat rehabilitation. The emphasis on reforestation and signage suggests a community-driven approach to environmental education and awareness. This CFR combines both ecological and social dimensions of management, aiming for long-term habitat recovery.

Boeng Loeu's management plan concentrated on pole installation, fish releases, and solar panel installation. The integration of renewable energy into fisheries management marks a practical innovation, enhancing sustainability and reducing dependence on external power sources for monitoring and lighting.

The Ang O'Ktom plan targeted canal construction to improve water circulation between the CFR and nearby rice fields. Although other objectives were unspecified ("No" in columns 2 and 3), the project represents an important hydrological management intervention linking water conservation with fishery enhancement.

Sangke Chrum's management plan remains unimplemented, though its stated purposes — the rehabilitation of CFR habitats and the construction of fish passages — mirror broader national priorities in fish habitat connectivity. The delay underscores the need for technical support and financing to ensure plan execution.

Table 12: Comparative analysis of the studied CFRs

Indicator	Highest observed	Lowest observed	Observations
Existence of plan	6 CFRs (100%)	—	Universal coverage of CFR plans.
Implementation	5 CFRs (83%)	1 unimplemented (Sangke Chrum)	Implementation rates are high overall.
Key purpose	Rehabilitation (4 sites)	Structural construction (2 sites)	Ecological rehabilitation dominates priorities.
Community awareness	100% across sites	—	All committees understand the purpose of their plans.

Source: Field data compilation, 2025

The findings reveal strong community participation in CFR planning and implementation, with a high level of local awareness and ownership. However, gaps remain in financial sustainability, technical supervision, and documentation of results. Key recommendations include:

- Institutionalise monitoring frameworks to track plan implementation progress.
- Strengthen financial mechanisms, including commune budget allocations for CFR maintenance.
- Promote knowledge exchange among CFR committees to share successful practices (e.g., Boeng Ream's patrol system or Boeng Loeu's solar-powered infrastructure).
- Integrate CFR plans into Commune Development Plans (CDPs) to ensure alignment with broader land-use and water governance strategies.

The assessment underscores that Cambodia's community-managed fish refuges are not only functional but also strategically directed toward habitat restoration, infrastructure improvement, and community governance. The widespread preparation and implementation of CFR management plans demonstrate institutional maturity and community commitment. Sustaining these efforts requires continuous support for capacity building, technical guidance, and budgetary integration to ensure long-term ecological and socio-economic benefits.

4.7. Funding sources and financial support for CFRs

The financial sustainability of CFRs depends heavily on access to both external and internal funding sources, which enable community committees to carry out habitat restoration, infrastructure maintenance, and enforcement activities. The table below summarises the availability, types, and origins of funding for six CFRs—Boeng Ream, Boeng Banteay, Sbov Ambaeng, Boeng Loeu, Ang O'Ktom, and Sangke Chrum—over the past three years.

Among the six CFRs assessed, four sites (Boeng Ream, Boeng Banteay, Sbov Ambaeng, and Boeng Loeu) have received financial support within the past three years, primarily from external donors, NGOs, and development partners (DPs).

The Boeng Loeu CFR received financial support from WorldFish, including the construction of a protective fence around the CFR and the release of 3,000 fish in 2025. Financial assistance of KHR4,000,000 (approximately USD1,000) per year was provided for three years (2022–2024). In addition, the CFR committees initiated local fundraising efforts by installing a public savings box and mobilising funds from the commune budget. Additional

activities include organising an annual solidarity festival to raise funds and requesting commune sponsorship for fuel to pump water into Boeng Loeu, ensuring year-round water availability for fish preservation.

Table 13: Funding sources supporting CFRs

CFR name	Funding support in the last 3 years	External funding support	Private sector support	Company support	Buddhist temple support	Government support	Other Sources	Commune development fund
Boeng Ream	Yes (outside & inside)	NGOs / Development partners	No	0	0	0	0	0
Boeng Banteay	Yes (outside & inside)	NGOs, Private	Yes	0	1	0	1	0
Sbov Ambaeng	Yes (outside & inside)	NGOs / Development partners	No	0	0	0	0	0
Boeng Loeu	Yes (outside & inside)	NGOs	No	0	0	0	0	0
Ang O'Ktom	No	No	No	0	0	0	0	0
Sangke Chrum	No	No	No	0	0	0	0	0

Source: Field data compilation, 2025.

In contrast, Ang O'Ktom and Sangke Chrum reported no funding support, indicating gaps in both donor engagement and local financing mechanisms. This distribution suggests that two-thirds (67 percent) of CFRs currently depend on external resources, while one-third (33 percent) rely solely on community self-management without external support. In Ang O'ktom, the committee raises funds from water users, with fees determined by the size of their farmland. Despite these efforts, the CFR leader expressed concern that the CFR may eventually disappear due to the lack of a reliable water source.

4.7.1. External funding sources

External financial assistance remains the primary source of support for CFRs. Organisations categorised as NGOs and Development Partners (DPs) play a pivotal role in financing community fisheries activities, such as rehabilitation of refuge areas; capacity-building for CFR committees; infrastructure construction (e.g., guard posts, fish passages, and signage); and awareness programmes on sustainable fishing and biodiversity conservation.

Boeng Ream, Sbov Ambaeng, and Boeng Loeu explicitly identified NGOs/DPs as their main financial partners, while Boeng Banteay reported additional involvement from private actors. These external contributors often provide short-term project grants rather than continuous operational funding, highlighting a dependency cycle that can challenge long-term sustainability once projects close.

Among all sites, Boeng Banteay stands out for attracting private sector involvement, particularly through corporate or business-linked support in collaboration with NGOs. Although the data do not specify the company's identity, this reflects a positive trend toward public–private partnerships (PPPs) in community-based resource management.

Boeng Banteay's private engagement included fencing of conservation areas (private sponsorship of materials); guard post construction (joint NGO–company initiative); and small-scale financial contributions for awareness or logistics activities.

Such collaboration models demonstrate the potential for leveraging local corporate social responsibility (CFR) funds to complement donor support, especially in areas with agro-industrial or service sector presence near the CFR.

The Buddhist temple (pagoda) played a modest but symbolic role in supporting CFR activities. Only Boeng Banteay reported receiving contributions from a temple, likely in the form of communal labour or small material donations (e.g., bamboo, nets, or seedlings for restoration). Although these contributions are non-monetary, they are significant in fostering moral legitimacy and community solidarity, aligning conservation actions with Buddhist principles of harmony between humans and nature. In other communes, no temple-related funding was reported, indicating that religious institutions remain an underutilised ally in community fisheries support.

None of the CFRs received direct government financial allocations or support from the Commune Development Fund (CDF) in the past three years. This gap illustrates a critical disconnect between community conservation initiatives and sub-national public investment systems. While commune councils regularly acknowledge CFRs within their development plans, financial allocations remain rare, often due to competing priorities (roads, schools, irrigation).

The lack of commune-level funding also means that CFR committees rely entirely on external aid or volunteer efforts, making it difficult to sustain routine operations such as patrols, reporting, and small maintenance activities once donor funding ends.

Boeng Ream received funding from WorldFish for internal and external activities, focusing on rehabilitation and awareness. No private, government, or religious contributions were noted. The most financially diverse CFR, Boeng Banteay, benefited from WorldFish, private sector, and temple contributions. This mixed funding model reflects strong community networking and active committee leadership capable of mobilising multiple partners.

Sbov Ambaeng was supported by development partners and WorldFish, focusing on ecological restoration and the installation of signage. Funding remains external and project-based.

Boeng Loeu received limited support from NGOs, likely for minor rehabilitation or capacity-building. Despite being one of the oldest CFRs (established in 2006), its funding remains sporadic and donor-dependent.

Ang O'Ktom and Sangke Chrum, both reported no financial support from any source over the last three years. This lack of funding severely constrains their management capacity, especially for activities such as patrols, maintenance, or awareness campaigns.

Table 14: The funding supports CFRs and the comparative insights

Categories of funding	No. of CFRs receiving funding support
CFRs with funding support	4 out of 6 (67%)
Main external source	NGOs and development partners
Private sector engagement	Only Boeng Banteay
Temple support	Only Boeng Banteay
Government & CDF support	None reported
Completely unfunded CFRs	Ang O'Ktom and Sangke Chrum

Source: Field data compilation, 2025.

The comparison highlights that NGOs and DPs remain the dominant supporters, with minimal engagement from government or local funding systems. However, Boeng Banteay's success in mobilising multiple stakeholders demonstrates the potential for diversification and sustainability through multi-source collaboration. To strengthen financial sustainability, the following measures are proposed:

1. Integrate CFR activities into Commune Investment Plans (CIPs) to unlock funding from the Commune Development Fund.
2. Establish partnerships with local companies to leverage CFR contributions for conservation activities.
3. Encourage religious and cultural institutions (pagodas) to provide in-kind support for awareness and habitat rehabilitation.
4. Create a revolving community fund managed by CFR committees to reinvest income from fish releases, ecotourism, or agricultural linkages.

The analysis reveals that while most CFRs have benefited from external donor funding, their financial base remains fragile and externally driven. The absence of systematic public investment underscores the need for institutional mainstreaming of CFR financing within commune and provincial budgets. A blended funding model—combining donor, private, religious, and public contributions—offers the most promising path toward the long-term financial and ecological sustainability of Cambodia's CFRs.

4.7.2. Membership fees in the studied CFRs: How the system works

All six studied CFRs apply a membership fee system as a basic mechanism to support local management and enforcement. Membership is generally open to households within the commune or villages that benefit directly from the CFR. Fees are agreed through community consultation and endorsed by the CFR management committee, commune council, and the FiAC, ensuring transparency and legitimacy.

In practice, membership fees are modest and affordable, reflecting local income levels. Fees are typically collected annually and used to finance routine activities such as committee meetings, patrol allowances, basic equipment (e.g., flashlights, fuel, uniforms), boundary marking, and minor maintenance of refuge infrastructure. In some CFRs, households that actively participate in patrolling or management may receive fee reductions or exemptions, reinforcing voluntary contributions and collective responsibility.

Despite their importance, membership fees contribute only a small proportion of total CFR financing. Revenues are insufficient to cover major costs such as habitat rehabilitation, infrastructure repair, or long-term monitoring. As a result, CFRs remain heavily reliant on external support from NGOs and development partners, with no regular allocation from government or Commune Development Funds. This highlights that while membership fees strengthen local ownership and accountability, they cannot alone ensure the financial sustainability of CFR management.

Table 15: Comparison of membership fees, uses, and limitations across the studied CFRs

CFR type / Sites	Membership fees (how it works)	Main uses of fees	Key limitations
Perennial CFRs (Boeng Loeu, Boeng Ream, Sbov Ambaeng)	Annual household membership fees set through community agreement and managed by the CFR Committee. Participation-based exemptions may apply for patrolling members.	Meeting costs, patrol allowances, fuel, basic equipment, minor maintenance of refuge boundaries.	Fees insufficient for large-scale maintenance, sediment removal, or water-control structures; cannot finance long-term monitoring or infrastructure.
Seasonal CFRs (Boeng Banteay, Sangke Chrum)	Low annual fees reflecting seasonal benefits and variable water availability. Collected mainly to support enforcement during the wet season.	Patrols during peak fishing periods, signage, community awareness activities.	Highly seasonal benefits reduce willingness to pay; revenues fluctuate and drop during dry seasons.
Ephemeral CFR (Ang O'Ktom)	Minimal or symbolic fees due to the absence of dry-season water and limited year-round benefits.	Occasional meetings, awareness raising during flood season.	Fees generate negligible revenue; management heavily dependent on external support; weak financial base.

Source: Field data compilation, 2025.

Membership fees play an important governance role beyond revenue generation. Even though the amounts collected are small, the act of paying a fee establishes formal membership, strengthens a sense of ownership, and legitimises CFR rules within the community. CFRs with regular fee collection tend to show higher compliance with fishing regulations, more active participation in meetings, and greater willingness to contribute labour for patrolling and habitat protection.

However, the documents also show that financial contribution does not scale with management responsibility. As CFRs increasingly take on roles related to water storage, irrigation coordination, and landscape governance, the limited fee-based system constrains enforcement intensity and institutional effectiveness. Without complementary public financing, governance performance remains dependent on voluntary labour and external projects rather than stable institutional capacity.

5. CFR framework for integrating water, land and aquatic food systems

CFRs constitute a critical institutional entry point for advancing integrated, decentralised food system governance at the district level. Evidence from Boeng Ream, Sbov Ambaeng, Boeng Banteay, and Boeng Sneh demonstrates that CFRs shape a district-wide governance architecture in which ecological processes and administrative responsibilities intersect.

5.1. The Roles of CFRs in promoting the integrated decentralised food system governance Top of Form

This section examines the roles of CFRs in promoting integrated food system governance. Figure 4 illustrates Boeng Sneh Lake as the central hydrological and governance node within a broader landscape-scale food system that links the MR, irrigation infrastructure, CFRs, and rice fields. Rather than functioning as isolated components, these elements are shown as interconnected through bidirectional water flows, canals, and management institutions, forming an integrated water–food–livelihood system. The MR represents the primary source of natural water flow. Seasonal river rises supply water to the Vaiko Irrigation System (VIS) and indirectly to Boeng Sneh Lake through streams and floodplain channels. This establishes the Mekong as the upstream driver of flood pulses that shape lake levels, irrigation supply, and downstream agricultural productivity. Boeng Sneh Lake functions as a natural reservoir and regulator, receiving inflows from the Mekong system and redistributing water to surrounding landscapes. The lake connects directly to:

- Irrigation systems, which convey water to rice fields and CFRs;
- Natural streams, which maintain ecological connectivity; and
- CFRs, which act as intermediary storage and refuge nodes.

The VIS and associated canals distribute water from the Mekong–Boeng Sneh system to rice fields and CFRs. These canals are shown with arrows indicating two-way movement: (1) During the wet season, canals deliver water into CFRs and rice fields, (2) and during the dry season, water is extracted outward from lakes and CFRs for irrigation. This demonstrates how irrigation infrastructure links ecological systems with agricultural production.

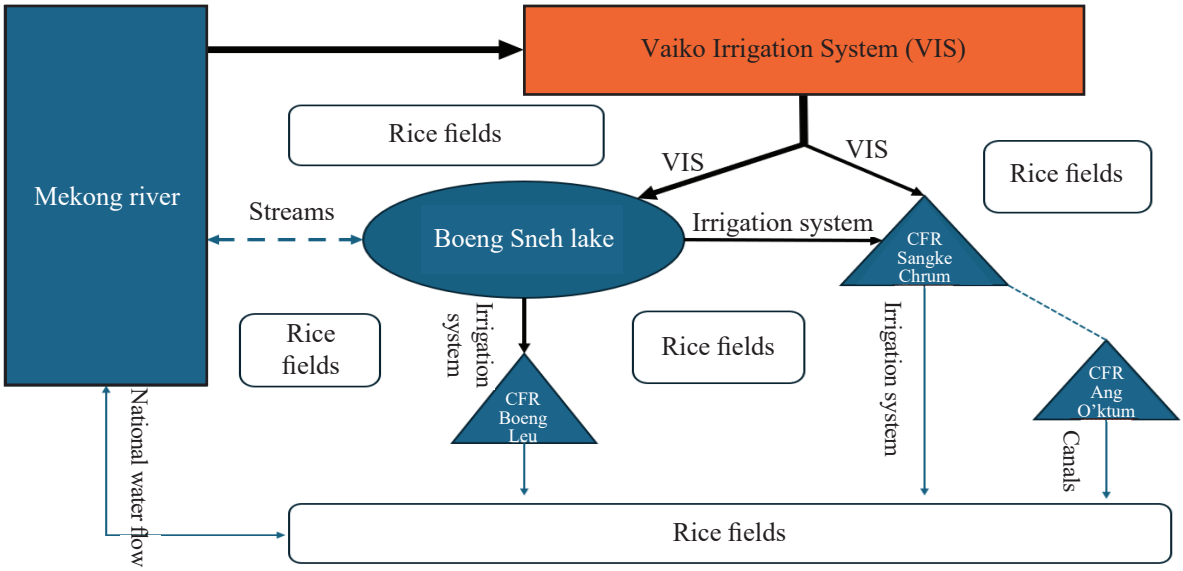
The diagram highlights three CFRs—Boeng Loeu CFR, Sangke Chrum CFR, and Ang O'Ktom CFR—strategically positioned between the lake, canals, and rice fields. Their roles include:

- Fish refuge and biodiversity conservation: CFRs retain water and habitat for fish, especially during the dry season.
- Water storage and buffering: CFRs receive water from irrigation systems and Boeng Sneh Lake in the wet season and release or retain water during dry periods.
- Hydrological connectors: CFRs link lake water, canals, and rice fields, enabling fish migration and nutrient exchange.
- Conflict mediation spaces: Because CFRs sit at the interface of irrigation and fisheries, they become focal points for negotiated water sharing between farmers and fishery managers.

Rice fields surround the lake and CFRs and are shown as both water users and ecological corridors. In the dry season, rice fields receive irrigation water pumped from canals and CFR-connected systems. In the wet season, flooded rice fields become temporary aquatic habitats, allowing fish and nutrients to move between CFRs, Boeng Sneh Lake, and the wider floodplain.

Thus, rice fields function not only as food production areas but also as hydrological and ecological connectors.

Figure 4: The central roles of CFRs in promoting the food system governance in Boeng Sneh



Source: Compiled by authors, 2025.

Furthermore, Figure 5 presents the TKIS as the primary managed water-distribution backbone connecting the TSL, surrounding rice fields, and a network of CFRs—notably Boeng Ream, Sbov Ambaeng, and Boeng Banteay. Together, these elements form a coupled hydrological–governance system in which agricultural production, fisheries conservation, and water management are jointly negotiated.

TSL functions as the natural reservoir and seasonal driver of water availability. During the wet season, lake levels rise and feed water upward into the TKIS through main canals. In the dry season, the lake remains the ultimate sink and reference point for drainage and return flows. This positions Tonle Sap as the ecological foundation of the system, supporting both fisheries and agriculture.

TKIS appears as a vertical and horizontal canal network distributing water from the lake to rice fields and CFRs. The arrows indicate bidirectional flow:

- Wet season: Water flows from Tonle Sap through TKIS into rice fields and CFRs, expanding aquatic habitats.
- Dry season: Water is pumped outward from canals and connected CFRs to irrigate rice fields, while some flows return toward the lake.

This illustrates TKIS not merely as irrigation infrastructure, but as a regulatory interface between natural hydrology and food production.

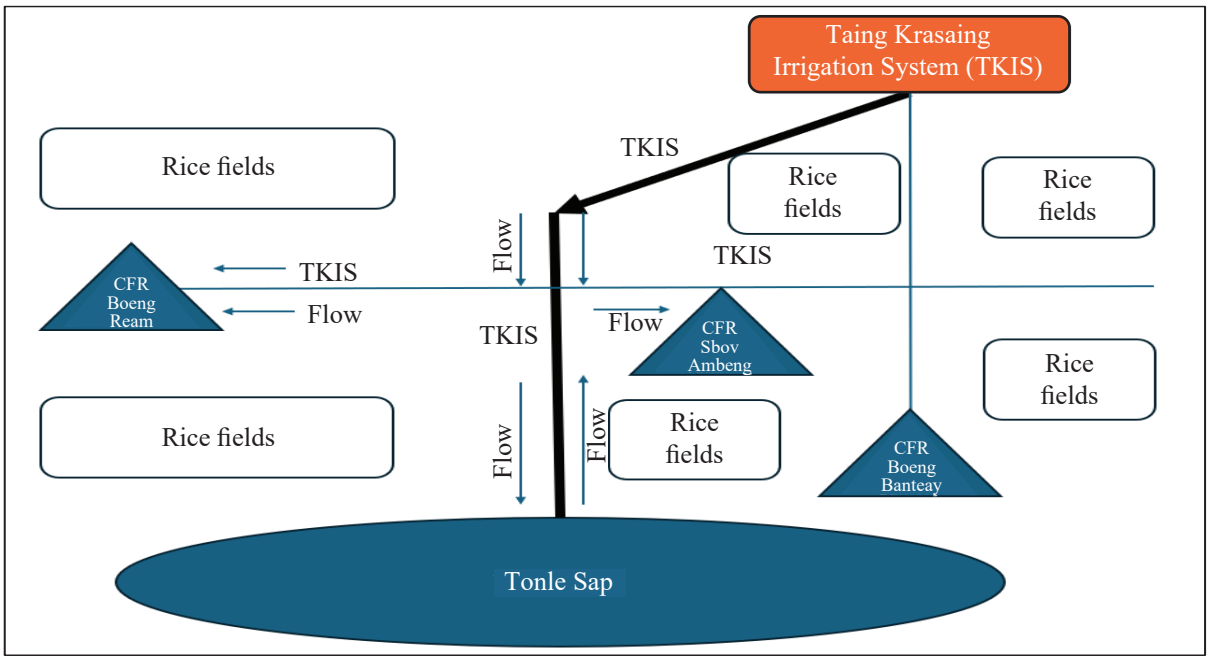
The CFRs—Boeng Ream, Sbov Ambaeng, and Boeng Banteay—are strategically positioned along TKIS canals and adjacent to rice fields, highlighting their intermediary role:

- Fish refuge and biodiversity conservation: CFRs retain water and provide habitat for fish, especially during dry-season low water.
- Water buffering and regulation: CFRs receive water from TKIS during high flows and, in some cases, release or retain water during dry periods, influencing irrigation availability.

- Hydrological connectivity: CFRs link Tonle Sap, canals, and rice fields, enabling fish migration and nutrient exchange across the landscape.
- Governance focal points: Because CFRs sit at the interface of fisheries and irrigation, they become key sites where water-sharing rules are negotiated between farmers and fishery managers.

Boeng Ream, in particular, is shown connected laterally to TKIS, illustrating how its water levels are actively managed to balance fish refuge needs with irrigation demand.

Figure 5: The central role of CFRs in promoting integrated food governance in Boeng Ream and TKIS



Source: Compiled by authors, 2025.

Rice fields surround the CFRs and canals, indicating their dual function. In the dry season, they are water recipients, relying on TKIS and, indirectly, CFR-connected water for irrigation. In the wet season, flooded rice fields become temporary aquatic habitats, allowing fish to move between CFRs and the wider floodplain and enhancing soil fertility through sediment deposition. Thus, rice fields act as both food production zones and hydrological connectors.

Overall, the diagram illustrates integrated food system governance by showing how water, fish, and nutrients circulate across interconnected natural systems (river–lake–floodplain) and managed infrastructures (irrigation canals, TKIS, VIS), linking the Mekong and Tonle Sap systems with CFRs and surrounding rice fields. Fish migrate seasonally between rivers, lakes, CFRs, and flooded rice fields, while rice production depends on the combined effects of natural flooding and managed irrigation. Within this network, CFRs function as embedded governance nodes rather than isolated conservation sites, anchoring coordination between fisheries protection, irrigation management, and agricultural production. As a result, decisions on water abstraction, refuge protection, and rice cultivation are inherently interdependent and require cross-sectoral coordination. This landscape-scale integration is central to sustaining fisheries, rice production, and livelihood resilience in the Boeng Sneh–Mekong floodplain and the Taing Krasaing-Tonle Sap ecosystem.

5.2. Hydrological connectivity of the CFR system to the ecosystems

The six CFRs collectively sit within the same watershed system that links the Prey Veng floodplain (Boeng Sneh Lake) with the MR and the Santuk wetland–irrigation system (Boeng Ream and Sbov Ambaeng) with the Tonle Sap floodplain.

5.2.1. The hydrological connectivity of the CFRs in Boeng Sneh Lake

Prey Veng CFRs (Sangke Chrum, Ang O'Ktom, Boeng Loeu) drain into and draw water from interconnected rice-field canals, tributary channels, and river-fed irrigation systems, all of which eventually flow toward the Boeng Sneh Lake basin in the lower floodplain. Boeng Loeu's two water gates and river connection explicitly tie it to downstream lakes.

The hydrological connectivity of CFRs with the Boeng Sneh Lake system reflects a highly integrated landscape where lake water, irrigation flows, rice-field drainage, wet-season flood pulses, and dry-season water extraction interact continuously throughout the year. The data from the CFRs in Prey Veng—including O'Ktom, Boeng Leu, and Sangke Chrum—demonstrate that these water bodies form part of a single hydrological and ecological network supporting fisheries, rice farming, and household water use.

(a) Wet-Season connectivity: Flood pulses, river inflows, and rice-field exchange

During the wet season, water levels in Boeng Sneh Lake and its surrounding CFRs rise substantially, enabling horizontal water expansion into rice fields and connecting channels. For example, Boeng Loeu CFR expands to 36 ha during the wet season, receiving water directly from the MR through two functioning water gates, as well as inflows from Andoung Village's irrigation network that channels river water into the CFR pond. This ensures stable water levels and continuous exchange between lakes, channels, and rice fields.

Similarly, O'Ktom CFR receives rainwater, rice-field inflows, and tributary-channel flows that connect it to surrounding agricultural land. These inflows link O'Ktom hydrologically to the Boeng Sneh landscape, as water moves from rainfall into fields, through the CFR, and outward to the Boeng Sneh Lake through connected canals during the rainy season. Also, Sangke Chrum CFR, supported originally by JICA canal construction, is also connected through man-made channels with the Boeng Sneh Lake that bring wet season flows in and out of the system, integrating it into the broader seasonal floodplain dynamics of the area.

Wet-season flooding also facilitates fish migration from Boeng Sneh Lake to the rice fields and then the CFR, with households reporting abundant fish movement in and out of CFR areas and surrounding rice fields, a process similar to the ecological spillover seen in connected lake–CFR corridors. In the dry season, fish seeks refuge in the CFRs for the rest of the year.

(b) Dry-season connectivity: Water storage, pumping, and irrigation extraction

In the dry season, hydrological connectivity shifts from natural inflow toward water retention, human extraction, and groundwater recharge. Boeng Loeu CFR retains at least 2 metres of water, making it a key dry-season water source for the surrounding communities' rice production and domestic use. Farmers draw water from Boeng Loeu for two to three rice cycles, supported by the river–CFR–irrigation linkage, while the CFR remains sufficiently deep to maintain fish refugia.

O'Ktom CFR also acts as a dry-season reservoir, but here connectivity creates tension between irrigation demand and fishery conservation. Farmers pump water from the CFR to irrigate rice, resulting in water shortages and biodiversity loss when extraction exceeds natural inflows, highlighting a hydrological imbalance within the Boeng Sneh linkages during the dry season.

Sangke Chrum CFR maintains dry-season water levels through irrigation canals connected to the wider Boeng Sneh Lake system, enabling farmers to irrigate rice fields while the CFR remains a functional refuge at depths of around 1.5 metres. Water exchange between rice fields and the CFR continues even in the dry season, affirming strong two-way flows between human-modified and natural components of the landscape.

(c) Rice fields as hydrological connectors

Across all CFRs around Boeng Sneh Lake in Prey Veng, rice fields serve as intermediate hydrological zones, carrying water into CFRs during rainfall and receiving water from CFRs during the dry season via irrigation. Boeng Loeu farmers explicitly report using the CFR waters for three rice crops per year, demonstrating how irrigation flows bind the CFR directly to the agricultural calendar and water demand cycles of the surrounding landscape. The inflow and outflow between fields and CFRs create a mosaic of micro-watersheds, through which water, sediments, nutrients, and fish larvae circulate, forming a dynamic system that sustains both fisheries and crop productivity.

The rice fields around Ang O'Ktom CFR act as seasonal hydrological connectors, linking floodwaters, nutrients, and aquatic organisms across the floodplain landscape. Covering approximately 133.5 ha, these rice fields are inundated during the wet season when floodwaters spread laterally across the low-lying terrain. During this period, rice paddies temporarily connect Ang O'Ktom to surrounding wetlands and channels, allowing water, sediments, organic matter, and fish to move freely across the landscape. Although Ang O'Ktom does not retain water in the dry season, the rice fields play a critical intermediary role during floods by facilitating fish migration, spawning, and feeding within flooded paddies. As floodwaters recede, these fields channel water and nutrients back toward larger water bodies, contributing to soil fertility and downstream productivity. In this way, rice fields around Ang O'Ktom function less as water-storage or irrigation assets and more as transient conduits that sustain flood-pulse connectivity, ecological exchange, and short-term fisheries productivity. Their hydrological role is therefore essential to maintaining landscape-level ecological processes, even in the absence of permanent refuge or dry-season irrigation capacity.

The rice fields surrounding Sangke Chrum CFR function as seasonal hydrological corridors that connect Boeng Sneh Lake, the CFR, and the broader floodplain landscape. During the wet season, rising water levels from Boeng Sneh Lake spread laterally across the floodplain and enter surrounding rice fields through natural channels and irrigation–drainage networks. These inundated rice fields temporarily become part of the aquatic system, enabling the movement of water, sediments, nutrients, and fish between the lake and Sangke Chrum CFR. Through this process, rice fields act as transitional habitats and conduits for fish migration, spawning, and feeding. Fish move from the lake into flooded paddies and the CFR during peak flooding, while nutrient-rich waters enhance soil fertility and support rice production. As floodwaters recede, the rice fields facilitate the gradual return of water and organic matter back toward Boeng Sneh Lake, maintaining downstream ecological productivity. Although these rice fields do not provide permanent water storage in the dry season, their role as hydrological connectors during the flood period is essential for sustaining flood-pulse dynamics, fisheries productivity, and integrated rice–fish systems within the Sangke Chrum landscape.

(d) Irrigation systems as structural connectors to Boeng Sneh Lake

All three CFRs in Prey Veng are connected to irrigation systems that either discharge water into the CFRs, extract water from the CFRs, or do both, depending on the season and farming demand. Sangke Chrum CFR occupies a strategic position within the Boeng Sneh floodplain

system, serving as a nodal connector between permanent lake waters, seasonal floodplains, and surrounding rice fields. During the rainy season, rising water levels in Boeng Sneh Lake inundate adjacent floodplains and flow through natural channels and irrigation–drainage networks into Sangke Chrum CFR. This process expands the refuge from a small dry-season core (about 0.64 ha) to more than 15 ha, re-establishing hydrological continuity across the landscape. As floodwaters spread into surrounding rice fields, Sangke Chrum facilitates the lateral exchange of water, sediments, nutrients, and fish, enabling rice paddies to function temporarily as aquatic habitats and migration pathways. Fish move from Boeng Sneh Lake into the CFR and adjacent rice fields for spawning and feeding, while nutrient-rich waters enhance soil fertility and crop productivity. During the dry season, although the CFR's irrigation role remains limited, the retained water body provides a residual hydrological link, slowing drainage, moderating water stress, and maintaining ecological connectivity until floodwaters return. In this way, Sangke Chrum CFR operates less as a storage reservoir and more as a seasonal conduit, sustaining flood-pulse connectivity between Boeng Sneh Lake and rice-field ecosystems and reinforcing the integrated functioning of fisheries and agriculture within the floodplain landscape.

Boeng Loeu's connection to the Andoung irrigation system is particularly significant in shaping its multifunctional role within the floodplain landscape. During periods of high water in the rainy season, the Andoung irrigation channels convey floodwaters from the wider lake–floodplain system into the Boeng Loeu CFR, replenishing water levels, expanding the refuge area, and sustaining aquatic habitats. In contrast, during the dry season, the same channels are used by farmers to extract water outward from the CFR to support rice cultivation in surrounding villages. This bidirectional and cyclical water flow embeds the CFR within a multi-village agricultural network, linking local irrigation practices directly to lake and river hydrology. As a result, Boeng Loeu functions simultaneously as a fish refuge, water buffer, and hydrological regulator within an integrated agro-ecological system.

Photo 5: The Boeng Sneh Lake ecological system

Source: Photo by authors, 3 October 2025.

Ang O'Ktom Community Fish Refuge (CFR) is directly connected to local irrigation and drainage channels, which function as bidirectional water pathways within the Boeng Sneh floodplain system. According to community accounts and field observations, the CFR receives water during the rainy season, when rainfall and floodwaters from the wider Boeng Sneh system flow through channels into the low-lying area, temporarily forming the refuge and supporting seasonal fish habitats. Conversely, during periods of lower water availability, farmers use the same channels to release or drain water outward, primarily to manage rice fields and prevent waterlogging. This dual function reinforces Ang O'Ktom's position within the Boeng Sneh hydrological continuum, where water movement is governed by seasonal rainfall rather than permanent storage, embedding the CFR within broader floodplain and agricultural water dynamics.

(e) The rice fields-CFR-lake system as a unified hydrological unit

Taken together, the evidence from the studied sites demonstrates that the CFRs surrounding Boeng Sneh Lake operate as an interdependent landscape-scale hydrological unit rather than as isolated water bodies. During the wet season, rising water levels in Boeng Sneh Lake spread laterally across the floodplain and enter CFRs and surrounding rice fields through a network of natural channels, drainage paths, and irrigation infrastructure. This process allows lake water to feed CFRs and rice fields simultaneously, expanding refuge areas, inundating agricultural land, and facilitating the transfer of sediments, organic matter, and nutrients across the system.

As floodwaters recede in the dry season, CFRs retain water to varying degrees, depending on their depth and connectivity. Perennial and semi-permanent CFRs function as local water stores, moderating dry-season water scarcity and sustaining aquatic habitats when surrounding rice fields and ephemeral wetlands dry out. At the same time, irrigation channels regulate bidirectional flows, enabling controlled release of water from CFRs to agricultural land or drainage back toward the lake, depending on rainfall and farming needs. Rice fields themselves act as active hydrological interfaces, serving alternately as inflow zones during flooding and as outflow pathways during recession periods.

Within this connected system, fish migrate seasonally between the lake, CFRs, floodplains, and rice fields, using channels and inundated paddies as corridors for spawning, feeding, and refuge. These movements underpin fisheries productivity and nutrient redistribution across the landscape. Consequently, the CFR network constitutes a landscape-scale water governance system, where water, fish, sediments, nutrients, and human water use are continuously circulated within a shared hydrological network directly anchored to Boeng Sneh Lake.

In the Boeng Sneh Lake, FWUCs are central institutions responsible for managing irrigation water distribution to rice fields, particularly during the dry season. FWUCs operate irrigation canals and pumping schedules following approvals from the Provincial Department of Water Resources and Meteorology (PDWRAM), which controls the opening of main canal gates and authorises seasonal water releases. Through this hierarchy, FWUCs play a decisive role in determining how much water is diverted to agriculture and how much remains within connected wetlands, canals, and CFRs.

Conflicts between FWUCs and CFRs arise primarily during the dry season, when water availability is limited and competing livelihood needs intensify. FWUC members prioritise water extraction to sustain dry-season rice production, often pumping water from canals, irrigation ponds, and, in some cases, directly from CFRs. CFR committees, by contrast, seek to maintain minimum water levels to protect fish refugia, broodstock survival, and biodiversity. These

tensions are compounded by a dual governance and enforcement structure. Under irrigation governance, pumping irrigation ponds to dryness typically carries no legal sanction. However, under the fisheries law enforced by the FiAC, pumping a CFR dry is illegal and can result in arrest. As a result, farmers perceive an imbalance in enforcement, while CFR committees view unchecked irrigation pumping as a direct threat to fish habitats. The conflict is further internalised because many villagers hold dual institutional identities, serving simultaneously as FWUC members and CFR committee members.

Despite persistent tensions, the documents show that conflicts are managed rather than eliminated through a combination of technical, institutional, and negotiated governance mechanisms. First, physical and technical measures have been introduced. In some CFRs, designated sections have been deepened and protected as permanent fish refuge pools. Communities agreed that water retained in these deepened zones would be reserved exclusively for fish, regardless of irrigation demand, while abstraction could occur from non-protected sections or through regulated outlets. Second, institutional coordination mechanisms play a key role. Conflicts are increasingly addressed through the DTWG, where FWUCs, CFR committees, commune councils, FiAC, and PDWRAM representatives jointly negotiate dry-season water use. DTWGs provide a forum to align irrigation schedules with ecological water requirements and to clarify acceptable pumping thresholds. Third, local mediation and negotiated compliance are critical. Commune councils facilitate dialogue between FWUCs and CFR committees, encouraging graduated responses—warnings, negotiated reductions in pumping, and temporary restrictions—before formal enforcement is applied. This approach recognises overlapping livelihoods and prioritises social cohesion over punitive action.

These arrangements have reduced the intensity and frequency of conflicts, though they have not eliminated them entirely. The Boeng Sneh experience demonstrates that water conflicts between FWUCs and CFRs cannot be resolved solely through sectoral authority. Instead, they require integrated governance, treating irrigation and fisheries as interdependent components of a shared hydrological system. By combining engineering solutions, negotiated rules, and cross-sector coordination, the Boeng Sneh system illustrates a pragmatic pathway to balance rice production and fisheries conservation during water-scarce dry seasons.

5.2.2. The hydrological connectivity of the CFRs in the Boeng Ream

The CFR Systems in Santuk District, in Kampong Thom (Boeng Ream, Sbov Ambaeng, Boeng Banteay) form part of an upper-watershed network connected through irrigation canals, the Stung Slab River and Stung Sen River systems. The Stung Slab River discharges toward lower floodplain systems of the TSL, contributing to flows that ultimately move downstream into the Tonle Sap floodplain, of which Boeng Ream is a part.

The CFRs in Santuk District—particularly Boeng Ream and Sbov Ambaeng—form part of an interconnected hydrological network that links the Kakoh's irrigation systems, rice fields, floodplains, river systems, and natural resources through seasonal water flows. These systems operate within the broader governance and ecological landscape shaped by PDWRAM, FWUCs, commune councils, District authorities, and FiAC, who jointly coordinate water–agriculture–fishery management in Kakoh and Taing Krasaing communes.

Photo 6: The hydrological connectivity of Boeng Ream and the surrounding rice fields

Source: Photo by authors, 8 October 2025.

(a) Wet-season hydrological connectivity

During the wet season, Boeng Ream, Sbov Ambaeng, and Boeng Banteay CFRs undergo substantial spatial and hydrological expansion, becoming fully integrated into the surrounding floodplain landscape. Boeng Ream CFR, for instance, expands from approximately 2 ha in the dry season to about 12 ha in the wet season, as rising floodwaters from the wider floodplain and irrigation network inundate adjacent low-lying areas. This expansion reconnects the CFR with surrounding rice fields, irrigation canals, and natural floodplain depressions, transforming previously fragmented habitats into a continuous aquatic system. As water spreads outward, fish are able to migrate from the CFR into flooded rice fields and canals, using these areas as feeding and nursery grounds during peak inundation.

The wet-season transformation is even more pronounced in Boeng Banteay CFR, which becomes entirely submerged during periods of high water. Seasonal flooding converts the area into an extensive aquatic landscape where rice fields, canal networks, and the wider Taing Krasaing floodplain merge into a single hydrological unit. In this state, water circulates freely through canals and natural channels, while entire blocks of land shift from terrestrial to aquatic habitats. According to observations from the District Office of Agriculture, this period of high water creates widespread hydrological connectivity, enabling fish to move from rivers and floodplains into CFRs and onward into agricultural landscapes. This seasonal connectivity underpins fish spawning, dispersal, and productivity, illustrating how wet season flooding temporarily dissolves boundaries between lakes, CFRs, floodplains, and rice fields into a single, interconnected system.

During the wet season, Sbov Ambaeng Community Fish Refuge (CFR) plays a more stabilising and anchoring role in the floodplain hydrological system compared with highly expanding CFRs such as Boeng Banteay or Boeng Ream. Evidence from the attached documents shows that Sbov Ambaeng experiences only limited surface expansion in the wet season: its area remains at around 0.5 ha, while water depth increases modestly from about 4 m in the dry

season to around 5 m in the wet season. This indicates that Sbov Ambaeng functions as a semi-permanent or perennial waterbody, rather than a flood-driven expansive refuge. Hydrologically, Sbov Ambaeng does not rely primarily on lateral floodplain inundation. Instead, its wet-season dynamics are shaped by controlled inflows from the TKIS, which stabilise water levels even as surrounding rice fields and floodplains are inundated. While adjacent landscapes shift from terrestrial to aquatic habitats during peak rainfall, Sbov Ambaeng remains a deep, continuous refuge, providing a reliable core habitat for fish. Ecologically, this makes Sbov Ambaeng particularly important in the wet season as a broodstock reservoir and refuge of last resort, anchoring fish populations while enabling seasonal migration outward into flooded rice fields and canals. Its role is therefore less about spatial expansion and more about hydrological stability, depth, and continuity, complementing more dynamic floodplain CFRs within the broader landscape system.

(b) River and irrigation system inflows

The Boeng Ream and Sbov Ambaeng CFRs are part of an integrated river–irrigation–CFR network in the Kakoh irrigation system, which is situated in the downstream of the TKIS. Water from the TKIS, the Stung Slab River, and the Stung Sen River is redistributed across the district depending on seasonal flows. In earlier years, TKIS water was discharged into the Stung Slab River and flowed toward the Tonle Sap; currently, the Stung Slab River gate is closed, ensuring more water remains available for Boeng Ream and the surrounding commune areas. The Kampong Thom provincial canal-digging project now diverts water from the Stung Sen River into the Stung Slab River, increasing water availability before it reaches the Tonle Sap. This enhances hydrological stability for Boeng Ream and other CFRs. Thus, wet-season water flows form an upper–middle basin connectivity system, linking river systems to CFR bodies and irrigated agricultural landscapes.

Boeng Banteay Community Fish Refuge (CFR) is primarily supplied by seasonal river–floodplain inflows, with secondary contributions from irrigation and drainage channels linked to the Taing Krasaing floodplain system. Unlike perennial CFRs that rely on controlled canal inputs to stabilise water levels, Boeng Banteay's hydrology is dominated by wet-season river rises and rainfall-driven surface flows. During the monsoon, rising water from the wider floodplain spreads laterally into the CFR through natural depressions, field drains, and canal connections, rapidly expanding the refuge from a small dry-season core (≈0.7 ha) to a broad inundated area (≈32 ha). Irrigation channels connected to surrounding rice fields function mainly as conveyance pathways rather than storage feeders. In the wet season, these channels allow floodwater to move into the CFR alongside overbank flows, reinforcing connectivity among rice fields, canals, and floodplain wetlands. In the dry season, however, inflows from irrigation infrastructure are minimal; water levels in Boeng Banteay decline sharply as floodwaters recede and evaporation increases. Consequently, the CFR does not act as a dry-season irrigation reservoir. Instead, its inflow regime supports a flood-pulse refuge model—maximising wet-season connectivity, fish migration, and spawning—while remaining highly dependent on river and rainfall dynamics rather than controlled irrigation supply.

(c) Dry-season hydrological connectivity

During the dry season, Boeng Ream CFR retreats to a core area of about 2 ha, while Boeng Banteay contracts to only its permanent CFR body, with surrounding rice fields drying out completely. In both sites, irrigation canals remain connected, and farmers extract water from the CFRs to support dry-season rice cultivation. This situation has repeatedly generated tensions between the FWUC members, who prioritise irrigation supply, and the CFR committees,

which are responsible for maintaining minimum water levels for fish survival. These conflicts are intensified by the fact that many villagers hold dual institutional identities, simultaneously belonging to FWUCs and CFR committees, blurring sectoral boundaries and accountability.

To manage these competing demands, communities—facilitated by commune councils, the FiAC, and district technical offices—agreed on a physical modification and governance compromise. Parts of the CFRs, particularly in Boeng Ream, were deepened to create a permanent refuge pool, and a water-level control system was introduced to maintain a minimum depth of around one metre even during peak irrigation extraction. Crucially, it was collectively agreed that water retained in the deepened section would be strictly reserved for fish, regardless of dry-season irrigation demand. Pumping from this protected zone is prohibited, while abstraction is allowed only from non-protected sections or through regulated outlets.

This arrangement has not eliminated tension entirely, but it has significantly reduced conflict by clearly separating fish refuge water from irrigation water and aligning the physical design with institutional rules. The solution demonstrates how engineering measures combined with negotiated governance rules can reconcile overlapping livelihood needs within CFR–irrigation systems, especially where communities depend on both fisheries and rice farming for dry-season survival.

Dry-season water management is heavily regulated through FWUC operations, which need PDWRAM approval to open main canal gates. The commune and district authorities, along with local communities, request that PDWRAM release irrigation water to farmers during the dry season. PDWRAM then informs FWUCs to manage distribution. This hierarchical structure dictates how much water remains in CFRs, how much is released for rice production, and how much is conserved for fish habitat. Because fish are "not part of irrigation," farmers sometimes pump excessively, reducing fish refugia. As PDWRAM noted, pumping from irrigation ponds to dryness does not lead to any arrests of farmers. However, pumping from CFRs to dryness results in farmers being arrested under fishery laws. This dual governance structure produces competing enforcement regimes. All CFRs have canals "in and out" that move water and fish between them, rice fields, and main rivers.

Dry-season water management is currently governed by a hierarchical irrigation structure: irrigation releases require approval from the PDWRAM, which then instructs FWUCs to distribute the water. Fisheries management, by contrast, is regulated under the FiA and enforced through CFR rules. To resolve conflict, joint dry-season water allocation protocols should be formally established, requiring PDWRAM, FWUCs, FiAC, and CFR committees to co-approve dry-season water levels. This would ensure that minimum ecological water levels for CFRs are embedded within irrigation release decisions, rather than treated as secondary concerns. The DTWG was established to improve the coordination at the district level to address the water conflicts between farming and fishing. Because many villagers are members of both FWUCs and CFR committees, conflicts are often internalised within communities.

d) Hydrological connectivity to land, natural resources, and production systems

Evidence from the study sites shows that rice fields, CFRs, irrigation systems, and natural habitats form an integrated hydrological continuum, in which water movement simultaneously shapes agricultural production, fisheries, and ecological processes. Rice fields play a dual hydrological role within this system. During the dry season, they function primarily as water recipients, receiving pumped irrigation water drawn from CFRs, canals, and connected water bodies to support rice cultivation. During the wet season, the same rice fields become

hydrological conduits, allowing floodwaters, fish, sediments, and nutrients to move freely across the landscape.

In Boeng Ream and Sbov Ambaeng CFRs, this bidirectional connectivity is particularly evident. Water is supplied to rice fields through irrigation canals during dry months, while runoff, drainage, and canal return flows transport water and nutrients back into the CFRs. This cyclical exchange creates a nutrient-enriched agroecosystem in which sediments and organic matter from cultivated land enhance aquatic productivity, and CFR water supports crop production. The result is a tightly coupled rice–fish system that benefits both agriculture and fisheries.

In contrast, Boeng Banteay CFR operates through a more seasonal floodplain dynamic. During the wet season, widespread inundation transforms rice fields into temporary aquatic habitats, reconnecting them hydrologically and ecologically with the CFR and the surrounding floodplain. Fish migrate into flooded fields for spawning and feeding, while nutrient-rich floodwaters replenish soils. In the dry season, pumping rapidly desiccates rice fields, severing hydrological connections and resetting the cycle for the next monsoon.

Across all sites, flooded forests within CFRs, canal vegetation, soil fertility, and fish habitats are governed by the same water flows. Flooded forests planted inside CFRs provide shelter for fish, reduce wave action, and help stabilise water levels. Seasonal flooding replenishes soil fertility on surrounding farmland, while hydrological connectivity supports the movement of biodiversity across agricultural and natural landscapes. Together, these processes demonstrate that CFRs are embedded within landscape-scale production and ecological systems, not isolated conservation sites, and their effectiveness depends on maintaining functional hydrological connectivity across land, water, and livelihoods.

5.3. Ecological connectivity through fish migration

5.3.1. The ecological connectivity of the Boeng Ream CFR systems

TKIS canals feed and redistribute water across Kakoh and Taing Krasaing communes, tying irrigation operations to CFR hydrology. After TKIS reservoir repairs in 2025, gate operations now retain and route more water toward areas around Boeng Ream and Sbov Ambaeng CFRs, stabilising dry-season levels and reducing conflict over water use; DTWG, PDWRAM, FWUCs, and communes coordinate these releases. The CFRs themselves have in- and outflow canals for water control and fish movement, making the irrigation grid a corridor that sustains aquatic refuge during the dry months and expands access in the wet months.

During the wet season, Boeng Ream (2 ha dry / ~12 ha wet), Boeng Sbov Ambaeng and Boeng Banteay become inundated with surrounding rice fields, allowing juvenile fish to disperse onto the floodplain agro-ecosystem; in the dry season, fields drain back and fish retreat to deeper CFR pools, while farmers often pump from CFRs for irrigation—pressuring refuge depth unless managed. Water connects "irrigation–rice field–CFR" as a single ecological unit, with fish present in canals and paddies as much as in the refuge body—an explicit governance focus of the DTWG in Santuk.

All three CFRs are embedded in a larger river–floodplain network. In the wet season, fish migrate from river systems and floodplains into CFR areas via connected canals; in the dry season, some migrate back to rivers while a significant share seek refuge within the CFR pools until floods return. This cyclical pathway underpins stock replenishment in rice landscapes and the refugees themselves. DTWG and commune testimonies also report greater fish abundance

in 2025, consistent with effective seasonal protection and improved water conditions. CFR committees and local authorities deploy samras/brush parks, release fingerlings, and plant flooded forests within CFRs—actions that create structural habitat, shade, and food for broodstock, improving recruitment and survivorship that later spill over into fields and canals. These interventions are coordinated with district and provincial agencies (FiAC, PDWRAM, PDAFF) and FWUCs under the DTWG umbrella.

For Boeng Ream, a water-level control system and local rule to maintain ≥1 m water depth in the dry season protects fish refugia and broodstock while still allowing some irrigation; where pumping threatens to dewater pools, the commune and CFR committee intervene. Damaged and old control structures, such as water gates, shallow canals and damaged canals at Boeng Ream and Boeng Banteay, need maintenance—critical for sustaining dry-season ecological function.

CFR ecological performance is shaped by surrounding natural resource management. Pesticide and fertiliser runoff from rice fields, opportunistic dry-season pumping, and illegal fishing can erode the connectivity benefits of the CFR systems with rivers and floodplains. Communes, DTWG, and CFR committees respond through patrols, awareness-raising and integrating CFR actions into commune investment/management plans to fund posts, markers, and access controls that safeguard the refuges' ecological role.

The ecology of Boeng Ream, Sbov Ambaeng, and Boeng Banteay is not confined to their ponds; it is produced by seasonal exchanges with TKIS canals, rice paddies, and river–Tonle Sap floodplain corridors. When gates and refuge depths are managed, and habitat interventions are maintained, the CFRs function as dry-season lifeboats and wet-season sources, sustaining fisheries across the district's working landscape while supporting irrigation and farming goals.

5.3.2. Ecological connectivity of the Boeng Sneh CFR system

The CFRs surrounding Boeng Sneh Lake—including Boeng Loeu, Ang O'Ktom, and Sangke Chrum—form an ecologically interconnected landscape linking irrigation systems, rice fields, river-fed channels, floodplains, fish migration routes, biodiversity habitats, and local natural resources. This landscape functions as an integrated ecological system whose productivity depends on the seasonal rhythms of water, fish, and farming activity.

Across all CFRs around Boeng Sneh Lake, irrigation systems act as ecological corridors that shape water levels, fish movement, and habitat conditions. Boeng Loeu CFR is directly connected to the MR system and receives water through two water gates, with additional inflow from the Andoung Village irrigation system. This steady supply maintains deep water and supports both fish refugia and year-round rice farming. Ang O'Ktom CFR is linked to tributary channels and rice-field drainage, forming part of the local irrigation mosaic. When farmers pump from the CFR during the dry season, biodiversity declines—showing how irrigation practices directly affect ecological integrity. Sangke Chrum CFR receives water via JICA-built irrigation canals, creating stable inflows that prevent the CFR from drying and allow ecological continuity even in the dry season. Thus, irrigation systems around Boeng Sneh do more than supply water—they define habitat depth, water exchanges, nutrient circulation, and fish refuge capacity.

Rice fields surrounding the CFRs serve as critical ecological linkages, functioning as temporary wetlands during the rainy season and as hydrological return channels during the dry season. In Boeng Loeu, rice farmers use CFR water for three cropping cycles per year, indicating continuous water exchange between CFR and rice fields. Wet season flooding transforms

rice fields into shallow fish nurseries, allowing fry and juvenile fish to disperse outward from the CFRs. During dry months, rice fields drain back into CFRs through canals and natural depressions, returning nutrients and sediments while channelling fish back into the deeper refuge pools. Rice fields, therefore, operate as bi-directional ecological filters, transferring fish, organic matter, and agricultural runoff between the CFR and the broader Boeng Sneh basin.

The CFRs around Boeng Sneh Lake support a seasonal fish migration system shaped by water levels, river connections, and floodplain hydrology. Inflows from the river adjacent to Boeng Leu bring larval and adult fish into the CFR during the wet season. As water spreads across fields and channels, fish migrate from CFRs into rice paddies, feeding, breeding, spawning and growing before returning to the CFR as water retracts. In Ang O'Ktom, fish populations decrease sharply when water pumping lowers water levels—showing that the ecological connectivity relies heavily on maintaining adequate refuge depth. Fish migration, therefore, connects rivers, CFRs, rice fields, and local canals into a single ecological production system.

Although Boeng Sneh Lake is not directly part of the Tonle Sap system, its hydrology mirrors Tonle Sap's floodplain ecology, where water rises, spreads, and retreats seasonally. Boeng Leu is directly linked to a river, which brings water and fish species that would not otherwise be present. This connection also stabilises water levels and supports high biodiversity. Floodplain processes—rainfall, sheet-flow from fields, and canal inflows—connect Ang O'Ktom and Sangke Chrum CFRs to the wider Boeng Sneh ecosystem through shared water and sediment flows. These linkages create a patchwork floodplain ecology that integrates rivers, ponds, fields, and natural depressions.

The ecological health of CFRs around Boeng Sneh is closely tied to local natural resource conditions. Tree planting, flooded-forest growth, and brush-park deployment inside CFRs create diverse habitats for broodstock, enhancing fish recruitment and species richness. Water quality and biodiversity decline in Ang O'Ktom when farmers pump the lake heavily for irrigation—demonstrating how natural resources (fish, aquatic vegetation, soils) are affected by water extraction. Across all CFRs, biodiversity benefits spill over into rice fields, supporting local subsistence fishing and contributing to household nutrition. These features show that CFRs act as biodiversity reservoirs, stabilising ecological productivity across the entire Boeng Sneh agricultural landscape.

5.4. Governance connectivity through DTWGs, FiACs, PDWRAM, and commune councils

5.4.1. Governance connectivity of the CFR through DTWGs in the Boeng Sneh landscape

The governance of CFRs in the Boeng Sneh Lake system is not exercised by a single authority but rather emerges from a multi-layered, interconnected governance network that links district, provincial, and community institutions. This governance connectivity is essential because CFRs simultaneously function as fish refuges, hydrological nodes, and agricultural water sources, placing them at the intersection of fisheries, irrigation, and local development planning.

At the district level, DTWGs play a central coordinating role. DTWGs provide a platform where representatives from fisheries, water resources, agriculture, commune administrations, and community institutions jointly discuss seasonal water management, CFR protection, and irrigation demands. In the Boeng Sneh landscape, DTWGs help align decisions related to dry-season water allocation, flood management, and enforcement priorities, reducing sectoral fragmentation and facilitating negotiation when conflicts arise between irrigation users and fish conservation objectives.

The FiAC serves as the primary technical authority for fisheries management at the provincial level. FiAC provides formal recognition of CFRs, supports the establishment and training of CFR committees, and enforces fisheries regulations within refuge boundaries. In the Boeng Sneh system, FiAC plays a critical role in mediating conflicts when irrigation abstraction threatens fish refugia, particularly during the dry season. Its authority to enforce fisheries law—such as penalising pumping that dewaters CFRs—gives institutional weight to conservation rules agreed at community and district levels.

In parallel, the PDWRAM governs irrigation infrastructure and water allocation. PDWRAM authorises the opening of main canal gates and determines the timing and volume of dry-season water releases. Commune and district authorities, together with local communities, formally request PDWRAM to release irrigation water, after which FWUCs manage distribution at the scheme level. This hierarchy directly shapes how much water remains in CFRs, how much is diverted to rice fields, and how water flows through the "in-and-out" canals linking CFRs, rice fields, and Boeng Sneh Lake.

At the local level, commune councils act as institutional bridges between state agencies and communities. They facilitate the formation of CFR committees, endorse local rules, convene consultations, and mediate disputes among users. Commune councils are particularly important in the Boeng Sneh landscape because many villagers hold *dual institutional roles*—as members of both FWUCs and CFR committees—requiring locally negotiated solutions rather than purely sectoral enforcement.

Together, these institutions form a connected governance architecture in which authority, responsibility, and enforcement are distributed across scales. While this arrangement can generate tensions—especially where irrigation and fisheries laws overlap—it also enables adaptive and negotiated governance. The Boeng Sneh CFR system, therefore, operates not as isolated community ponds but as part of a landscape-level governance system, where hydrological connectivity is matched by institutional connectivity linking water, fisheries, agriculture, and local government.

In the Boeng Sneh Lake landscape of Prey Veng, CFR committees play a critical role within the DTWG by representing fisheries and community perspectives in district-level coordination and decision-making. Their participation ensures that CFRs are not treated as isolated conservation sites but as integral components of district food system, water, and land governance. Within the DTWG, CFR committees act primarily as community representatives and technical informants. They provide first-hand information on seasonal water levels, fish migration patterns, dry-season refuge conditions, and emerging conflicts related to irrigation abstraction and fishing pressure. This local knowledge informs DTWG discussions on dry-season water allocation, irrigation scheduling, canal operation, and enforcement priorities, particularly in areas hydrologically connected to Boeng Sneh Lake.

CFR committees also function as bridging institutions within the DTWG framework. Many committee members simultaneously belong to FWUCs, enabling them to translate and reconcile the sometimes-competing objectives of fisheries protection and rice production. Through the DTWG, CFR representatives participate in negotiations with irrigation authorities and agricultural officers to safeguard minimum water levels in CFRs during the dry season while accommodating irrigation needs. This role is particularly important in Prey Veng, where irrigation decisions strongly influence whether CFRs retain water or are dewatered.

In addition, CFR committees contribute to the implementation and follow-up functions of the DTWG. After district-level agreements are reached—such as seasonal water-use rules, patrol coordination, or habitat protection measures—CFR committees are responsible for communicating decisions back to villages, mobilising members for compliance, and monitoring outcomes on the ground. They report violations, ecological changes, and community concerns back to the DTWG through commune councils and technical agencies, creating a feedback loop between local practice and district planning.

Overall, the involvement of CFR committees in the DTWG strengthens vertical and horizontal governance connectivity in the Boeng Sneh system. By embedding community-based fisheries institutions within district coordination mechanisms, the DTWG enables CFRs to actively contribute to integrated, decentralised food system governance, balancing fisheries conservation, irrigation management, and agricultural livelihoods at the landscape scale.

Table 16: Actors involved in building the governance connectivity through CFR

Governance body	Key roles	Ecological effect
DTWG	Multi-sector coordination	Aligns irrigation, rice farming, and fisheries
FiAC	CFR recognition, fish releases, enforcement	Sustains fish populations and habitats
PDWRAM	Water gate control, irrigation distribution	Determines water levels and refuge integrity
Commune councils	Local enforcement, planning, conflict mediation	Ensures community compliance and support
CFR committees	Daily management and ecological stewardship	Protect CFR ecosystems and maintain biodiversity

Source: Field data compilation, 2025

The CFR system in Boeng Sneh Lake is governed through a multi-level, institutionally interconnected framework that links national technical agencies (FiAC, PDWRAM), local administrative institutions (commune councils), and community mechanisms (CFR committees) through coordination platforms such as DTWGs.

This governance connectivity is not administrative—it is ecological: it determines where water flows, how fish migrate, how deep refuge pools remain, how rice fields receive water, and how community resources are protected. Boeng Sneh's governance connectivity therefore forms the institutional backbone that sustains the lake's ecological productivity, fisheries, rice-field biodiversity, and community livelihoods.

5.3.2. Governance connectivity of the CFR system in Kakoh Commune through DTWGs, FiACs, PDWRAM, and commune councils

According to documents from the 2025 KIIs and PDWRAM interviews, the governance of the Boeng Ream and Sbov Ambaeng CFRs in Kakoh Commune is shaped by a *deeply interconnected*, multi-level governance system involving DTWG-Santuk, FiAC, PDWRAM, commune councils, district authorities, and CFR committees. This system operates as a cross-sectoral network linking water management, fisheries conservation, agricultural production, and local administration.

DTWGs as the central coordination mechanism: DTWG-Santuk functions as the primary integrative platform, bringing together commune councils, FiAC, PDWRAM, PDAFF, district administration, FWUCs, and CFR committees. DTWG applies an ecosystem governance model that unifies irrigation, rice fields, CFRs, and FWUC structures into a single management system.

The PDWRAM interview confirms that DTWG members "cooperate well between commune administration, NGOs, CFRs, and FWUCs," particularly in habitat restoration (samras deployment), fish releases, and flooded forest planting.

DTWG also coordinates irrigation rehabilitation, such as the repair of 4 km of canals in Kakoh Commune, funded jointly by FWUCs and PDWRAM. Through DTWG, sectoral agencies align their mandates to ensure that water distribution, fisheries protection, and rice cultivation do not undermine one another.

FiAC as technical authority and legitimiser of CFR governance: FiAC Kampong Thom plays a pivotal role in establishing, recognising, and technically guiding CFRs. FiAC worked with WorldFish to establish Boeng Ream (2021) and Sbov Ambaeng (2016) and create their CFR committees and management plans. FiAC conducts fish releases, leading to increased fish abundance reported in 2025. FiAC recognises the CFR committees and participates in district-level coordination through DTWG. As the fisheries "father" institution, FiAC provides enforcement authority and technical legitimacy, complementing PDWRAM's mandate over water. FiAC, therefore, anchors CFR governance within Cambodia's national fisheries management structure while aligning with local administrative systems.

PDWRAM is responsible for water governance and hydrological regulation. PDWRAM manages the TKIS, water gates, and broader irrigation flows that affect CFR integrity. According to PDWRAM officials:

- FWUCs must request PDWRAM to open main irrigation gates; secondary canals require notification.
- Commune and district authorities request water on behalf of farmers, and PDWRAM instructs FWUCs accordingly.
- Water shortages in 2023–24 and recovery in 2025 directly shaped fish and rice outcomes in Kakoh Commune.

Most importantly, PDWRAM explicitly states that the governance of water–agriculture–fisheries in Kakoh Commune is coordinated through the DTWG, which brings together irrigation systems, rice fields, CFRs, and FWUCs into a single ecological governance system. PDWRAM provides the hydrological authority that determines water levels in Boeng Ream and Sbov Ambaeng, directly affecting fish migration, dry-season refuge conditions, and agricultural water access.

Commune councils as local governance backbone and mediators: Commune councils in Kakoh Commune provide the local administrative interface between communities and provincial agencies.

- They work closely with CFR committees on patrolling, conflict resolution, water pumping control, and integrating CFR plans into commune development processes.

- Commune councils help manage community contributions, oversee the maintenance of physical infrastructure (posts, water markers, boundary lines), and coordinate with FiAC and PDWRAM on enforcement and water disputes.
- They support multi-sectoral work but lack direct technical mandates, requiring collaboration with FiAC and PDWRAM to protect community interests.

Commune councils act as the administrative bridge, ensuring that technical policies translate into community-level action.

CFR committees as local stewards and implementers: CFR committees for Boeng Ream and Sbov Ambaeng are the frontline managers of the CFR system:

- They conduct daily/weekly patrolling, manage boundaries, prevent dry-season pumping, and maintain a minimum 1-metre water level in Boeng Ream during dry periods.
- They coordinate community-based habitat management, fish releases, and rehabilitation activities.
- Members are simultaneously FWUC members, creating strong cross-institutional linkages between irrigation and fisheries governance.
- They struggle with limited funding after NGO support ended, showing the vulnerability of community-led resource management without financial backing.

CFR committees operationalise governance on the ground, linking ecological protection with community livelihood needs. Drawing from all documents, Kakoh Commune's CFR governance functions as a four-way connectivity system.

Table 17: The governance connectivity

Institution	Core mandate	Connectivity role
DTWG-Santuk	Multi-sectoral governance	Integrates irrigation–rice–CFR–FWUC systems; facilitates joint planning
FiAC	Fisheries management	Establishes CFRs, provides technical authority, supports monitoring and fish releases
PDWRAM	Irrigation & water governance	Controls hydrology, allocates water, mediates conflicts via DTWG
Commune councils	Local administration	Coordinates community actions, supports enforcement, links communities to higher agencies
CFR committees	Community resource stewards	Implement management plans, maintain water levels, patrol, coordinate with FWUC and Commune

Source: Field data compilation, 2025.

The governance connectivity of the CFR system in Kakoh Commune is not a simple hierarchy but a networked governance ecosystem. DTWGs integrate the mandates of FiAC, PDWRAM, commune councils, District authorities, and CFR committees to jointly manage fish, water, and rice systems. This interdependence ensures that fisheries governance aligns with irrigation control; water allocation supports ecological refuge needs; community-level institutions have administrative backing; and local and provincial agencies coordinate to reduce resource conflict. Together, these governance linkages create a resilient, multi-sectoral system that supports both ecological sustainability and local livelihoods in Kakoh Commune.

Based on the above discussion, the study constructs the Framework for CFR-Centred Integrated Water, Land, and Aquatic Food System Governance in which CFRs function as central socio-ecological nodes that integrate hydrology, irrigation infrastructure, rice-based agriculture, and inland fisheries. Rather than operating as isolated conservation ponds, CFRs are embedded within interconnected irrigation systems (TKIS and VIS), floodplains, rice fields, and river–lake systems and are governed through multi-level institutional arrangements involving communities and state agencies. The framework comprises six key elements of CFRs: connectivity; the roles of hydrology and water; CFRs as reservoirs connecting irrigation systems with rivers and lakes; CFRs in providing water for agriculture and fisheries; communities as dual users and FWUCs and CFRs; and multi-stakeholder and multi-level governance.

(a) Connectivity of TKIS, VIS, floodplains, and rice fields

The TKIS and VIS form the managed water-distribution backbone linking TSL, the MR, floodplains, CFRs, and rice fields. During the wet season, floodwaters from river–lake systems move laterally across floodplains and through irrigation canals, inundating CFRs and rice fields. During the dry season, the same canals convey water outward to support rice cultivation. Rice fields, therefore, operate both as water recipients (in the dry season) and as hydrological connectors (in the wet season), enabling water, fish, sediments, and nutrients to circulate across the landscape.

(b) Hydrology and water resources

Hydrologically, the system is governed by seasonal flood pulses and managed irrigation flows. Wet-season river and lake rises replenish CFRs and floodplains, expanding aquatic habitats and supporting fish migration and spawning. In the dry season, water availability is constrained and carefully regulated through irrigation gates, pumping, and canal operations. CFRs moderate this variability by retaining water to varying degrees, depending on depth and connectivity, thereby buffering ecological stress and supporting both fisheries and agriculture during low-water periods.

(c) CFRs as reservoirs connecting irrigation systems with rivers and lakes

CFRs act as intermediate reservoirs linking TKIS and VIS with the TSL and the MR. In high-water periods, CFRs receive inflows from irrigation canals and floodplains; in low-water periods, they either retain water for fish refuge or release limited volumes for agricultural use. This positioning allows CFRs to function as hydrological bridges, ensuring continuity between natural river–lake systems and managed irrigation infrastructure.

(d) CFRs in providing water for agriculture and fisheries

CFRs support dual food-system functions. For fisheries, they provide dry-season refugia, broodstock protection, and habitat stability. For agriculture, CFRs contribute indirectly to irrigation by storing and regulating water within TKIS and VIS networks, stabilising local water availability and supporting dry-season rice cultivation. Technical measures—such as deepened refuge pools and water-level control structures—allow parts of CFRs to be reserved for fish even when irrigation demand is high, aligning ecological protection with agricultural needs.

(e) Communities as dual users: FWUCs and CFRs

Local people are not separated into "farmers" and "fishers"; rather, many households are simultaneous members of FWUCs and CFR committees. Communities depend on both rice farming and fisheries for their livelihoods, using irrigation systems and CFRs in complementary

ways across seasons. This dual membership embeds integration at the social level but also generates tensions during dry-season water scarcity, when irrigation abstraction and fish refuge protection compete.

(f) Multi-stakeholder and multi-level governance

Integrated functioning of the system depends on polycentric governance, involving:

- Fisheries Administration Cantonment (FiAC) – fisheries regulation, CFR recognition, and enforcement
- Provincial Department of Water Resources and Meteorology (PDWRAM) – irrigation infrastructure and water allocation
- Farmer Water User Communities (FWUCs) – local irrigation distribution and pumping
- CFR committees – community-based fisheries stewardship and refuge management
- District Technical Working Groups (DTWGs) – cross-sector coordination and conflict negotiation
- Commune councils – local mediation and institutional bridging

Through these interacting institutions, decisions about water release, pumping, refuge protection, and enforcement are negotiated rather than imposed, reflecting the interconnected nature of water, land, and livelihoods.

This framework shows that CFRs are the institutional and hydrological pivot of an integrated system linking irrigation, rice fields, floodplains, and river–lake ecosystems. By anchoring governance at the interface of agriculture and fisheries, CFRs enable integrated water, land, and food system management, transforming potential conflicts into negotiated trade-offs. Sustaining this system requires recognising CFRs not as isolated conservation tools, but as central infrastructure for resilient, landscape-scale food system governance in the Mekong–Tonle Sap floodplain.

6. Conclusion

The findings demonstrate that CFRs play a critical role in strengthening the ecological, hydrological, and governance systems that support fisheries, rice cultivation, and rural livelihoods in Cambodia. In the Mekong–Tonle Sap landscape, CFRs serve as ecological anchors by conserving aquatic biodiversity, maintaining dry-season refugia, and promoting connectivity among permanent waterbodies, floodplains, and rice field ecosystems. The effectiveness of CFRs depends on environmental dynamics, institutional capacity, community participation, and the availability of financial and technical resources.

Analysis of six study sites in Kampong Thom and Prey Veng reveals significant ecological diversity, encompassing perennial deep refuges, seasonal floodplain ponds, and ephemeral pools. Each refuge type contributes distinctly to fish recruitment, habitat stability, and seasonal water regulation. CFRs maintain strong hydrological linkages with adjacent rice fields and irrigation systems, highlighting their role in integrated landscape management. Nevertheless, these ecosystems face challenges from declining Mekong flows, altered flood pulses, sedimentation, and competing agricultural demands, all of which undermine conservation objectives.

The institutional assessment indicates strong commune-level recognition and widespread establishment of CFR committees, reflecting progress in Cambodia's decentralised fisheries governance. Most committees are functional and active, particularly in older CFRs, and community patrolling systems demonstrate substantial local ownership. However, persistent challenges include irregular committee elections, limited gender inclusion, inconsistent patrolling capacity, and inactivity in certain committees, underscoring the need for further institutional development. Furthermore, although commune and district recognition is robust, the absence of provincial-level endorsement limits policy alignment, budget integration, and long-term institutional stability.

Financial sustainability remains a major constraint. Over the past three years, only four of six CFRs received financial support, primarily from development partners. None of the sites secured funding from government programmes or Commune Development Funds, revealing a disconnect between local conservation priorities and public financing mechanisms. Reliance on short-term project funding threatens the continuity of ecological rehabilitation, patrolling, and the implementation of management plans, especially at sites such as Ang O'Ktom and Sangke Chrum, which have not received funding.

Despite these challenges, the results underscore the transformative potential of CFRs as landscape-based models that integrate water, land, and aquatic food systems. CFRs operate within broader socio-ecological systems, linking households, rice fields, floodplains, and local governance structures. Through effective management plans, community enforcement, hydrological restoration, and multi-level institutional recognition, CFRs can significantly enhance fisheries productivity, strengthen livelihoods, and improve climate resilience. Scaling the impact of CFRs requires developing an integrated governance model that connects CFR committees, FWUCs, CFis, DTWGs, and commune councils. Achieving this integration necessitates improved financing mechanisms, strengthened inter-institutional coordination, gender-inclusive management, regular elections, and the incorporation of CFR priorities into Commune Development and Investment Plans. These measures will maximise the benefits of CFRs amid changing hydrological conditions in the Mekong Basin and ensure that community-based aquatic resource management remains central to Cambodia's rural resilience strategy.

In summary, the study confirms that CFRs are essential for sustaining biodiversity, supporting food security, and reinforcing community governance. With targeted support, consistent institutional recognition, and integrated landscape planning, CFRs can serve as scalable and resilient models for managing Cambodia's water and natural resources amid climate change and ecological uncertainty.

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