INITIATIVE ON
Asian Mega-Deltas

Water-Land-Food Nexus: Water Governance for Fish Production and Rice Farming

Mak Sithirith, Sok Sao, Sanjiv De Silva, Heng Kong, Chay Kongkroy, Tim Thavrin and Hy Sarun.

November, 2023

CGIAR

INITIATIVE ON

Asian Mega-Deltas

Contents

1. Background

Rice, fish and other crops are the main foods for the Cambodian population. Million tons of rice, fish, and crops are produced annually in Cambodia by agricultural households across the country. As a rapid rate of increased population and economic growth, more foods are produced and more lands are farmed to provide foods and agricultural produce to feed people and the economy.

Water plays essential roles in farming and fishing, which are the main food production activities across Cambodia. Water availability determines the productivity of farming, fishing, and other cropping activities. Rainfall is a potential source of water for agriculture and fishery. Also, river systems in Cambodia, including the Mekong and Tonle Sap River systems, provide abundant water resources to Cambodia. Thus, Cambodia has abundant water resources in the rainy season, but little in the dry season. These have become the main challenges for agriculture and fishery development, undermining food production. Thus, improved water management is key to agricultural development and fishery management.

Improving water management is key to agriculture and fishery in the context of climate change. Climate change has induced heavy rainfalls and frequent floods in Cambodia in recent years, causing damage to infrastructure, household properties, livelihoods, and agricultural produce. Also, climate change has increased frequent droughts, affecting rice farming, aquaculture, and fishery management. The El Nino event has had more effects on agriculture in Cambodia. Furthermore, it has contributed to lower water levels in the river system, affecting fishery habitats. Given the lack of resources and limited institutional capacity of government agencies in response to climate change, rural households are vulnerable to climate change.

On the other hand, water management is facing challenges in the context of increased developments along the Mekong River, particularly the hydropower and irrigation schemes in the upstream countries, tapping river waters to sustain their country's industrial development such as in China, Thailand, and Vietnam. There has been a declining water level in the Mekong River and Tonle Sap Lake since 2020, affecting fishery, farming, and livelihoods of local communities. The continued lower water level in TSL raises concerns about the future of Tonle Sap Lake and its surrounding floodplains, where farming and fishing dominate the food production and livelihood activities.

The increased cropping patterns in some provinces around Tonle Sap Lake, and along the Mekong River from one crop to 2-3 crops per year require lots of water resources. The demands for water for agriculture have increased and farmers compete to get water at high costs for their rice farming at the expense of fishery, biodiversity, and domestic uses.

This study examines the roles of water in fishery management and rice farming in Cambodia. It looks into the case studies of FWUCs, CFis and CFRs in three provinces—Prey Veng and Takeo Provinces in the Mekong Delta and Kampong Thom Province in TSL.

2. Conceptual Frameworks

In water, there is fish. Also, water is used to grow rice and other crops. Fish, rice, and other crops are food items for human diets. Water governance is key to fishery production and rice farming, contributing to food security. A bulk of literature discusses water governance in fishery and rice farming. A literature review suggests six dimensions of water governance in relation to fishery production and rice production.

First, water governance is influenced by physical dimensions of river, lake, and floodplains, particularly the quantity and quality. It is concerned the upstream and downstream farming and fishing communities along the rivers, lake and floodplains, between the wet and dry seasons. In the river system, in the dry season, the upstream communities often tap more water for their own uses and release small quantity of water downstream, causing water shortage and rice farming of downstream communities spoiled, leading to conflicts between communities. Sometime, the upstream communities release more water during the flood season, causing flooding of rice fields in the downstream communities which create tensions between communities.

Second, water governance is influenced by sectors and actors. Some sectors are more economically essential than the other sectors and thus, are prioritizing in planning and investing to extract more water to generate more incomes and benefits. In the sector, there are actors with power and interests, driving the sectors. In the Mekong River, water has been prioritized for hydropower development rather than supporting fishery, aiming at boosting industrial developments in the Mekong countries. Energy development has been promoted in the Mekong Region at the expense of fisheries and agriculture. Hydropower company is actively involved in driving the hydropower development, supported by states in the upstream of the Mekong River. The industrial sector has also competed for water to utilize and support industrial development, affecting fishery, agriculture and natural resources.

Third, different sectors are guided by different policies and institutional frameworks to access, govern and use water, sharing and management. Policies are set of rules and regulations in place developed by institutions and actors governing the sectors in access and govern water resources to benefit the sector at large. Policies are shaped by technicality and specializations existed in the institutions to influence other institutions. Policy is linked with power and politics. Power is the commodity that sustains politics and policy, and politics is the whole set of processes that are involved in achieving, exercising and resisting power while policy relates to the intended outcome—the things that power allows one to achieve and that politics is about being in a position to do. As a process, politics operate in and through institutions and sectors (Jones, Jones and Woods, 2004: 3). Power as a strategy, practice and technique involves the *organization of space* and inserts the control over the space, which requires forms of territoriality in attempts to control relations and resources in space through classification of precise geographic areas, boundaries and communication of those to people. The organization of space is actually rationalized based on technical and scientific capacity, economic and political interests (Lefebvre, 1991). Henri Lefebvre (1991) highlights that:

Specializations divide space among them and act upon its truncated parts, setting up mental barriers and practice-social frontiers. Thus architects are assigned architectural space as their private property, economists come into possession of economic space, geographers get their own place in the sun, and so on. The ideologically dominant tendency divides space up into parts and parcels in accordance with the social division of labor (Lefebvre, 1991: 89-90).

Fourth, using, sharing, and control of water for fishery, agriculture, industry, etc., involves decision-making by actors at different levels. Dore (2014) in the deliberative water governance and Dore et al. (2012) in a framework for analyzing transboundary water governance complexes in the Mekong Region, suggest that water governance is a social process of dialogue, negotiation and decision-making, in which there are many different actors dealing with a variety of issues influenced by their individual and shared context—actors engage in multiple arenas, depending on opportunity, necessity and choice; drivers are what influence and motivate actors; actors employ drivers to establish and legitimize their positions, inform debate and influence negotiations; decisions emerge from the arenas, and the impacts of decisions result in fairness and sustainability of water allocation (Dore et al., 2012, Lebel et al., 2010). In addition, Ratner et al. (2013) look at the governance of the aquatic agricultural system (AAS) from three governance's dimensions: (i) Stakeholder representation—which actors are represented in decision-making and how? (ii) Distribution of authority—how is formal and informal authority distributed with regard to decisions over resource access, management, enforcement, dispute resolution, and benefit sharing and (iii) Mechanisms of accountability—how are power-holders held accountable for their decisions, and to whom? These form the basis of governance of resources (Savenije & Zaag, 2002).

Access to water resources is essential for the livelihoods of the rural poor. Furthermore, access to water plays important roles in assuring the well-being of people and reducing crop failures during dry spells, and provides opportunities for farmers to grow two or three rice crops a year. However, treating water as a public good and the subsequent logic of it being free to all does create a few problems. The first is the inability of state institutions to respond to the needs of their citizens. Perry et al. (1997) argue that the state is, by its nature, slow to respond to people's needs, due to bureaucracy, rules and regulations. Secondly, treating water as a public good can lead to wasteful use, as it is free and wastage does not incur any cost (Savenije & Zaag, 2002; ADB, 2004; Global Water Partnership, 2002). Then, people have to pay to use water, and because people are usually interested in maximizing profit/minimizing cost, they

will only use enough water to satisfy their immediate needs (Perry, Rock & Seckler, 1997). In addition, markets can respond to people's needs faster than the state (Perry, Rock & Seckler, 1997). Water governance is intimately linked to the physical infrastructure that has been constructed and operated for the regulation, abstraction, storage, transport and distribution of water. The design and functioning of water infrastructure has an impact on the ecological and social landscape in which it is situated, and vice versa, as the prevailing social systems and processes shape the physical infrastructure used for management of water. Understanding a particular water governance configuration thus requires the recognition of the interdependency of prevailing social, technological and ecological systems. What this interaction also highlights is the dynamic nature of governance arrangements and processes (Rogers & Alan, 2003; Savenije & Zaag, 2002).

Last, different platforms across scales will be used for decision-making, involving actors at different levels, supporting by information and technology.

3. Material and Methods

3.1. Site Selection

Four field sites were identified after visiting several locations across Prey Veng, Takeo and Kampong Thom provinces. Prey Veng and Takeo are located within the Mekong delta and Kampong Thom is part of the Tonle Sap floodplain.

Four sites in three provinces are selected namely (1) Beung Sneh Area, (2) Beung Phlang, (3) Beung Ream and (4) Ta Soung (See Table 1). Overall, these four sites will enable us to produce the following insights that offer evidence-based policy and methodological contents:

- Testing community and district-based interventions to re-connect fragmented landscapes to restore especially Rice Field Fisheries that is a mainstay of rural animal protein
- Related to the above, testing approaches to strengthen CFR/CFi sustainability, including conflict management such as relating to fish vs irrigation at both local (CFR/CFi-FWUC) and broader (MoWRAM-FiA) scales and engendering more active stakeholder participation in maintenance including fundraising.
- Providing insights on the question: what will it take to give effect to the Prime Minister's decision to integrate water, agriculture, and environment at the District level, for landscape and ecosystem service and food production benefits, taking into account distributary questions.
- There is firstly a need to document the true nature of the integrated/holistic management challenge that applies to all of the above. This is not well understood and is thus a first barrier to change. The next question applicable to all of the above is what we learn from attempting reconnection in terms of further illuminating the nature of the challenge, but also the efficacy of tested interventions.
- Working at the a) local institution (e.g. CFO, FWUC); b) cross-institution (e.g. CFO-FWUC), and c) district scales will highlight the connects/disconnects across different scales of governance both below and above the district level, thus speaking to a core WP4 question of how decentralization affects water-land/landscape management and how this can be improved. The links with other WPs (especially in Beung Sneh) provide an opportunity to place governance within a more systemic/holistic One CG approach that can generate learning on the advantages of more transdisciplinary interventions in line with the demands of dealing with social-ecological systems.

Figure 1. The Studied Sites in Targeted Provinces.

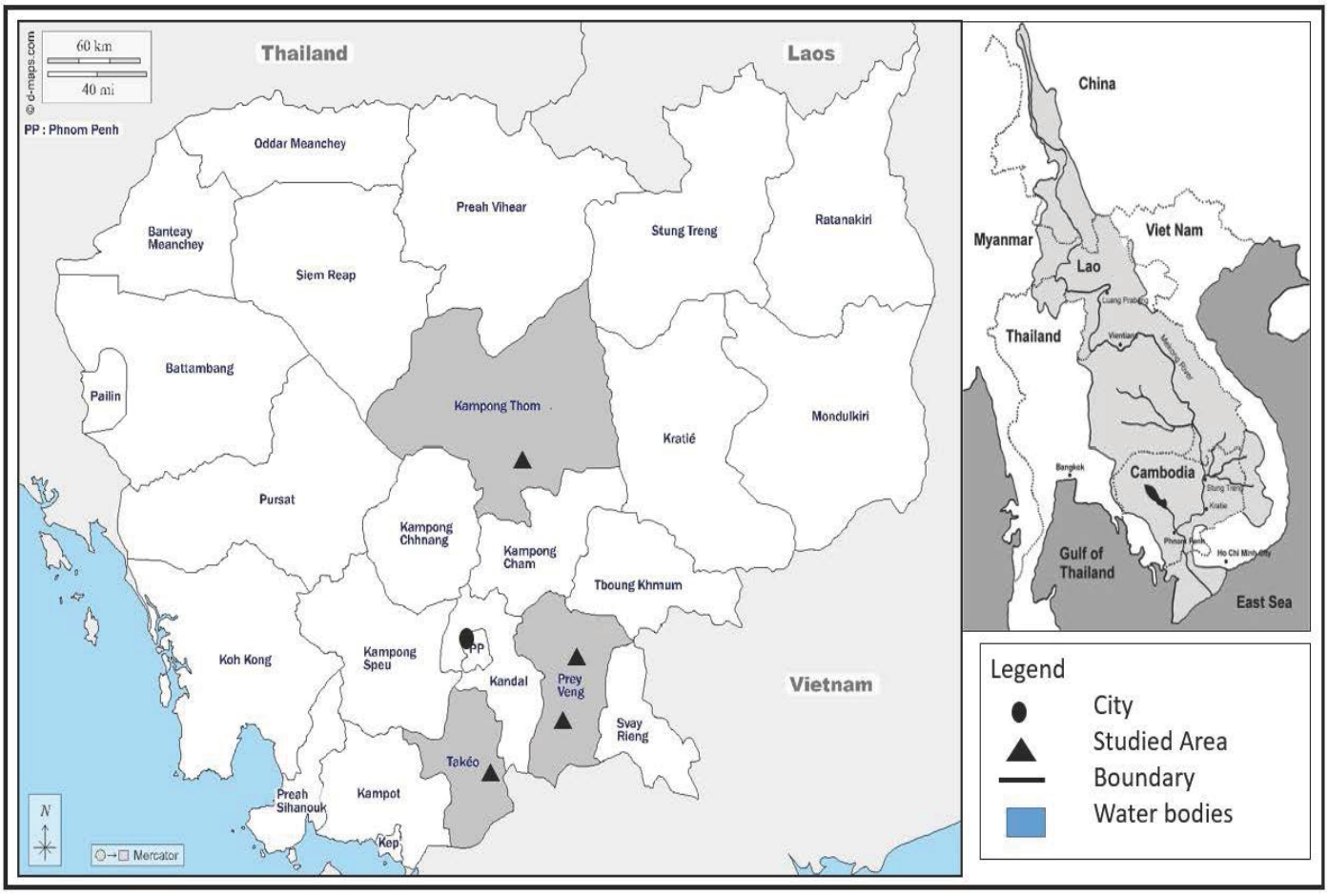


Table 1. Sites selected for WP4 interventions.

Province	Site	District/ Commune	Irrigation /FWUC	CFR	CFi	WP4 Focus
Prey Veng	1. Beung Sneh	Theay Commune, Ba Phnom Distric,	X	no	X	• Linking CFi with the Irrigation system by exploring how the FWUC-CFR-CBE can collaborate for more integrated water-land management to increase especially water productivity and diversity of water values (i.e. more MUS). Strengthen the work of the integrated district office. • By aligning site-level work with the new District office that now integrates Water, Agriculture, and the Environment (i.e. MoWRAM, DoA and DoE), we will explore and document what it will take to put into practice this very important shift from siloed to integrated landscape management. By working with the District office, we will document and communicate: – the opportunities, challenges, and conditions for success viz a viz key landscape management challenges in the district – supporting evidence on knowledge/tools/capacity and structural needs, attitudinal dimensions and overall political economies involved to inform national policy that will need to invest in this transition. – How sensitivity to national (and SDG) goals around poverty and gender can be strengthened in how individual community institutions operate and how integrated the planning at District level can account for these.
	2. Beung Phlang	Ampil Krau Commune, Sithor Kandal District	Farmer pumping	X	no	• Strengthen CFR management, especially building capacity to better engage with local CFR beneficiaries towards more effective collective action that can also generate some of the funds needed for CFR maintenance. • This issue of maintenance emerges as a common challenge across CFRs and reflects a deeper weakness in the way this CPR is managed (i.e. an absence of true collective action given a disconnect between the management committee and the beneficiaries and other stakeholders. • Connect CFR and irrigation scheme to strengthen RFF/aquaculture to stem the sale of land to the brick industry. Link to strengthening integrated district office land-water management.
Takeo	3. Ta Soung Irrigation Scheme	Ban Kam, Prey Lvea, Kampong Reap, and Pou Romchuk Communes, Prey Kabbas District	X	no	X	• Primary site for exploring the opportunities, challenges, and conditions for successfully implementing the recent decision to integrate DoA, MoE and MoWRAM. See above for details. • Exploring the possibility of integrating fisheries into the irrigation system, linking the CFi with the irrigation system, and promoting the rice field fisheries. • Influencing the design of the irrigation system to include fisheries in the system.
Kampong Thom	4. Beung Ream	Kokoh Commune, Santuk District	X	X	no	• Explore how the Rice Field Fishery (RFF) landscape (a traditional open-access seasonal system) can be restored by linking the irrigation scheme and CFR (and reconnecting this landscape). • Again, explore how the integrated District office can support such activities, and use this activity to build capacity within the District office for more integrated thinking about water-land values, use, and how these link to key socio-economic goals.

FWUC = Farmer Water User Committee; CFR = Community Fish Refuge; CFi = Community Fishery; CBE = Community-Based Ecotourism

3.2. Data Collection

Understanding these systems and reconnecting them will require us to gather information and data. Both secondary and primary data will be collected from the sites selected above.

- The secondary data will be collected from National, Provincial, and local levels. These data could include the number of villages around Beung Sneh area, farmland areas, rice yield, rice irrigated areas, fish catch, no. of fishermen, and others. Some of this data nay need to be recall data given the need to understand the production of RFF systems prior to the formal irrigation schemes.
- This is explorative research. Thus, the primary data will be collected using Informant Interviews (KIs) and Focus Group Discussions (FGDs). The information and data to be collected include practical insights on the operation and impacts of policies and legal frameworks; institutional arrangements, roles, and responsibilities; planning process; designs; the management system, and maintenance; benefit sharing mechanism; the participation of local communities and underlying drivers; budgeting, staffing, and capacity; and coordination issues. The research questions will be developed for each of our four case study sites based on the three research themes listed above.
- In some sites, fish catch and consumption may be surveyed to assess fish availability and its abundance in the areas. The household survey may be conducted if funds are available to assess the degree of chemical pesticide and fertilizer uses in the sites.
- The dialogues with stakeholders will be organized at the district/provincial and national levels. It will allow us to validate the key finding with key stakeholders and government agencies.

3.3. Data Analysis

- The data collected will be recorded in Excel. It will be analyzed using Excel and also SPSS.

3.4. Research Team

- The research work will be carried out by the research team. The team would compose 3 researchers from WorldFish and IWMI, 04 students from RUA/RUPP and 01 researchers from IFReDI/FiA, and CDRI. We will select four students to do the thesis research with the WP4 Team, one placed in each site.
- At the provincial level, the research team will involve one staff from FiAC and one staff from PDoWRAM in each province.
- WP4 shall sub-contract the Inland Fishery Research Development Institute (IFReDI)/Fishery Administration (FiA) to facilitate research works at four different sites and organize the provincial dialogues.

4. Results & Discussion

4.1. The food system

FWUCs, CFis, and CFRs are organized around river systems, lakes, or ponds. A river system is a natural system that is an integrated system—water, fish, floodplain, and plants. The human take the floodplains to cultivate rice based on seasonality, wet and dry seasons, and collect aquatic plants and animals, including fish to consume with rice. Rice is also cultivated on land that is not flooded, relying on rainfalls, but in some dry years takes water from the river through natural streams or canals. During the wet season, river water rises up gradually and it spreads all over the floodplains and the connected rice fields. Fish swims from the river into rice fields and breed and lays which increases the fish population. Fish and rice together with aquatic plants and animals live in a closely connected river-floodplain system. In the dry season, water recedes in the areas and assembles in the river channels for the rest of the years. Fish also migrate back to the river channels and some get caught by the fish trapped or nets, laid by farmers. Farmer starts harvesting their paddy rice. These form a food system.

4.2. System Breakdown

The irrigation system was developed to provide water to irrigate rice farming. Canals are dug across the food system (rice field, water, and fishery) to take water to irrigate the expanded rice lands, and also increase farming seasons. To manage the water from the irrigation scheme, farmers organize themselves into the "farmer water user community (FWUC)'. Members of FWUC have benefited from joining FWUCs as their paddy rice is not spoiled since they have secured water from the irrigation schemes. Farmers instead pay the fees for water use for rice farming.

On the other hand, the fishery is organized by the community into the Community Fishery (CFi) and in some places into the Community Fish Refuge (CFR). CFi & CFR are established to protect and manage fish in the designated territory for community use. Certain rules and regulations are established to manage the CFi & CFR and limit certain activities that are hazardous to the fishery.

These systems are separated by physical canals, sub-canals, pumping stations, dike systems, and zoning. They are also separated by fish, rice, and other crops. These are separated by seasonality—rainy and dry seasons; and activities that are carried out by villagers in different seasons. Also, these are separated by farmers and fishers, who are fishing and farming for trade and subsistence. Technology has been used by farmers or fish who do small-scale or large-scale to maximize their benefits. They are also separated by the rules, regulations, and institutions that govern these resources.

Nevertheless, they are connected by water, where water has been weaponized and utilized to maximize their benefits. But water has been controlled by canals, gates, dikes, and pumping. Also, water is controlled by rules, relations, and institutions.

4.3. Irrigation System

In Cambodia, there are 2,500 irrigation schemes across which could irrigate 2.32 million ha among which, 65% are located in the Mekong floodplains and Delta, and 35% in the Tonle Sap floodplains. In the Mekong Delta, we study the irrigation system in Prey Veng and Takeo, and in Tonle Sap floodplain, we study the irrigation scheme in Kampong Thom Province. In Prey Veng, we study the irrigation system in the Beung Sneh areas and the Vaiko Irrigation System in Sithor Kandal District within the Ampil Krav Commune. In Takeo, the Ta Soung Irrigation Scheme in Prey Kabbas District is key site undertaken for this study, while in Kampong Thom, we study the Taing Krasaing Irrigation, connecting with Beung Ream in Santuk District. The main water sources for these irrigations are the Beung Sneh Lake in Prey Veng; Prek Ambel River for the Ta Soung Scheme in Takoe province, which is a tributary of Bassac River; the Mekong River for the Vaiko Irrigation schemes, connecting with Beung Phlang in Prey Veng, and the Taing Krasaing and Stung Chinit Rivers for the Beung Ream in Kampong Thom. The irrigation systems in four sites in three provinces could irrigate 63,895ha, which is about 3% of the national targeted irrigated area of 2 million ha in 2023 (MOWRAM, 2019). Between 2019-2023, MOWRAM has a policy to increase the irrigated lands from 1.8 million ha in 2018 to 2 million ha in 2023 and to increase cropping system to 2-3 crops a year, aiming at increasing farming incomes and job for rural farmers (MOWRAM, 2019).

Irrigation is a mechanism for increasing agricultural production and hence increasing incomes of the rural poor and developing the national economy, as described by the Royal Government of Cambodia (RGC) in the planning and development document the Rectangular Strategy (RGC 2004; RGC, 2009). The RGC Rectangular Strategy (2004) emphasises growth in irrigated rice and in response investment in irrigation infrastructure by RGC has been US$60 million per year between 2007 and 2010 (Sophal et al, 2010). It is estimated that only 30% of the suitable land for irrigation has been developed (Pech and Sunada 2008) and hence the potential for ongoing investment in irrigation schemes in Cambodia is very large indeed. Many of these schemes are being refurbished and new ones built.

4.3.1. Engineering Irrigations and the Changing Waterscapes

In these four study sites, the study identifies 16 primary irrigation canals connecting to 32 secondary canals. However, only 18 tertiary canals are built. These irrigation systems are equipped with 38 water gates that could control water supply and distribution. For the Ta Soung Irrigation Scheme, water is pumped by 01 pumping station with 05

pumping machines from the Prek Ambel River into two primary canals, and then into 10 secondary earth canals, and 08 secondary concrete canals, to irrigatye 1,511ha in 15 villages. The Beung Phlang area is surrounded by the Vaiko Irrigation Scheme with two primary canals, six secondary canals, 5 water gates and one pumping station that could irrigate 153,400ha in Kampong Cham, Prey Veng and Svay Rieng Province—the scheme is originated in Koh Sotin in the Mekong River in Kampong Cham province, flowing through the Sithor Kandal District in Prey Veng and end in Svay Rien Province for a total length of 78km (Table 3).

The Taing Krasaing Irrigation Scheme is another scheme in Kampong Thom Province, originating in Stung Chinit River and flows into the Beung Ream in Koh Koh Commune, Santuk District with a total distance of 22km. In Kakoh Commune, the Taing Krasaing Scheme has one primary canals with six secondary canals and 16 tertiary canals with two water gates that could irrigate 9,869 ha (Table 2).

In the Beung Sneh, the study identifies 11 irrigation canals that take water to irrigate the rice field around Beung Sneh. Eight irrigation systems are listed in the database and investment planning of MOWRAM, located in 4 communes in 3 districts—03 irrigation canals in Theay Commune, Ba Phnom District, 03 irrigation canals in Prey Kandieng Commune, Peam Ro District, and 02 irrigation canals in Svay Anthor District. However, three irrigation canals are identified in Prey Kandieng and Ta Kao Communes during the studies, which are not listed in MOWRAM database. Around Beung Sneh, some 10 secondary irrigation canals and 2 tertiary canals are connected with 21 water gates that are operational to regulate water to irrigate 9,080ha of rice fields. Some 10,911 households from 44 villages utilize water from Beung Sneh to irrigate rice farming 2-3 times a year at the present time.

Table 2. Irrigation Systems—primary, secondary and tertiary canals in the studied site.

Site	No. of main canals	No. of Sub-canal	No. of Tertiary canal	No. of Water gates	No. of Pumping station	Potential Area (ha)--DS	No. of families who have some irrigated rice land
Beung Phlang	2	6		5	1	60000	50
Ampil Krau	2	6		5	1	60000	50
Beung Sneh	11	10	2	21	1	9080	3272
Baray	0	0	0	0	0	0	528
Damrei Puon	1	1	2	21	1	2100	568
Me Bon	0	0	0	0	0	0	88
Prey Kandieng	4	3	0	0	0	250	755
Samraong	1	1	0	0		0	224
Ta Kao	2	3	0	0	0	0	830
Theay	3	2	0	0	0	1545	279
Tuek Thla	0	0	0	0	0	0	0
Boeung Ream	1	6	16	2	0		570
Kakoh	1	6	16	2	0		570
Ta Soung	2	10		10	1		977
Ban Kam	2	10		10	1		421
Kampong Reab							120
Pou Rumchak							104
Prey Lvea							332
Grand Total	**16**	**32**	**18**	**38**	**3**	**63,895**	**4,869**

The irrigation schemes in Cambodia are grouped into four categories. The first category refers to the "river lake or stream diversion by gravity", which are used for wet season supplementary irrigation and only some dry season irrigation as there are no storage facilities. The second category refers to the "water pumping from rivers or canals", which can provide water for both the wet and dry seasons and recession rice. The third category refers to "reservoirs/lakes/ponds" storing local rainfall runoff for wet season supplementary irrigation and recession rice. Water is abstracted from the reservoir by gravity or mobile pumps provided by farmers. Last, but not least, the "reservoirs/lakes storing flood waters from the Tonle Sap, Bassac and Mekong rivers, where water released by gravity to canal system that maybe either above or below ground. These areas also benefit from natural flooding for land preparation; rice is planted as the floodwater recedes and irrigated during the growing season with the water stored in lakes and reservoirs. All studied irrigation schemes fall either in the second or fourth categories, which are made of irrigation canals, connecting to the rivers, lakes and reservoirs, where in some places water is flown directly from the river and lake into the rice fields and in some other places, the pumping stations are built to take water from the river to the rice fields. The irrigation schemes in the study areas comprise the primary, secondary, and tertiary canals, which have been built and rehabilitated by MoWRAM to provide water to irrigate rice lands. Since 2000, RGC has heavily invested in rehabilitating the irrigation schemes with a total budget of USD 1.3 billion, 80% of this fund came from the Development Partners (DPs) and 20% from a national budget. These investments cover 467,000 ha of irrigated land–327,000 ha of the wet season rice and 140,000ha of dry season rice. The effectiveness of the investments in irrigation schemes has not been assessed entirely (MOWRAM, 2019). However, the irrigation investment up until 2019 has been focused on the primary irrigation canals, not on the comprehensive irrigation system.

Table 3. Irrigation schemes in the study sites.

Site	Irrigation Scheme	Length (km)	Water Sources	Irrigated Area (ha)	Province coverage	Total fund (million)	Donor	Year of construction	Year of Completion
Beung Phlang	Vaiko	78	Koh Sotin, Mekong River, Kampong Cham	153,400	Kampong Cham, Prey Veng & Svay Rieng	99.3	China	2012	2017
Ta Soung	Ta Soung Irrigation	50	Prek Ampil River	1,511	Prey Kabbas in Takeo	2	DFAT	2016	2017
Beung Ream	Taing Krasain	22	Stung Chinit	9,869	Taing Krasaing, Kampong Thom	40	ADB	2013	2015
Beung Sneh	Chamcar Kouy	9	Beung Sneh Lake	2,010	Damreiu Poun Commune	10	ADB	2013	2019

4.3.2. The Ta Soung Irrigation System

The Ta Soung Irrigation was built in 2017 by the grants from DFAT. The scheme falls under the category no.2, in which the system relies on water pumped from the Prek Ambel River to irrigate the rice fields in four communes in Prey Kabbas District–Ban Kam, Kapong Reab, Pou Rumchak, and Prey Lvea. These four communes are partly flooded by water from the Prek Ampil River in the wet season, while another half of the areas are not flooded. In these four communes, there are 6,350ha of rice farming area, of which about 40% is a wet season rice farming areas and 60% are dry season rice farming areas. Kampong Reab Commune is located close to the Stream, where 98% of the land is flooded during the wet season and only 2% of the total land could cultivate the wet season rice. During the dry season, the floods recede and farmers cultivate the dry season rice on 98% of the total farmlands. For other communes, nearly half of the total farmlands was cultivated the wet seasons, and another half was cultivated the dry season rice. The Pou Rumchak Commune has the highest percent of the wet season rice farming, constituted 59% of the total rice lands, followed by Prey Lea Commune 49% and Ban Kam Commune 42% (See Table 6).

Table 4. The Ta Soung Irrigation System in Takeo Province.

Commune	Scheme Name (EN)	Infrastructure		Potential Area (ha)		Management		Water Sources
		Construction	Last Rehabilitation	DS	WS	FWUC	Date	
Kampong Reab	Kampong Chork Canal	1976	2007	747	0	yes		Basak river
Ban Kam	Kouk Pring	1976	2004	764	0	Yes	2003	Basak river
Prey Lvea	Prey Lvea or Trapeang Chork Canal	1976	2007	0	1511	yes		Basak river
				1511	1511			

Source: *FWUC Database, 2021*

Before the scheme was built in 2017, most of the 970 farming households in Ta Soung could only grow one rice crop each year, using the receding waters from the annual flood. In 2017, CAVAC supported the rehabilitation of the Ta Soung Irrigation System, irrigating 1,511ha and benefiting 970 agricultural households in 15 villages. CAVAC had invested around USD2 million to rehabilitate the Ta Soung Irrigation Scheme in 2017, and put them into operation. The CAVAC phased out the support in 2021. After it ended, CAVAC formed the Mekong Water Solution (MWS) to take over and support FWUC to manage the irrigation system. Farmers who used water from the irrigation system to irrigate their rice fields pay the water fees to the FWUC. Farmers now produce two or three crops each year, more than doubling their agricultural income. Water costs have reduced almost threefold, and average rice yields have grown from 4 to 5.5 tonnes per hectare.

Ta Soung is a complete irrigation scheme built by the Australian Government-funded Cambodia Australia Agricultural Value Chain Program (CAVAC). Ta Soung is connected to the Prek Ambil river – and uses a single pump station to transport water through almost 50 kilometres of canals and field channels directly into farmers' fields. Before the scheme was built in 2017, most of the 970 farming households in Ta Soung could only grow one rice crop each year, using the receding waters from the annual flood. Farmers now produce two or three crops each year, more than doubling their agricultural income. Water costs have reduced almost threefold, and average rice yields have grown from 4 to 5.5 tonnes per hectare (Australian Embassy in Phnom Penh, 2020).

The Ta Soung Irrigation scheme has a total length of about 5km long. The irrigation system comprises (1) two primary canals, (2) 10 secondary earth canals, (3) 08 secondary concrete canals, and (4) 07 flooded-releasing canals. It is equipped with 01 pumping station with 05 pumping machines. The entire irrigation system is organized into 10 blocks and each block has formed one sub-FWUC. Each block could cover around 200 ha and has set up a sub-canal with water gates that could take water to the remote rice fields. The release of water will be done by blocks, and FWUC has hired 2 farmers in each block to open and close the water gates. In total, it has hired 12 farmers to work in 10 blocks. It is overseen by 4 FWUC Committee members.

The Ta Sung Irrigation Scheme are taking water from the Kampong Ream Stream, a tributary of the Bassac River where 4 CFis in Prey Kambas District, namely (1) CFi Kampong Reap; (2) CFi Pour Romchaok, (3) CFi Ban Kam, and (4) CFi Prey Lvea are situated to manage fishery resources there. These CFis were established in 2000 and 2002 by FiA/FiAC, to manage 844,793 ha of fishing areas with 1016 households as members.

The water is pumped from the CFis by the pumping station to supply water to rice farming in the four communes. The Ta Soung Irrigation canals, dikes, water gates and pumping stations regulate floods and water to irrigate rice farming. Farmers are now farming three rice crops a year regardless the farming season and farming areas (wet and dry season rice lands).

The irrigation system disconnects the river and land system by the dikes, canals, water gates and pumping systems. These systems disrupt the floods and flows of water between the river and the floodplains. It also separates fishery from the water for irrigated rice farming. Communities are also fragmented by nature of farming and fishery, although they are one. It makes the farming system homogenous.

4.3.3. Beung Ream and Taing Krasaing Irrigation System

Beung Ream is connected to the Taing Krasaing Irrigation System, located in Kakoh Commune, Kampong Thom Province, right below the national highway no.5, within the Tonle Sap floodplain. In the wet season, the water level in Tonle Sap Lake rises up and reaches the areas around Beung Ream in Kakoh Commune, bringing fish and aquatic animals to refuge in the Beung Ream, and enabling villagers to cultivate the wet season rice farming, covering 5,099ha**.** On the other hand, the Taing Krasaing River flows from the eastern watershed areas into the Tonle Sap Lake, cutting through the Kakoh Commune in Kampong Thom Province. These make the areas abundant water resources in the wet season, which are productive for fishery and rice farming.

The Taing Krasaing Irrigation System (TK system) was constructed during the period 1975-1978, underwent rehabilitation in 2000, and had partial sections improved and modernized in 2005 and 2012. The watershed upstream is

estimated at some 1100 km^2. In 2015, RGC rehabilitated the Taing Krasaing Irrigation System with funding support from ADB. The Kampong Thom Province Provincial Department of Water Resources and Meteorology proposes to extend the Taing Krasaing main canal beyond National Road No.6 so that the paddy field area to the west of the end of the main canal could also benefit from canal rehabilitation. The system comprises of five sections, covers 9869 ha: (1) First section—2664ha in the upper area, (2) Tipou—2989ha—high grounds with pumping station; (3) CAVAC—1370ha; (4) Chroab—855ha, only partly developed as rainfed; and (5) Kakoh—1991ha, fully developed as rained. It has a total length of 22 km long.

The Taing Krasaing Irrigation Schem enters the Kor Koh Commune with 10 villages which could irrigate 1991ha, constituting 39% of the total rice farming areas in Kakoh Commune. In Kakoh commune, it has one main canal of about 5.6km long with five sub-canals (secondary), 16 tertiary canals and 5 water gates that could irrigate 1,991ha in 10 villages: 1) Svay Roling, (2) Beung Takrom; (3) Beung Sour Ambeng, (4) Beung Toul Taing Russey, and (5) the Svay Kantrum. The fifth Sub-canal, which is the Svay Kantrum Sub-canal distributes water to rice fields around the Beung Ream. Three villages in Kor Koh Commune receive water for their rice farming from Svay Kantrum Sub-irrigation canals—(1) Kirivan, (2) Chey Chumneas, and (3) Samnak. However, the other six villages in Kor Koh Commune receive water from the Sub-irrigation schemes: (1) Svay Roling Scheme, (2) Beung Takrom Scheme; (3) Beung Sour Ambeng Scheme, and (4) Beung Toul Taing Russey.

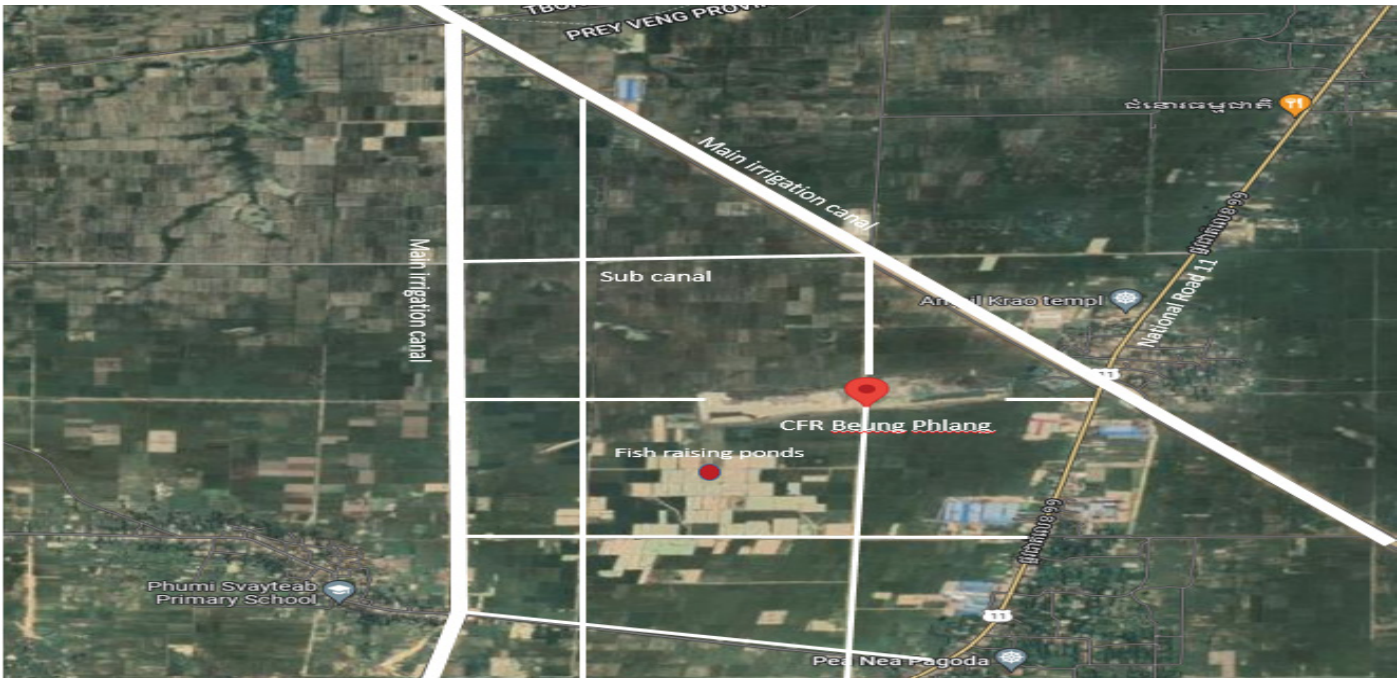
The Beung Ream is established into the Community Fish Refuge (CFR), which the provide the refuge area for fish in the dry season, and in the wet season, fish from the Beung CFR could migrate via the sub-canal to a wider irrigation system and to the rice fields. Also, the CFR Beung Ream is connected to the Kakoh irrigation system through the Svay Kantrum Sub-canal.

Since the Kakoh Irrigation System has been constructed, farmers in Kakoh Commune have changed their farming practices from one crop to 2-3 rice crops a year. About 2,000 ha of farming land has been cultivated the dry season rice. The dry season has consumed more water, resulting in water shortage, causing spoiled to rice farming almost every between January and April. Competing for water for dry season rice farming has often resulted in conflicts between FWUC members and CFR members. The CFR members want to keep water to protect CFR and fishery, while the FWUC members intend to pump water to irrigate rice fields. Since farmers have increased the rice farming season from one crop to 2-3 crops a year and the cost of production, they have concerned about rice farming more than fish. Fishery has not been well managed in the irrigation system and low priority.

4.3.4. Beung Phlang Site

Beung Phlang is located in Ampil Krav Commune in Sithor Kandal District, Prey Veng Province. In Ampil Krav Commune, there is surrounded by the Vaiko Irrigation Schemes built by Chinese Firms in 2015—02 main canals and five sub-canals, and six water gates. The Vaiko Irrigation systems were built in 2015 under the Chinese funds, extending from Kampong Cham to Prey Veng and Svay Rieng Province. Also, the Vaiko irrigation systems in the Beung Phlang site fall under the category no.2, where the pumping stations are equipped with the long irrigation canals, pumping water from the rivers. The source of water for the Vaiko Irrigation is the Tonle Touch, a tributary of the Mekong River, which originated Koh Sotin in Kampong Cham Province. There is a pumping station operated by electricity. The length of the Vaiko Canals is 78 km, covering a number of districts in Prey Veng Province. It could irrigate 153,400ha of rice fields (Figure 2).

Figure 2. Irrigation system in Ampil Krau in Sithor Kandal District.



There are six water gates to release water from the main canals to sub-canals. There are two vertical sub-canals and four horizontal sub-canals. One vertical and one horizontal sub-canal link the CFR Beung Phlang to the main canals. The CFR Beung Phlang is situated in the center of the Ampil Krau irrigation system, and it is surrounded by rice fields. Fish from CFR Beung Phlang could migrate from the CFR areas to rice fields through these sub-canals and will make the rice field abundant in fisheries.

However, the main canals and sub-canals are poorly managed and lacked maintenance. Some parts of the main canals are eroded which needs repairs. The sub-canals are shallowed which are unable to make the water from the main canals to the sub-canals. Due to poor maintenance, most of the sub-canals do not work and they are disconnected from the main canals and rice fields. As a result, farmers suffer from water shortages. The droughts and floods make further deterioration of the system, bringing about a greater disconnection between the irrigation system and rice fields. Villagers have not been using much water from the Vaiko Irrigation as there is not enough water and four out of five villages are doing only one rice crop a year, which is a wet season rice. Only one village, which is Svay Teap, is doing 3 rice crops a year. The canal system is getting shallow. At each village, there is a water gate and in each village, there is one person who is in charge of closing and opening up the water gate.

4.3.5. Beung Sneh Lake

However, in the Beung Sneh, there are eight large irrigation schemes, four schemes fall under the category no.2 and other four under no.4. The Po Louk, the Khse, Chamcar Kyou, and Kracham irrigation canals have water sources in Beung Sneh Lake. During the wet season, water levels in the Beung Sneh Lake rises up, flowing into the Po Louk, Khse and Kracham canals by gravity. Other four irrigation schemes—Top Sdach, Phum Chan, Prey Kandieng and Russei Muoy Kom canals rely on pumping machines to take water from the Beung Sneh Lake into the canals (see Table 5). At present, water levels in the Beung Sneh Lake are getting lower in the wet season due to the decline in water from the Mekong River, reducing the gravity to these canals. Thus, some canals have been rehabilitated and equipped with the pumping stations such as the Chamcar Kyou. On the other hand, water level in the Beung Sneh Lake is lower than before because farmers demand more water from the lake, and thus, people around the lake keep pumping water to irrigate their ricefield, and people in the downstream area of the Beung Sneh Lake demands the release of water downstream and thus, PDOWRAM releases water downstream, reaching the lowest. In the upstream, the lower water level in the Beung Sneh Lake means that the lake body is shrinking and more lands available for farming. Some lake's areas have been shopped up by the encroachers for private occupations.

Beung Sneh is a largest freshwater lake in Prey Veng Province, covering 3,585ha. The total water volume of Beung Snea is about 85 million cubic meters in the wet season, and it decreases to around 40 million m^3 in the dry season. Large volume annually upstream watershed discharges into Beung Snea and maintains the functionality of the lake. The lake was part of the Mekong River, in which in the wet season, water from the Mekong River flow into the Beung Sneh, however, the dry season, water returns to the Mekong River.

Around Beung Snea, huge rice field areas depend on water from the lake for agriculture and farming. They are home to many villages, most of them are farming. Given the increased farming seasonality, 2-3 crops per year, the demands for water for rice farming are increasing, causing water shortages in some years. Prey Veng Province has been ranked as number one in rice production, taking over Battambang.

The study identifies 11 irrigation canals that take water to irrigate the rice field around Beung Sneh. In the Beung Sneh, eight irrigation systems are listed in the database and investment planning of MOWRAM, located in 4 communes in 3 districts—03 irrigation canals in Theay Commune, Ba Phnom District, 03 irrigation canals in Prey Kandieng Commune, Peam Ro District, and 02 irrigation canals in Svay Anthor District. However, three irrigation canals are identified in Prey Kandieng and Ta Kao Communes during the studies, which are not listed in MOWRAM database. Around Beung Sneh, some 10 secondary irrigation canals and 2 tertiary canals are connected with 21 water gates that are operational to regulate water to irrigate 9,080ha of rice fields. Some 10,911 households from 44 villages utilize water from Beung Sneh to irrigate rice farming 2-3 times a year at the present time.

These irrigation schemes were constructed during the Khmer Rouge period between 1976 and 1978, but it was not utilized and it decayed. Until between 2004 and 2014, these systems were rehabilitated and started operating partly. Some of them were later rehabilitated. Beung Sneh has a high percentage of agricultural households having their rice land irrigated, accounting for 30% of the total population. About 55% of agricultural households in Ta Kao commune have accessed to irrigation system for their rice farming, followed by Prey Kandieng commune 36%, Damrei Puong and Baray Communes 32% respectively. However, 30% of agricultural households in Theay access to irrigation for their rice farming.

Agricultural households in the Me Bon, Damrei Puon, and Tuek Thla communities rely more on the wet season rice farming, as these communes are located in the Sreleu area. The Tuek Thla commune has a highest percentage of the wet season rice farming area, constituteing 98% of total agricultural lands, followed by the Samrong Commune 96%, Damrei Puon 94% of total agricultural lands, and Me Bon Commune 91%. On the other hand, the Ta Kao, Theay, Prey Kandieng, and Baray Communes are located in the Srekrom area in Beung Sneh and thus, the wet and dry season rice farming areas are almost equivalent. The Ta Kao commune has the highest percentage of the dry season rice farming area, constituted 83% of the total area, followed by Prey Kandieng 47%, Baray 46% and Theay 41%.

At the time of the study, around Beung Sneh Lake, farmers are not making distinctions between the wet and dry season rice farming, but they are doing all at once, in which they are

farming three rice crops a year on the wet and dry season rice farming areas, and they extract more water from the rivers, lakes, ponds and irrigation canals nearby to supply and secure the farming in both the dry and wet seasons. The development and rehabilitations of the irrigation systems around the Beung Sneh Lake contribute to more waters are taken out of the Beung Sneh Lake to support farmers to do no seasonal rice farming activities. Despite these, waters are still not enough to irrigate the increased rice cultivation, particularly between January and April each year and so, some farming communities share the cost to rehabilitate the canals which are not supported by the government programs.

Figure 3. The map of Boeung Sneh in Prey Veng Province.

Table 5. Irrigation Systems in Studied areas in Beung Sneh and Beung Phlang Area.

District	Commune	Scheme Name	Infrastructure		Potential Area (ha)		River Basin	Water Sources	Distribution	
			Construction	Last Rehabilitation	DS	WS			Gravity	Pumping
Ba Phnum	Theay	1. Po Louk Canal	1976	2008	170	4700	Mekong Delta	Beung Sne Lake	Y	
Ba Phnum	Theay	2. Khse Canal	n.a	1988	1300	1000	Mekong Delta	Beung Sne Lake	Y	
Ba Phnum	Theay	3. Top Sdach Canal	1990	2007	75	200	Mekong Delta	Beung Sne Lake		Y
Peam Ro	Prey Kandieng	4. Phum Chan Canal	1977	2004	150	80	Mekong Delta	Beung Sne Lake		Y
Peam Ro	Prey Kandieng	5. Prey Kandieng Canal	1977	2005	100	600	Mekong Delta	Beung Sne Lake		Y
Peam Ro	Prey Kandieng	6. Russei Muoy Kom	1977	n.a	150	0	Mekong Delta	Touch Peam Ro river		Y
Svay Antor	Samroung	7. Krochab Dam	1976	2006	0	200	Mekong Delta	Beung Sne Lake	Y	
Svay Antor	Damrey Puon	8.Chamcar Kuoy	1978	2014	0	2100	Mekong Delta	Beung Sne canal	Y	
Total	4	8			1945	9080	Mekong Delta		4	4

Source: *FWUC Database, 2022*

4.3.6. Changing Waterscapes

Water resources in the study areas are partly sourced in the Mekong River. The Beung Sneh Lake is a tributary of the Lower Mekong River. The Ta Soung water resources are sourced from the Prek Ambel River—a tributary of the Bassac River. The Vaiko Irrigation scheme has a water source from the Mekong River in Koh Sotin in Kampong Cham Province. Also, the Beung Phlang has a water source in both the Tonle Sap Lake and Taing Krasaing River, which is a tributary of Tonle Sap Lake. Traditionally, in the wet season, the high flood events in the Mekong River induce water flows from the Mekong River into these rivers, lakes and floodplains; flooding the floodplains, bringing fish, sediments and water, and sustaining the environments of the areas. In the dry season, the water reverses its flows from the lake and floodplain into the Mekong River, allowing farmers to fish and to farm on the floodplains.

The hydrological flows between the Mekong River and the floodplains and the lakes have changed in the last 15-20 years. Hydropower dams, irrigation system and infrastructure development have changed the hydrological flows. The Mekong River flow seasonality has decreased after many dams constructed in the mainstream of the Mekong River [31]. Reservoirs store water in wet seasons and release it during dry seasons, thereby altering the flow regimes [36]. Hydropower dams in the MRB reduces the flow in wet seasons but increases the streamflow in dry seasons, thus attenuating flow seasonality (Hecht, et al., 2019[1]; Shin et al., 2019[2]). The cascade of the Mekong dams has increased discharge in the dry season by 34-155% on average and has reduced discharge in the wet season by 29%–36% at the Chiang Saen station from 1985 to 2010 (Räsänen,et al., 2012)[3]. In the Srepok, Sesan, and Sekong ('3S) basin, which contributes the most out of all the tributaries to the Mekong River's discharge—the flow is found to have increased (decreased) by 63%–88% (22%–24.7%) in the dry (wet) season between 1986 and 2005 due to dam construction (Piman et al., 2013[4], Piman et al., 2016[5]). Human activities such as irrigation and cropland expansion have altered the water resources in the LMRB. The total water withdrawal from the entire LMRB has accounted for approximately 62 km^3—that is, 13% of the average annual discharge—of which Vietnam, Thailand, China, Laos, Cambodia, and Myanmar account for approximately 52%, 29%, 9%, 5%, 3%, and 2%, respectively (Frenken, 2011)[6]. In the MRB, approximately 80%–90% of water abstractions is utilized for agriculture, but the annual water utilization for agriculture is still less than 4% of the total annual streamflow in this region (Nesbitt, Johnston and Solieng, 2004)[7].

In the MRB, the irrigation could slightly decrease the annual flow of the Mekong River by 3% over the period of 2036–2065 compared with the period of 1971–2000 (Liu et al., 2022)[8]. Irrigation system contributes increasing rice farming activities. At the national level, about 30% for all agricultural households could access to irrigation system (ADB, 20??). In the study area, about 25% of agricultural households have their rice lands irrigated. Beung Sneh has the highest percentage of agricultural households could access to irrigation system, constituting 30%, followed by Ta Soung 26%, and Kakoh 16%. The Ta Soung irrigation scheme is built by financial and technical supports from CAVAC, and it is equipped with sophisticated irrigation canals large and small, water gates and pumping station. Also, in the Kakoh Commune, the Taing Krasaing Irrigation Scheme is built by MOWRAM with funding supports from ADB. However, Beung Phlang has a lowest percentage of agricultural households could access to irrigation systems, although two irrigation schemes—Vaiko irrigation systems—were built in 2017, farmer still do not use it much due to nature of the irrigation canals, without the gravity. Annually, the irrigation schemes in the study areas could extract 245.45 million m^3 from the rivers and lakes, which are parts of the Mekong River System to irrigate the dry season rice of at least 10,909 ha. The increased dry season rice farming in the area would lead to more wetlands cultivating the dry season rice and more water would be extracted to irrigate the dry season rice.

Access to irrigation system has increased farming seasons from a wet season rice farming to three farming seasons. These happen in all sites. In other word, farmers in all studied sites farmers cultivate the rice for the whole year non-stops, unless there is no water. Thus, water determines the farming season and the productivity of the rice fields. On the other hand, the irrigation scheme reduces floods and changes the floodplain-scape from flooding landscapes in the wet season and the dry landscape in the dry seasons to fully rice farming areas for the whole year. Also, it has also transformed some flooded areas into partially flooded areas for rice farming. Then, the landscape and waterscape are not differentiated by flooding and dry conditions, but are more less homogenous.

This is the case that flooding has not occurred in the past 10-15 years in the Beung Sneh area, particularly from the Mekong River due to canals and dykes constructed across the floodplains around the Beung Sneh Lake. Also, the Vaiko Irrigation canals prevent the Mekong flooding to flood the rice fields in Sithor Kandal in Prey Veng Province. The same happens to communities in the Ta Soung Irrigation Schemes where farmers do not see the flooding event in the past 10-15 years. The floods from the Tonle Sap Lake has not reached the Beung Ream in the last 15-20 years. These have changed the way in which farmers deal with water for rice farming in different seasons to livelihoods without seasons, where water is not anymore natural, but a manmade and control. The communities have been transformed from a water-land based to land-based communities where water are supplied by the human system such irrigation system, wells so on, not by river, lakes or ponds.

---

[1] Hecht JS, Lacombe G, Arias ME, Dang TD, Piman T. Hydropower dams of the Mekong River Basin: a review of their hydrological impacts. J Hydrol 2019;568:285–300.
[2] Shin S, Pokhrel Y, Yamazaki D, Huang X, Torbick N, Qi J, et al. High resolution modeling of river–floodplain–reservoir inundation dynamics in the Mekong River Basin. Water Resour Res 2020;56:e2019WR026449.
[3] Räsänen TA, Koponen J, Lauri H, Kummu M. Downstream hydrological impacts of hydropower development in the Upper Mekong Basin. Water Resour Manage 2012;26(12):3495–513.
[4] Piman T, Cochrane TA, Arias ME, Green A, Dat ND. Assessment of flow changes from hydropower development and operations in Sekong, Sesan, and Srepok rivers of the Mekong basin. J Water Resour Plan Manage 2013;139(6):723–32.
[5] Piman T, Cochrane TA, Arias ME. Effect of proposed large dams on water flows and hydropower production in the Sekong, Sesan and Srepok rivers of the Mekong basin. River Res Appl 2016;32(10):2095–108.
[6] Frenken K, editor. Irrigation in Southern and Eastern Asia in figures. Rome: Food and Agriculture Organization of the United Nations; 2011.
[7] Nesbitt H, Johnston R, Solieng M. Mekong River water: will river flows meet future agriculture needs in the Lower Mekong Basin? Water Agric 2004;116:86–104.
[8] Liu, J., Chen, D., Mao, G., Irannezhad, M., and Pokhrel, Y. 2022. Past and Future Changes in Climate and Water Resources in the Lancang–Mekong River Basin: Current Understanding and Future Research Directions. Engineering, 13: 144–152.

Table 6. The number of households having their rice land irrigated.

Sites	Total No. of HHs	# HHs having some irrigated rice land	%
Beung Phlang	1238	50	4
Ampil Krau	1238	50	4
Beung Sneh	10911	3272	30
Baray	1655	528	32
Damrei Puon	1756	568	32
Me Bon	641	88	14
Prey Kandieng	2107	755	36
Samraong	1772	224	13
Ta Kao	1504	830	55
Theay	918	279	30
Tuek Thla	558	0	0
Boeung Ream	3325	570	17
Kakoh	3325	570	17
Ta Soung	3731	977	26
Ban Kam	1607	421	26
Kampong Reab	532	120	23
Pou Rumchak	778	104	13
Prey Lvea	814	332	41
Grand Total	**19,205**	**4,869**	**25**

4.3.7. Changing Seasonality—Climate Change

Climate change has occurred in the MRB. It contributes to changing rainfall between wet and the dry season—more rains in the wet season and droughts in the dry season. The magnitude and frequency of flood events increased during the period 1961–2001, and this trend is expected to continue throughout the 21st century from 2011 to 2095 [34]. Climate change may increase the annual Mekong River flow by 15%, over the period of 2036–2065 compared with the period of 1971–2000, particularly in the wet season, but the dry season flow would by reduced of 2.18 per cent (Keskinen et al. 2009). However, the flow regulation by dams in the LRB will potentially reduce such a positive trend in climate-change-induced flood events [35]. In addition, the drought events occur frequently which offsets the wet season flows, resulting frequent droughts in the lower MRB.

In Cambodia, whether climate change or not, it has abundant water resources in the wet season, partly contributed by the Mekong River and another part by the rainfalls, which have created frequent annual floods, to some decree, destructive to agriculture and rice farming. However, the dry season, Cambodia has little water resources, which is not conducive to agriculture either. Furthermore, as local communities reported, floods in the wet season is no longer 'tuk thom' (big flood) occurred in the studied areas in the past 10-15 years. Together with frequent drought, the wet and the dry seasons in the study areas are homogenous with slightly differences in terms of a short wet season and a long dry season. The homogenous seasonality has triggered farming practice homogenously throughout the year, including using the same rice seeds for the entire years, requiring not different volumes of water for the plots of rice cultivation, and using the same quantity of agriculture cultural inputs to get the same rice yields per the same rice farm plots. The uncertainty of the rice yield remains with the climate, whether there will be a good climate or a worse climate in respective years, which could affect water availability for rice farming.

Climate change has been predicted to be worsened in the future. Rice farming will be affected by the availability of water. Farmers would compete for water for the dry season rice farming. This would lead to water conflicts among water users. The competition could occur between farming communities and communities and between farmers and farmers. In the dry season, when there is a lack of water, accessing water for agriculture is time-consuming and expensive.

4.3.8. Irrigation as Water Weapon

In the study sites, the total rice farming area is 37,363.5 ha, of which the wet season rice farming area constitutes 71% of the total farming areas and the dry season rice farming area constitutes 29%. In Beung Sneh, the total rice farming covers 22,899ha, of which the wet season rice farming area constitute 69% the dry season rice farming area constitutes 31%. The Ta Soung ranks a second after Beung Senh, having the wet season rice farming constituted 40% and the dry season rice farming area 60%. Nonetheless, the Beung Ream and Beung Phlang have no dry season rice farming, although the irrigation canals have been constructed. However, at present, in Beung Ream, the study identifies many agricultural households that are farming the dry season rice, transforming the wet season rice farming areas into the dry season rice, taking more water from the Taing Krasaing irrigation schemes and farmer water user

community (FWUC) is organized to manage the irrigation canal and water resources. The dry season rice farming is actually irrigated rice farming which rice cultivation is relied on the water from the irrigation schemes.

Irrigation system have transformed the communities in the studied sites into rice producing factories. To do so, they transform lands and water into ricelands and productive waters. As farmland is small, about 1.3 ha per households, the increased rice production is dependent largely on water and agricultural inputs. Thus, irrigation becomes a tool or a weapon to win the water competition between neighboring farming communities and between downstream and upstream river farming communities. This is the case in Ta Soung Community, Beung Sneh, and Kakoh Commune in Taing Krasaing Irrigation. Based on water productivity from the irrigation system for the dry season rice farming between 0.110 and 0.242 kg per m^3, to produce an average rice yield of 4 tons per hectare, it would need water input volumes of 22,500m^3 from the irrigation (Wokker et al., 2011). Farming communities in Kandal and Takeo Province located in the upstream and downstream of Prek Ambel River compete for water from the Prek Ambel River for fisheries and rice farming. The Ta Soung Irrigation Scheme has extracted at least 86.4 million m^3 of water from the Prek Ambel River to irrigate 3,840ha of dry season rice farming in four communes per season (Ban Kam, Kampong Reab, Pou Rumchak and Prey Lvea) in Prey Kabbas District, Takeo Province. However, farmers in the Ta Soung Community cultivate three rice farming a year and thus, the volumes of water extracted from the Prek Ambel River could be triple. The CFis in Prek Ambel River in Prey Kabbas District also report the impacts of pumping of water by the Ta Soung Irrigation Schem from the Prek Ambel River on fishery and the fish conservation, particularly, during the dry season, when the water level in the Prek Ambel River is lower, drying up some areas along the River. Farming communities in downstream of the Ta Soung, particularly in Prey Kabbas Commune complain about the shortage of water for their rice farming in the dry season.

In Beung Sneh area, there are water competitions among farmers having farmlands around the Beung Sneh Lake. In Damrei Puon Commune, there is a Chamcar Kyou Irrigation Schem which is used by farmers in this commune to extract water for rice farming, competing with other farmers in other commune. With the pumping station, it could extract at least 4 million m^3 per dry season rice farming. In Theay Commune, three irrigation schemes namely Po Louk, Khse ad Top Sda extract about 23.35 million m3 of water per dry season rice farming from Beung Sneh Lake. In Prey Kandien, three irrigation schemes namely Phum Chan, Prey Kandieng and Russei Muou Kom, extract 32.82 million m^3 from Beung Sneh Lake to irrigate 1,459 ha of dry season rice per dry season. In Ta Kao Commune, 2-3 irrigation canals are prevailed since the Khmer Rouge period, and have been rehabilitated by communities with their own costs. With the current available irrigation canals, farmers in Ta Kao have used these canals to extract 65.25 million m3 of water from the Beung Sneh Lake in the competition with other communes to irrigate 2,900ha of the dry season rice. However, at village and household levels, farmers own at least one household one pumping generator to pump water from the irrigation canals to irrigate their remote rice fields. Annually, about 158.94 million m3 of water have been extracted seasonally from the Beung Sneh Lake to irrigate the dry season rice of 7,064ha around the lake. The competition for water for dry season rice farming has made the lake critically low in 2022 and 2023, reaching the alarming level for emergency response. As consequence, all irrigation canals were dry out. Subsequently, communities around the lake dredge the irrigation canals into the lake to get the remaining water out of the lake into the irrigation canals in the dry season, and then, farmers use water pumping generators to pump water from the canals to the rice fields. These make water lowest in the lake, affecting fishery and biodiversity.

In Beung Sneh area, particularly in Torp Sdach Village in Theay commune, the private water pumping station was operated by private individuals from Phnom Penh, granted by District Authority. The operator receives a 4-year contract, from 2016 to 2024, to pump water from Beung Sneh and sold to farmers for 270,000-300,000 riel per hectare per season. The pumping station could pump water to irrigate 305 ha in 5 villages. Thus, this operation allows farmers to cultivate 2-3 rice crops per year. About 105 ha is an upland ricefield, which is not flooded by the rising water level in Beung Sneh, and therefore, farmers cultivate 3 rice crops per year. However, about 200ha is located within the Beung Sneh floodplain and thus, the area is flooded during the wet season therefore, farmers could only cultivate one rice crop a year, particularly from March to May which is a dry season rice. About 250-300 HHs rely on water from the private pumping station. Among them, about 175 HHs are doing dry season rice farming, and all of them own pumping generators at least one.

Also, in the Beung Sneh area, there are three water supply stations operated by Private Individuals that received the licenses from MOWRAM, pumping water from Beung Sneh, filtering it, and cleaning and selling it to villages. These two stations are operational and one is still under construction—one station is in Theay Commune, one in Samrong Commune and the newly construction one is in Damrey Poun Commune. About 50-60% of the population living around Beung Sneh use water from the water supply system for the price of 1800-2000 riel per cubic meter. It is estimated that one household uses 10 m^3/month.

In the Beung Ream, the Kakoh is the lowest part of the Taing Krasaing Irrigation Scheme. Farmers in 10 villages in Kakoh commune used to cultivate the wet season rice, which was one crop a year. With the Taing Krasaing Irrigation Schem, farmers in Kakoh Commune cultivate three rice crops per year. However, farmers in Kakoh Commune suffer from the delays of water release from the Taing Krasaing main canal to the Kakoh's canals, as upstream farming communities extract water from the main canals as much as they could before they release downstream. These would some time cause water shortage in Kakoh Commune, particularly during the high water demand season between January and April. Also, within the Kakoh Commune, there is competition for water between

farmers in 10 villages, particularly between the upstream and downstream villages. The Chey Chumnas, Kiriwon and Samnak Villages are located in the lowest reach of the Kakoh's canal of the Taing Krasaing Irrigation Scheme, complaining the shortage of water given more water tapped upstream and the left over released downstream. Instead, farmers in these villages take water from the Community Fish Refuge (CFR) in the Beung Ream area to irrigate their rice fields. Water conflicts have occurred between farmers in the upstream and downstream villages, and between rice farming and CFR.

Thus, irrigation system is considered as the water weapon that has been used by the community level to fight for water for the dry season rice farming. In addition, the water pumping generator has been considered as a water weapon used by household to compete with agricultural households within the same communities for limited water resources. Farmers use the water pumping generators to pump water from the irrigation canals into the remote rice fields. Also, there is a competition between farmers whose rice fields are close to the canals and those with remote rice fields. Farmers some time cooperate to pump water from the canals and sometimes work individually to pump water depending on their financial resources.

Table 7. The wet and dry season rice farming and water uses for dry season rice.

Site/Commune	Rice farming area (ha)	Total area of wet-season rice (ha)	%	Total dry-season rice land (ha)	%	Estimated water uses for one dry season rice farming (000m³)
Beung Phlang	3016	3016	100	5	0	112.5
Ampil Krau	3016	3016	100	5	0	112.5
Beung Sneh	22899	15835	69	7064	31	158.94
Baray	2430	1307	54	1123	46	25,267.5
Damrei Puon	2919	2743	94	176	6	3,960
Me Bon	1962	1794	91	168	9	3,780
Prey Kandieng	3111	1652	53	1459	47	32,827.5
Samraong	3373	3223	96	150	4	3,375
Ta Kao	3511	611	17	2900	83	65,250
Theay	2510	1472	59	1038	41	23,355
Tuek Thla	3083	3033	98	50	2	1,125
Boeung Ream	5099	3099	61	2000	39	45,000
Kakoh	5099	3099	61	2000	39	45,000
Ta Soung	6349.5	2509	40	3840	60	86,400
Ban Kam	1491.5	619	42	872	58	19,620
Kampong Reab	1458	27	2	1431	98	32,197.5
Pou Rumchak	1905	1123	59	782	41	17,595
Prey Lvea	1495	740	49	755	51	16,987.5
Grand Total	**37363.5**	**26459**	**71**	**10909**	**29**	**245,452.5**

4.3.9. Management and Coordination

The study irrigation systems are suffering from poor maintenance and decays due to lack of local participation in using and managing it. The primary canals were mostly built by the central level of MOWRAM and thus, remained centrally managed. The PDOWRAM still relies on MOWRAM to provide technical and financial supports for maintenance and operations. The operation and management of the system remain weak. The establishment of FWUC has been undertaken in many irrigation schemes, but faced legal limitations. Capacities of staff of MOWRAM in irrigation, hydrology, and water management are limited. There are about 1,250 staff, about half are based in 25 Provincial Departments of Water Resources and Meteorology (PDOWRAMs). The annual national budgets for MOWRAM is USD 35 million for rehabilitating the irrigation schemes, USD 15 million for the Operation and Management (O&M) of the irrigation schemes and USD 0.5 million for the establishment of FWUCs. The annual budget allocation to MOWRAM has been small and limited in addressing the management, rehabilitation and construction of the irrigation schemes.

The managements of the study irrigation schemes have been challenged by weak coordination and overlapping roles of ministries related to water management. Despite the integrated water resource management approach taken, insufficient cooperation takes place among the different ministries and even between different departments within a given ministry. Moreover, even though the MoWRAM is in overall charge of water management and conservation issues, intra-ministerial coordination is weak, meaning there is room

for improvement in terms of its management capacity. Data related to water collected by individual ministries should be passed to and be accessible through the MoWRAM, with a master dataset openly available to all the ministries

There is a lack of participation of civil societies and NGOs in the designing and development of irrigation schemes. The construction and building of irrigation schemes do not respond to the needs of local communities. As they are small holders, many farmers benefit poorly from large-scale irrigation schemes, and instead they keep relying on rainfalls for their rice farming.

Climate change has altered water regimes in the irrigation canals. Many built irrigation schemes suffer from lack of waters. For these reasons, farmers do not depend on water from the irrigation canal to irrigate their rice. Instead, they continue to use rainfalls to water their small farmers. In some provinces, farmers migrate to cities and oversea for non-farm jobs and they left their rice fields uncultivated.

4.3.10. Farmer Water User Community (FWUC)

The Royal Government of Cambodia(RGC) issued the Water Law in 2005. Article 19 of the Water Law states that "All farmers using water from the irrigation system or part thereof may form a Farmers' Water User Community (FWUC)."[9] As part of its water management strategies, the RGC has decentralized the responsibility for the operation and maintenance of irrigation schemes to Farmer Water User Communities (FWUCs) by Prakas 306 in 2006. By 2018, 544 FWUCs were established to manage the irrigation schemes (MOWRAM, 2019)[10]. In Prey Veng Province, there are 177 irrigation systems, and some 38 FWUCs have been established. In Kampong Thom, there are 258 schemes and 30 FWUCs have been established, but many FWUCs do not work, and only 10% are active.

Out of these FWUCs, we study five FWUCs in the study areas—02 FWUCs in Beung Sneh, and one FWUC in each site of Beung Phlang, Beung Ream and Ta Soung. The total agricultural lands covered by FWUCs are 9,058ha and 15,781 agricultural households are members. The Damrei Puon's FWUC in the Beung Sneh site is a largest FWUC in the study sites, followed by Ta Soung's FWUC in Takeo Province, and Theay's FWUC in the Beung Sneh lake.

Some FWUCs are too large and thus, established into Sub-FWUCs. The Sub-FWUC is further organized into Group FWUC. However, different FWUCs have different approaches in organizing water users. Some FWUCs are organized at District level, known as District FWUC. The District FWUC is further organized into the Commune FWUC. Then, the Commune FWUC is organized into the Village FWUC.

The Taing Krasaing (TK) irrigation scheme has organized into one FWUC in 2018, which is a District FWUC, led by 04 Committee members. The District FWUC of Taing Krasaing is organized into Commune FWUC, comprising 3 Communes, which are considered as Sub-FWUCs of Taing Krasaing Irrigation Scheme, led by one Sub-Committee Chief and two Deputy Cheifs. The Sub-FWUC or the Commune FWUC is further organized into village's FWUC. The Kakoh Commune is a Sub-FWUC or the Commune FWUC of TK's FWUC. The Kakoh's Sub-FWUC comprises 10 villages, with a total number of 3,328 HHs, who do farming 3 crops per year, and only 20-30 households per village are engaged in fishing. One village is organized into one Group-FWUC with 01 Group Leader and 02 Deputy Group Leaders who act to collect water fees. In total, there are 02 Sub-FWUC leaders and 17 Group-FWUC leaders across 10 villages. The Group-FWUC leaders report on monthly and weekly basis to Commune FWUC Leaders, and collect the seasonal water fees (three months) from members to provide to the Commune FWUC Leaders. The Commune FWUC Leaders collect the water fees from village's FWUC Leaders to provide to the District FWUC Chief, and reports the water uses and management to the District FWUC Committee Meeting. The Commune FWUC Leaders attends the District FWUC Monthly meeting to report to the District Chiefs.

In the Beung Sneh Lake**,** in Damrey Poun commune, one FWUC was established in 2018 supported by ADB namely the Chamcar Kouy. The Chamcar Kouy Irrigation scheme has 9km long canals, taking water from the Beung Sneh Lake to irrigate 2100ha of rice fields in 06 villages in Damrei Puon Commune in Svay Anthor District. There is one pumping station that pumps water from the Beung Sneh lakes to supply water to the main canals which could be controlled by 03 large and 18 small water gates. The Chamcar Kouy FWUC is organized at the Commune level, in which they elect 03 people as Chief, Deputy Chief and Treasury. The Chamcar Kuoy FWUC is organized into six village FWUCs, led by two people in each village, one as Village-FWUC Chief and one as Deputy Village Chieft. The Village-FWUC Chief and Deputy Chief collect the water fees from farmers in the villages and also provide the maintenance to the irrigation system if there is a damage. However, 15% of water fees collected will be used for the support to Chiefs and Deputy Chefts.

The Ta Soung Irrigation Scheme comprises (1) two main canals, (2) 10 earth canals, (3) 08 concrete canals, and (4) 07 flooded-releasing canals, and 01 pumping station which could irrigate 1,511 ha, supporting 970 households in 15 villages. The entire irrigation system is organized into 10 blocks and each block has formed one sub-FWUC. Each block could cover around 200 ha and has set up a sub-canal with water gates that could take water to the remote rice fields. The release of water will be done by blocks, and FWUC has hired 2 farmers in each block to open and close the water gates. In total, it has hired 12 farmer workers to work in 10 blocks. It is overseen by 4 FWUC Committee members. The irrigation system was built and financed by CAVAC in 2017 and it was phased out in 2021. After it ended, CAVAC formed the Mekong Water Solution (MWS) to take over and support FWUC to manage the irrigation system. Farmers who used water from the irrigation system to irrigate their rice fields pay the water fees to the FWUC.

[9] Ministry of Water Resources and Meteorology (MOWRAM). Sub-Decree on the Establishment and Dissolving of FWUC; Ministry of Water Resources and Meteorology: Phnom Penh, Cambodia, 2015.
[10] MOWRAM, Water Strategic Development Plan, 2019-2023.

Table 8. FWUCs in the management of water.

Site/commune	No. of FWUCs	No. of Sub-FWUC	No. of villages in FWUC	Total areas (ha)	No. of members (HHs)	Year of establishment
Beung Phlang	1	0	3	107	93	n/a
Ampil Krau	1	0	3	107	93	0
Beung Sneh	2	0	10	2350	1660	0
Baray		0	0	0	0	0
Damrei Puon	1	0	6	1570	984	2018
Me Bon	0	0	0	0	0	0
Prey Kandieng	0	0	0	0	0	0
Samraong	0	0	0	0	0	0
Ta Kao	0	0	0	0	0	0
Theay	1	0	4	780	676	2005
Tuek Thla	0	0	0	0	0	0
Boeung Ream	1	9	10	5099	13058	2018
Kakoh	1	9	10	5099	13058	2018
Ta Soung	1	15	15	1502	970	2022
Ban Kam	1	6	6	1502	970	2022
Kampong Reab		2	2			
Pou Rumchak		4	4			
Prey Lvea		3	3			
Grand Total	**5**	**24**	**38**	**9058**	**15781**	**0**

4.3.11. Water Fees

As part of the legislation, farmers are required to pay fees to FWUCs for the operation and maintenance of irrigation schemes. Water is no longer a free public good, but instead belongs to the state and is managed by the FWUC. However, the roles and responsibilities of the FWUCs are often unclear, and 91 percent of water user fees imposed by the FWUC were not paid in the areas assessed in this study (CDRI 2009). Knowledge of the 'value of water' thus becomes particularly important inorder to determine why farmers do not pay fees and how water should be priced.

In Kakoh Commune, farmers who used water from the sub-irrigation schemes pay the water fees. Actually, farmers pump water from the sub-irrigation canals using their water-pumping generators, which means that individual farming households own at least one pumping generator. The water fee is paid based on the size of the rice farming area and the distance from the rice fields to the irrigation canals. In the Sub-FWUC, water is managed by the Sub-FWUC leader, covering the entire commune of Kakoh. When farmers need water, they need to inform the village-FWUC leaders, and then the leader will inform the Sub-FWUC leader. The Sub-FWUC leader will inform the water gate operators to release the water. Water through the sub-canal takes 3-4 days to reach the last villages in the Kakoh FWUC. Water fee is 40,000 riel/ha/crop for a rice field located close to the irrigation and 20,000-30,000 riel/ha/crop for a rice field located far from the irrigation canals. The payments are made to the Group-FWUC Leaders. However, during the dry season, particularly from January to March or April, farmers pump water from the CFR area, but they do not pay water fees to CFR Committee, but to FWUCs. However, only about 50-60% of FWUC household members pay water fees. The water fee is not collected for the entire 3 crops in the years, only one crop is paid for the uses of water, particularly from November/December to February. The Group leader will receive 15% of the water fee collected.

In Beung Sneh area, farmers pump water from the Beung Sneh Lake to supply to FWUC members, and members pay the water fees based on the size of the ricefield per farming season. The water fee is based on the electricity cost, not the price of water, but the price of electricity. In Damrey Poun commune, the Chamcar Kouy FWUC, established in 2018 by 06 villages, charges water fees of 40,000 rield/ha by pumping and 70,000 riels by the gravity per season. The water fee is determined by the cost of the electricity FWUC Committee uses to pump water and then, they divided by the total number of FWUC members. In Prey Kandieng Commune, the water fee is charged at 10,000 riels/ha. In Top Sdach village in Theay Commune, the private water pumping station operator charges the water fee from farmers for 270,000-300,000 riel per hectare per season. At this cost, individual farmer is responsible for pumping water from the canals to their rice fields. However, farmers without the FWUC have used their water-pumping generators to pump water out of the Beung Sneh area and pay no fee for the water they use. There is competition among farmers over the uses of water from Beung Sneh areas. The water uses for rice farming has affected the fisheries. So far, CFis have not been active as most of their members are doing rice farming too.

Figure 4. The pumping of water from the Beung Sneh areas for Rice Farming.

In Ta Soung, FWUC charges water fees from farmers based on the cost of electricity they utilize to pump water from the Prek Ambel River and then divided by the total members of FWUC. Thus, the water fee is not fixed but varies from season to season, depending on the level of raining and the weather conductions.

However, water fee does not reflect the cost of water uses by farmers, but by the cost of electricity uses. Still, people considers water is given and free and therefore, farmers do not need to pay the fee for water uses, but only the cost of the electricity. The water fee they called is not used for sustainable water and invested back to protect the water sources as they always consider that there are water in the rivers and lake, and they are not depleted. On the other hand, water sources in these areas are protected by CFis and CFRs. There are trade-off between CFis/CFRs and FWUCs.

4.4. Fish and Fishery Resources

The study sites are rich in fishery, as they are connected to river, stream and lakes. Ta Soung Irrigation is connected to Prek Ambil River, a tributary of the Bassac River, which was a former fishing lot no. 20 in Takeo Province. The Beung Sneh is connected to the Mekong River and it is rich in fisheries where people from 44 villages have relied on fishing. Also, the Beung Ream is part of the Tonle Sap Floodplain, whereby fish from Tonle Sap Lake come and refuge in the Beung Ream in the wet season.

Fishery is part of local people livelihoods. The fishing households in the studied areas constitutes 24% of the total households. In Prey Kobbas District, the fishing households constitutes 33% of the total households. In Beung Ream in Kampong Thom, about 30% of households is still engaged in fishing. However, the fishing households in Prey Veng in general, and in Beug Sneh constitute 19%, which is low compared with other provinces.

Table 9. Fishing households in the study areas.

Province/Commune	No. of HHs	No. of households fishing	%
Kampong Thom	3325	998	30
Kakoh	3325	998	30
Prey Veng	12149	2341	19
Ampil Krau	1238	248	20
Baray	1655	n/a	n/a
Damrei Puon	1756	497	28
Me Bon	641	n/a	n/a
Prey Kandieng	2107	511	24
Samraong	1772	634	36
Ta Kao	1504	301	20
Theay	918	151	16
Tuek Thla	558	n/a	n/a
Takeo	3731	1227	33
Ban Kam	1607	336	21
Kampong Reab	532	293	55
Pou Rumchak	778	275	35
Prey Lvea	814	323	40
Grand Total	**19205**	**4566**	**24**

Thus, fisheries in the study areas have been managed into the community fisheries in some areas, and other areas as Community Fish Refuge (CFR). In the study sites, there are eight CFis and two CFRs established by FiA to manage fishery resources. The CFRs contribute to 30% of inland fish production in Cambodia (REFERENCEXXX). The CFi Effectiveness in 2018 identifies that CFis contribute to 15% of total inland fish production (REFERENCE, XXXX).

Table 10. The CFia, conservation areas and membership.

Row Labels	Sum of No. of CFis	Sum of Area (ha)	Sum of Conservation area (ha)	Sum of No. of villages	Sum of No. of members
Beung Phlang	0	0	0	0	0
Ampil Krau	0	0	0	0	0
Beung Sneh	4	85236	37.93	25	11034
Baray	0				
Damrei Puon	1	15841	0.8	6	4979
Me Bon	0				
Prey Kandieng	1	655	4	5	5118
Samraong	1	7266	13	10	634
Ta Kao	0	0	0	0	0
Theay	1	61474	20.13	4	303
Tuek Thla	0	0	0	0	0
Boeung Ream	0	0	0	0	0
Kakoh	0	0	0	0	0
Ta Soung	4	7633	1	17	1016
Ban Kam	1	2000	0	3	219
Kampong Reab	1	1938	0	3	199
Pou Rumchak	1	840	1	3	275
Prey Lvea	1	2855	0	8	323
Grand Total	**8**	**92869**	**38.93**	**42**	**12050**

4.4.1. Community Fishery (CFi)

The study identifies 8 CFis in the study area. These CFis cover 92,869ha of fishing grounds with 39 ha as CFi fishery conservation areas. Some 12,050 people from 42 villages have been involved in the establishment of these CFis as members. These CFis were established after 2000, following the release of commercial fishing areas for local communities. The CFi elect their members to be the CFi Committee to lead the CFi management and activities. The elections and the establishment of CFis are guided by the CFi Sub-decree under the authority of FiA and FiACs. The main roles of CFis are to conserve and protect fishery resources within the CFi territories. All members could fish openly throughout the year using the fishing gear defined in the By-laws of CFis. The By-laws allow CFi members to fish subsistent, not commercial, aiming at conserving fishery resources.

In the Beung Sneh lake, four CFis cover 85,236ha with 11034 people in 25 villages as members. The Beung Sneh is also connected to 08 large irrigation schemes where water is pumped to irrigate 22,899 ha around the lake. In Svay Anthor District, there are two CFis established in 15 villages in two communes, covering 23,107 ha. In Prey Kandieng Commune, the CFi Mohachey Chumneas is established by seven villages in Peam Ro District. Another CFi is the Beung Sneh Theay, established in 2012 by 04 villages in Ba Phnom District. The CFi Damrei Puon was established in 2012 in Damrei Puon Commune, covering 15,841ha, with 4979 people in six villages as members. The Samay Thmey Techor CFi in Samrong Commune was established by 9 villages in 2012 with 634 people as members, covering 7,266ha. In conclusion, the CFis in Prey Veng Province are established at the commune level. The CFi Committee (CFC) is elected from the villages in the communes. These CFis are supposed to elect their CFi Committee members every 3 years, but since 2012, CFCs have not been re-elected, so the old elected CFCs continue to remain in the positions.

The CFIs are established to manage and protect fisheries resources and sustain the livelihoods of fishing communities. It has been established that at least one ton of fish catch is taken out of the Beung Sneh water body within one day, supplying to a provincial town of Prey Veng. However, for the CFi Beung Sneh Theay, only about 16 households from 4 villages are fishing. The CFi Samay Thmey Techor in Samrong Commune has 09 villages as members, 36% of households are fishing in the Beung Sneh areas, and 85% are doing rice farming. The same happens to the CFi Damrey Poun, in which only 28% of households in six villages are fishing. In the Damrei Puon Commune, 24% of households are fishing. The rest of the households in these CFis are farming 3 rice crops a year with a rice yield of 4-5 tons/ha.

Also, the CFis protect the fish habitats inside the Beung Sneh Lake, designated as the CFi areas. In addition, CFis protect the fishery conservation area, set aside about 40ha inside the lake and 9 deep water in the Beung Sneh Lake as CFi protected areas. To do so, CFis keep the water level in the lake about 4-5m deep as the lowest in the dry season to allow fish to feed and to breed. However, the operations of CFis contradict to FWUCs, where farmers need to lease water from the Beung Sneh Lake and to pump water to irrigate the rice fields. Thus, CFis are suffering from losing water to rice farming, leading to lower water in the lake, affecting CFis and fisheries, leading to illegal fishing inside the areas. They are also suffering from destruction of flooded forest around the Lake and also the pumping of water from the lake, affecting.

Four CFis were established in Prey Kobbas District, Takeo Province, between 2000 and 2002, covering 844,793ha, locating in 15 villages in four communes. About 1016 people are involved in the CFis as members, of which about 550 people are female. The CFis are led by 36 CFC members (Community Fishery Committees (CFCs)), including 4 females. The Kampong Reab CFi was established in 2000 by 199 members to manage 1,938ha in Prek Ampil River. The Pou Rumchak CFi was established in 2002 by 275 members to manage 840ha downstream of Kampong Ream in Prek Ampil River. The Prey Lvea CFi was established in 2002 by 323 members to manage 2.855ha. These CFis were established by the Commune Level.

Oxfam Australia worked with these CFis between 2002 and 2015 to support communities to protect fishery resources for their livelihoods. Since the phase out of Oxfam works in the areas, CFis become inactive due to the lack of financial and technical supports. In 2022 and 2023, EU has provided the small grants to one CFi namely Kampong Reab for USD1000 per year. Despite that the small grant does not address issues that CFi faces, only the patrolling, the conservation and signboard for the CFi awareness.

Table 11. CFis in Beung Sneh Lake in Prey Veng Provicne.

No.	Cfi	Location			Year of establishment	Area (ha)	No. of members		CFC		Registration date	Management Plan developed	No. of Conservation areas (ha)
		Commune	District	No. of village			Total	Female	Total	Female			
1	Damrey Poun	Damrey Poun	Svay Anthor	6	24.2.2012	15841	4979	2555	9	2	07.5.2013	2013	1(0.8)
2	Samay Thmey Techor	Samong	Svay Anthor	9	24.4.2012	7266	634	4283	7	0	07.5.2014	2013	2(13)
3	Beung Sneh Theay	Theay	Ba Phnom	4	24.3.2012	61474	303	106	5	0	07.5.2015	2013	5(20.13)
4	Mohachey Chumneas	Prey Kandien	Peam Ro	7	24.5.2012	655	5118	2.66	7	0	07.5.2016	2013	1(4)
Total				**26**		**85236**	**11034**	**6946.66**	**28**	**2**			**37.00**

Source: *CFi Database, 2023*

Table 12. The Number of CFis in Prey Kobbas District, Takeo Province.

No	Cfi Name	Location		Year	Area (ha)	No. of members		No. of CFC		Registration date	No. of Conservation areas (ha)
		Commune	District			Total	Female	Total	Female		
1	Kampong Reab	Kampong Reab	Prey Kobbas	2000	1,938	199	27	11	1	24.10.2017	1
2	Pou Rumchak	Pou Rumchak	Prey Kobbas	2002	840	275	170	7	1	Under process	0
3	Ban Kam	Ban Kam	Prey Kobbas	2002	n/a	219	102	9	2	n/a	0
4	Prey Lvea	Prey Lvea	Prey Kobbas	2002	2,855	323	251	9	0	n/a	0
Total	4	4	1		844,793	1016	550	36	4	0	1

Source: *CFi Database, 2023*

CFis face many challenges including the encroachments into the conservation areas, illegal fishing inside the CFi core areas, the lack of participation of CFi members & non-members in the management of the CFi areas and the protection of fishery resources, the limited supports from FiA, FiAC and local government in managing the CFi areas, limited financial and technical supports from concerned agencies, the conflicts between CFis and FWUCs over the pumps of water from the CFi areas to irrigate the ricefields, the overlapped areas between the CFis and FWUCs, the lack of fishery management inside the FWUC areas, and the uses of pesticides & fertilizers in rice farming, killing aquatic animals and fish.

4.4.2. Community Fish Refuges (CFRs)

CFR is a form of community-based fishery management that is established to manage fishery in the natural lake, linking rice field fishery to the water bodies. The study focuses on two CFRs, one in Beung Ream in Kampong Thom and another one in Beung Phlang in Prey Veng Provinces. The Beung Phlang CFR was established in 2007 by 3 villages, while the Beung Ream was established in 2021 by 2 villages. The CFR is surrounded by large rice fields, and in the wet season, water from the Mekong River and Tonle Sap Lake floods the rice field around the CFRs, making fish migrate from the lake and the Mekong River into the CFRs and some fish species migrate from the CFRs into the rice fields, allowing farmers for catching more fish. The estimated fish catch in the rice field around the CFRs is 25kg/ha/season and 88kg/ha/season in Beung Phlang and Beung Ream CFRs respectively.

Table 13. The number of CFRs in the studied Area.

Areas/CFR	Beung Phlang	Beung Ream
No. of CFRs	1	1
No. of villages	3	2
No. of HHs	561	392
Area (ha)	27	13
Conservation area (ha)	12	2
Size of CFR in the dry season (ha)	10	2
No. of membership	4981	572
Rice field areas around CFR (ha)	1864	9000
Year of establishment	2007	2021
fish catch (kg/ha/season)	25	88
Funding (USD)	EU--USD1000 in 2022 and USD1000 in 2023	GIZ/WorldFish

4.4.3. CFR Beung Ream

WorldFish is implementing the Sustainable Aquaculture and Community Fish Refuge Project–Community Fish Refuge Component (SAFR-CFR) with 10 CFRs in Kampong Thom Province. The SAFR-CFR is financed by GIZ. On 15-16 February 2023, WorldFish organized the Annual Reflection Workshop to examine the progress and the improved performance of 10 CFRs in Kampong Thom supported financially by GIZ. Among the 10 CFRs, the CFR Beung Ream is selected as the site for the WP4.

It also provides the opportunity for us to communicate with the concerned stakeholders and the interactions with key stakeholders in Kampong Thom Province. It also provides a chance to meet with community leaders, the commune councilors, and the district authority. First, I attended the workshop and listened to the presentations made by 10 CFRs in Kampong Thom, including the CFR Beung Ream, and then, on the second day, I joined the field trip to Beung Ream and met with the CFR Committee, the Commune Councilors and Deputy Governor of Santuk District.

The CFR Boeung Ream was established in 2021 by four villages in Kor Koh Commune, Santuk District, Kampong Thom Province. The CFR Committee comprises of 07 members with two female members. They were officially elected on October 29, 2021, and recognized by the Commune, District, and FiAC-Kampong Thom.

The CFR area covers 13 ha, with the core areas of CFR covering 2ha for conservation. The water depth in the dry season is 2.5m. The Core area has been rehabilitated by CFR members with funding support from WorldFish/ANKO financed by GIZ in 2021. The CFR has been equipped with a water level monitoring system that could inform the CFR Committee about the level of water that could stop people from pumping water out of the CFR area. It has been demarcated with pillars for boundary demarcation, a security guard post, and a signed board demonstrating the prohibition of illegal fishing inside the CFR area.

There are 3 canals entering the CFR area: (1) O' Praing, (2) Beung Karav, another natural pond, connecting with Beung Ream; and (3) Irrigation canals built by MoWRAM. The O' Praing has been rehabilitated by a Private Company that took the soil/earth to build the roads. Since it has been rehabilitated,

it provides water to the CFR Beung Ream which keeps the water in Beung Ream year-round. The irrigation canal enters the CFR Beung Ream and supplies water based on the requests from CFR Committee. The irrigational canal is part of the Stung Chinit Irrigation Scheme built by MoWRAM, and financed by ABD.

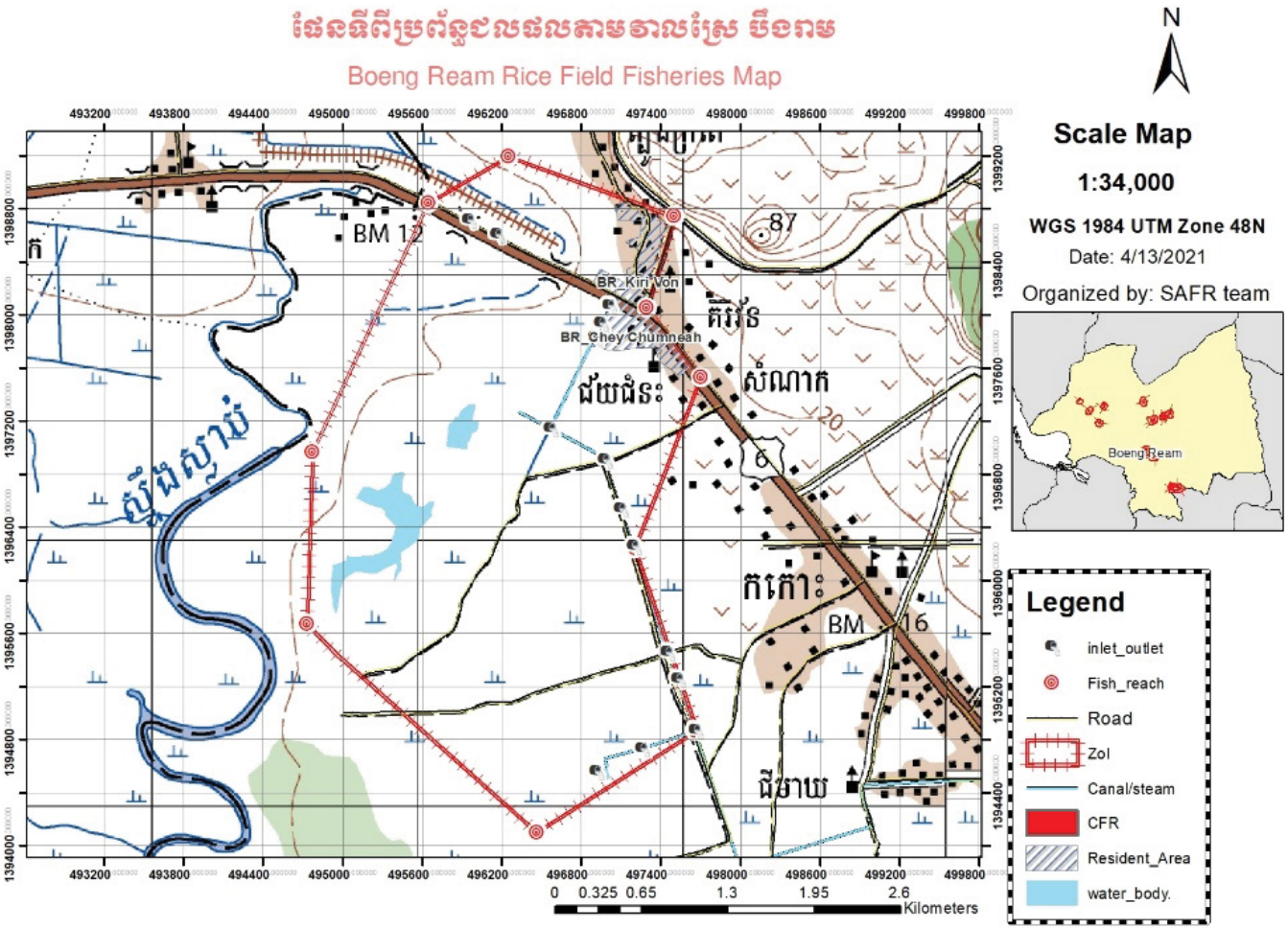
About 995ha of rice fields surround the CFR Beung Ream. Farmers have used water from the irrigation canals and Beung Ream to irrigate rice farming, particularly in the dry season. Farmers having rice fields around the Beung Ream cultivates 2-3 rice crops per year. First, from May to July/August, farmers cultivate rice, based on rainfall; second, from September to November/December, farmers cultivate rice using water from irrigation; third, from January to March, farmers use the water from the irrigation canals to cultivate the rice farming, but usually not enough, and therefore, they pump water from the CFR Beung Ream to supplement their rice farming.

There are about 572 households that do regular fishing, harvesting fish and aquatic animals, usually in the catchment area, which is flooded by the field fisheries system during the rainy season. Among them, 294 households do fishing in the CFR area. They fish for about 5 months a year. However, fish products from the field fisheries system benefit 716 families, about 20 percent of whom are poor farmers. The annual estimated fish catch from the rice field fishery is about 88kg/household/year. In addition, the annual estimated catch of other aquatic animals (OAAs) is about 48kg/household/year.

CFR Committee has collected the membership fees from villagers of about 3000 riel/household/year. About 63 households only paid the membership fees in 2022. The CFR Committee has also raised funds during Buddhist ceremonies such as Khmer New Year and other religious ceremonies. There is a record of financial management by the Cashier.

The CFR Committee and its members have developed the annual plan 2023 to implement the activities to protect the CFR. This plan covers several activities including: (1) Digging the ponds in CFR, (2) Building the guarding post for the patrolling team to keep watching the CFR area; (3) Install the Solar panels in the CFR areas; (4) Digging the canals around the CFR area; (5) putting the signed boards.

Figure 5. Map of the CFR Beung Ream and the Streams and Canals entering into the CFR Area.



4.4.4. CFR Beung Phlang

The CFR Beung Phlang is situated in the center of the Ampil Krau irrigation system, and it is surrounded by ricefields. Fish from CFR Beung Phlang could migrate from the CFR areas to ricefields through these sub-canals and will make the ricefield abundant in fisheries. Next to the private's dug pond is the Community Fish Refuge (CFR). Some areas on the western side of the CFR were excavated to supply soil to the brick industries, and it later was established by three villages in Ampil Krau Commune—(1) Peanea; (2) Kbal Beung, and (3) Svay Teap—to be the CFR to protect the land, fish and biodiversity in the CFRs for communities to use. It is only fishing areas remaining in Ampil Krau for villagers to fish apart from rice farming.

Ampil Krav Commune has 5 villages with a total population of 17,572 people from 2112 HHs. About 85% are doing farming and 20% are fishing. There are 8 brick industries in the commune that could employ 5,000 people from within the commune. About 70% of them are working as laborers in the textile industry. In Ampil Krav Commune, there is surrounded by the Vaiko Irrigation Schemes built by Chinese Firms in 2015—02 main canals and 10-12 sub-canals. However, villagers have not been using much water from the Vaiko Irrigation as there is not enough water and four out of five villages are doing only one rice crop a year, which is a wet season rice. Only one village, which is Svay Teap, is doing 3 rice crops a year. The canal system is getting shallow. At each village, there is a water gate and in each village, there is one person who is in charge of closing and opening up the water gate.

The CFR Beung Khlan covers about 27 ha with about 1,800m in length and 200m in width, and it is about 6 m in depth. The CFR holds water year round with a 6m water level in the wet season and 2m in the dry season. The deepest area covers 12ha, managing as the conservation area. It has been demarcated with poles plotted around the CFR areas. Communities have released fish fingerlings 2-3times in the past, and the fish stocks in the CFR have been rich, which sometimes migrate to ricefield around the CFR (Figure 2). There is a CFR Committee of nine members, elected from the three villages mentioned above, and it is chaired by Mr. Chheang Mao from Peanea Village. Villagers from these villages are allowed to fish inside the CFR, but not in the conservation areas.

The CFR Beung Phlang is located within the Vaiko-1 irrigation system, which was built in 2015 by a Chinese Company, with a total length of 28km that could irrigation 60,000ha in Prey Veng Province. In this system, there are two main irrigation canals with one pumping station to pump water to supply these two canals. There are several water gates along the main canals to release water from the main canals to sub-canals. There are two vertical sub-canals and four horizontal sub-canals. One vertical and one horizontal sub-canal link the CFR Beung Phlang to the main canals.

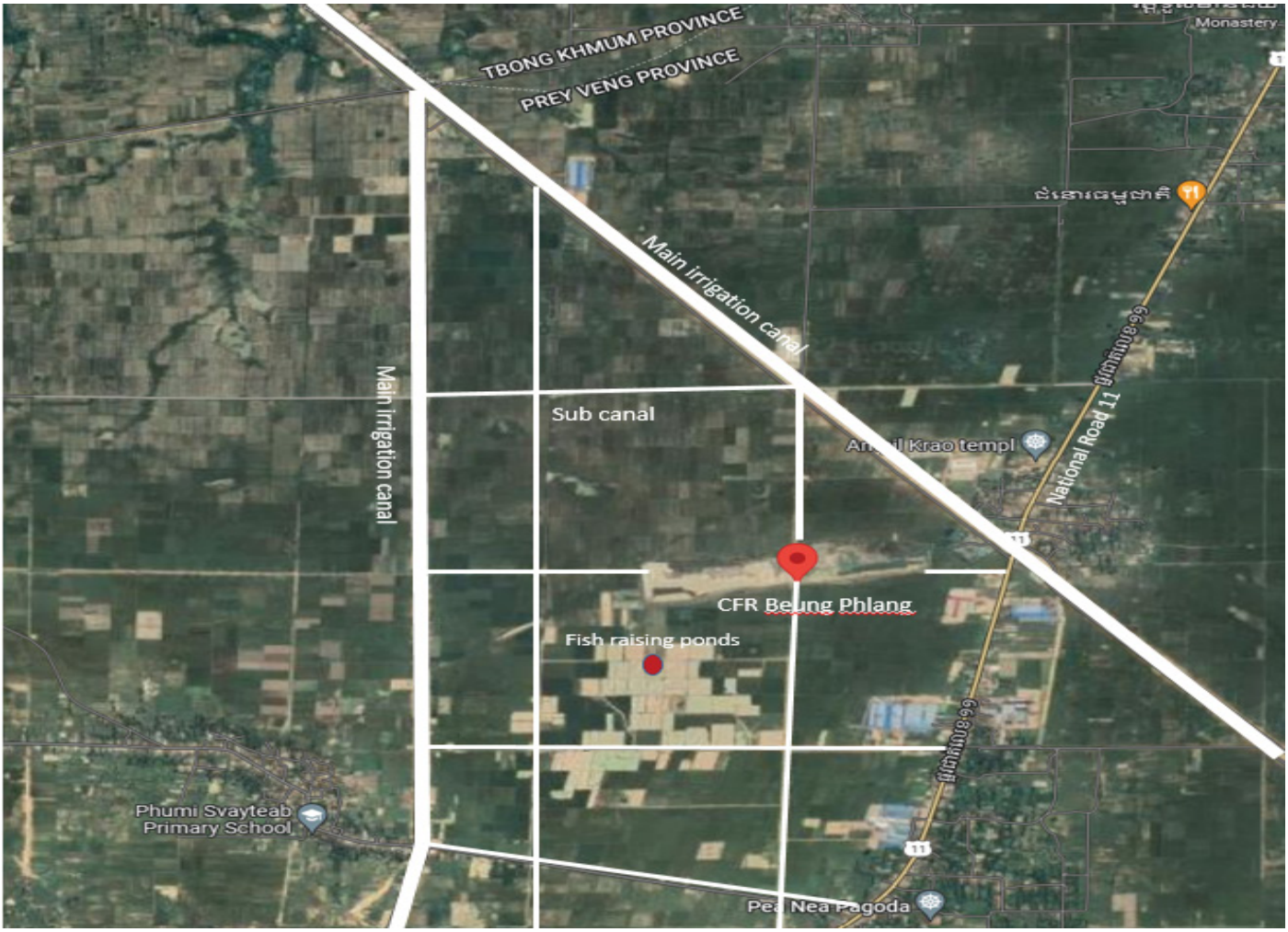
CFR Beung Phlang is established by 3 villages in the commune—Svay Tep, Penea, and Kbal Beung. The Beung Phlang is still rich in the fishery and it is surrounded by ricefield. The fish catch is estimated at about 25kg/ha. About 10% of villagers are doing fish raising. People consume more fish in their daily foods. Around the Beung Phlang, there are about 20 ponds, which raise fish by the pond owners. Farming is a main source of income. The rice yield is 3 tons/ha—wet season rice, which is done by many households. The dry season rice yield is about 4 tons/ha.

However, the main canals and sub-canals are poorly managed and lack maintenance. Some parts of the main canals are eroded which needs repairs. They are now shallowed and are unable to convey water from the main canals to the sub-canals. Due to poor maintenance, most of the sub-canals do not work and they are disconnected from the main canals and ricefields. As a result, farmers suffer from water shortages. The droughts and floods make further deterioration the system, bringing about a greater disconnection between the irrigation system and ricefields. As a consequence, some farmers give up farming and migrate to cities or overseas for wage employment, as they need quick returns, as cannot rely on farming. Some sold out their farmlands to private individuals, who dig the clay soils to supply the brick industries. About 75% of the population in the commune works in the brick industries, as they earn more income, and some migrate to work in the cities and overseas.

Some 20 private individuals bought land in Ampil Krau commune to excavate the clay soils to supply the brick industries. It later turns out to be a big pond or hole. Some owners release fingerlings into the ponds. Later these areas turn out to be aquaculture ponds. The depth of the pond is about 5-6m depth and the size is about one hectare for the smallest one. To do so, the private owners of the aquaculture ponds start keeping the water in the ponds for the aquaculture and sometimes during the dry season pump water in to keep their aquaculture productive. Thus, water becomes an essential and needed resource for aquaculture.

The CFR, ricefields, irrigation canals and sub-canals, and ponds form a closed system, which could produce a lot of food to support the livelihoods of local communities. However, the system is disconnected due to the design, weak coordination, lack of participation of local communities in managing and maintaining it, impacts of climate change on rice farming and water scarcity, and low yields. These have made farmers give up farming activities and move to other wage labor. The influence of the private sector over land speculation made some farmers sell out their farmland to provide for individuals and turned the farmlands into a deep hole, which cannot be used for rice farming. In the long run, it turns out negative without appropriate measures to support farmers.

Figure 6. Irrigation system in Ampil Krau in Sithor Kandal District.



4.4.5. Water and Fishery in the Irrigation System

Water is key to the survival of fish and its productivity. Water flows have been changed across the study areas due to the canal development, irrigation system building, and infrastructure construction, which affect the fishery and migratory fish. These canals, irrigation and infrastructure development have disconnected the Mekong River, Tonnle Sap Floodplain and the Prek Ampil River from the Beung Sneh Lake and Ta Soung Floodplains. The dis-connectivity between the Rivers and the Beung Sneh Lake and Ta Soung Floodplain have reduced the water flows in the lake and the floodplains, which have affected the lake environment, fishery and biodiversity. These changes would have affected on the fishery production and the fishery resource uses.

The fishery domains such as rivers, lakes and floodplains are divided by the canals and water gates, which control and regulate the flows of water between rivers, lakes and ricefields. Fish and fish migrations from the rivers to the lakes and floodplains have been blocked partly and wholly. Thus, through the observation and the discussions with communities, there are less fish population in the rice fields in the studied sites.

Also, the irrigation system and policy pay less attention to fishery, only to water management for rice farming. The irrigation canal operations to some extends undermine fisheries, for instance, sometimes irrigation canals are empty in order to get out water to rice fields, leading to destruction of fishery resources in the irrigation canals. Often, farmers pump the water from the irrigation canals until the empties of waters in the canals, which is destructive to fishery. There is also no management system of fishery in the irrigation canals and so, farmers often are empty the canals to catch fish.

4.4.6. Competing for Water between CFis/CFRs and FWUCs

CFis are organized at the sources of water for the irrigation schemes. Some areas in the CFis are managed as fishery conservation covered by full water for year round. CFis and CFRs work to protect rivers and lakes and waters in the lakes and rivers to maintain a conducive environment for fish and fish habitat so that fish could survive.

However, all irrigation schemes in the study areas have water sources in these CFis. These irrigation schemes are built to take water from the Prek Ambel River, Taign Krasaing River, and the Beung Sneh lake, where CFis and CFRs are established. The FWUCs are actually established to decentralize water extraction for rice farming, particularly in the dry season,

involving agricultural households. Without water, the dry season rice farming will be spoiled and this means farmers lose their incomes. Thus, all efforts are made to secure water for the dry season rice farming at any cost.

Thus, CFis/CFRs and FWUCs/irrigation schemes are working in two different directions—one protects the water sources as much as they can to maintain the fishery productivity, while the other one needs to extract water from the water sources for rice farming to improve the rice yield. However, the extraction of water for rice farming would remove the water from fish and if the removal at the great volumes would spoil the fishery and aquatic animals in water sources, in this case, the Beung Sneh, Prek Ambel River, Taing Krasaing and Beung Ream. If water is kept for CFis and CFRs at large would result in losing the dry season rice farming, as water shortage prevails and farmers need to protect their rice farming from losing yield and production. These become dilemma for farmers in the study areas.

In Beung Sneh Lake, four CFis suffer from lowest water levels in the dry season in three consecutive years 2020-2023 due to competing pumps of waters for the dry season rice farming by 11 irrigation schemes around the lake and by 10,911 agricultural households in 44 villages. At least, one household pumps using one water pumping generator. The Ta Soung Irrigation Scheme pumps the water from the Prek Ambel River to irrigate 1,511 ha of ricelands in four communes in Prey Kabbas District. Also, in Beung Ream CFR, in the dry season of 2023, farmers pumped water from the CFR, to the lowest water level, to irrigate the rice fields. These have led to endured tensions between the CFis/CFRs and FWUCs, although they are from the same communities.

4.4.7. Pesticide and Fertilizers Affecting Fishery

Fish and fishery have been affected by the rice farming, particularly the pesticide and the fertilizer uses. The pesticide and fertilizer uses for rice farming in the irrigation systems in the stydied areas have significantly increased. About 73% of households in the studied area use fertilizers to fertilize their rice lands during the wet and dry rice farming periods. About 80% of households in Prey Veng applies fertilizers, compared with 67% in Takeo and 31% in Kampong Thom Provinces. In Prey Veng Province, Samraong, Tuek Thla and Damrei Puong communes have the highest percentage of farming households using fertilizers, constituting 88%, 87% & 85% respectively. In Takeo Province, about 82% and 85% of farming households in Kan Kam and Pou Rumchak Communes respectively apply fertilizers in rice farming.

Farmer uses chemical fertilizer for 5-7 bags per ha for one farming season (3 months) starting from the time they broadcast the rice seeds till they harvest. The fertilizers they used include DAP, Urea, and other various types of fertilizer. One bag of fertilizer is about 50kg. However, farmers do not know these fertilizers, but they use them because their neighbor farmers also use them, and when they buy, they learn them from the sellers. The cost of fertilizer is 120,000 riel (USD30) per bag, and in total, it cost USD150-210 for fertilizer uses per ha. These fertilizers are imported mostly from Vietnam and they are sold publicly. The knowledge about fertilizers and how they should be used is limited based on the discussion with them during the interviews.

Apart from fertilizer, farmers apply pesticides to kill the pests that destroy their paddy rice. Farmers do not know the trademarks of pesticides, but they use because their farmer neighbors use them and the sellers instruct them how to use them. About 70% of households in the studied communes apply pesticides at all times during rice farming seasons. Farmers in Prey Veng Province use pesticides more than other provinces, accounting for 78%, followed by Takeo at 69%. In Prey Veng, farmers using pesticides in Damrei Puon, Samraong, Ampil Krav, and Prey Kandieng Communes constitute 90%, 83%, 81% and 80% respectively, which are the highest compared with other communes in the studied areas. These are the communes that are located in a distance from the Beung Sneh, which experience water shortages during the rainy season. In Takeo, Pou Rumchak and Ban Kam Communes have higher percentages of farmers using pesticides for rice farming, accounting for 83% and 80% respectively.

Figure 7. Pesticide uses by farmers in Beung Sneh, Prey Veng Province.

The farmer informs us that they use 9 containers of pesticide per hectare. One container costs 15,000 riels (USD3.75) and then, the total cost of the pesticide used per hectare is USD33.75. The fee for pesticide spraying is 5,000 riel/ha (USD1.25). The sum of the total cost for pesticide use per hectare is USD35. However, the farmer sprays pesticide 3-4 times/ha until the rice is harvested, and then, the total cost is USD105-140. The uses of pesticides kill aquatic animals, including fish, and thus, not many fish are reported by farmers in the ricefields. Farmers also report about the uses of other chemical inputs to kill grasses and invasive snails. There is an increase in invasive snails in their rice fields, which destroy the paddy rice without proper protection. However, the percentage of households using organic pesticides and fertilizers is relatively low, 2% and 5% respectively. In some villages such as in Prey Kandieng Commune, farmers are no longer used organic fertilizers and pesticides.

Many kinds of fertilisers, distributed by different importers and distributors, were available in the market. The single-nutrient products were urea and muriate of potash (KCl). Compound nitrogen-based fertilisers included di-ammonium phosphate (DAP) (18-46-0) and ammonium sulphate (16-20-0). Compound nitrogen, phosphorus, and potassium (NPK) products were available on the market in ratios of 15-15-15, 16-16-8-(13S), and 20-20-15. All fertilisers were sold in 50 kg bags, though farmers could buy products by the kilogramme. Most of the fertilisers sold in the market were labelled in Khmer, with the exceptions of 16-16-8-13 produced in the Philippines and urea from China and Vietnam, though these products were marked with small stickers in Khmer.

4.5. Improving Water Governance—Way Forwards

Improving water governance is essential to improving rice farming and fishery production. In doing so, the integrated approaches—institutions and policy—should be promoted and decentralized. Indeed, decentralization has been implemented in natural resource management. CFis and CFRs are forms of decentralized fishery management where local communities are empowered to manage their own resources for their uses and management. Also, FWUCs are another form of decentralization of water resources by local communities. These are sectoral decentralization in which technical sectoral centralized agencies are undertaken the vertical decentralization, but they are not doing the horizontal decentralization. These decentralization practices remain challenges as technical and financial resources remain centralized. As a consequence, two FWUCs were established in the Beung Sneh by MOWRAM, four CFis were established by FiA, and one Community-based Eco-tourist (CBET) was established by MoE in the Beung Sneh Lake. Each community organization is institutionalized by the centralized and technical lined ministries, which make the CFis, CBET and FWUCs unintegrated and listen to their lined ministries. Also, in Ta Soung Communities, although they are from the same communities, CFis are under the direction supervisions of FiA and FiACs, while FUWC is under MOWRAM/PDOWRAM.

Furthermore, in the Beung Sneh Lake, different Communes tend to manage the Beung Sneh Lake from the geographical locations of the Communes in the lake, and it lacks the integrated approaches to manage the Beung Sneh Lake. Competitions between communes in the lake have led to the uncertainty of the lake in the future. In the Ta Soung, CFis and FWUCs are two different entities in the same Communes, for instance, Ban Kam and Pou Rumchak, where FWUCs take water from the CFis to sustain rice farming and collect water fees from rice farmers in the communes, but do not return any inputs to protect their water sources where CFis are existed to protect it. Lack of integration and connection between FWUCs and CFis leaves in uncertain sustainable future. Also, the Beung Ream and the Kakoh Irrigation Canal are connected in one integrated system, but they are operating indepently, one under the FiA and another one under MOWRAM/PDOWRAM.

However, FWUCs in Taing Krasaing, Ta Soung and Chamcar Kyou Irrigation Systems are managed under the District Agriculture, Environment and Water Resource Office (DAEW), in which District Officers in charge of water resources are responsible for managing FWUCs. Also, District Agriculture Officers are also responsible for fishery management as well as agriculture. DAEW is coordinating the agriculture, environment and water management at the district level, and they report to District Governors and also the Provincial Departments of Agriculture, Water Resources and Meteorology, and Environment.

Nonetheless, DAEW is still new and has limited capacity and resources to deal with the growing issues of water, fishery, and agriculture. They still have not given the fully power to implement their roles and responsibilities given the limited capacity and staff. They need at large the capacity building and orientations to improve water governance, fishery management and agricultural development. In the future, working with DAEW would address the integration of water, fishery and agriculture and the decentralization of natural resource management.

The Uses of Chemical Inputs in rice farming.

Site	Commune	No. of HHs	HHs using chemical fertilizers		HHs using organic fertilizers		HHs using pesticides		HHs using organic pesticides (nature) for killing pests and grass	
			No	%	No	%	No	%	No	%
Beung Phlang	Ampil Krau	1981	1610	81	77	4	1606	81	71	4
Beung Sneh	Theay	2964	2240	76	186	6	2170	73	157	5
	Damrei Puon	2679	2284	85	32	1	2402	90	16	1
	Samraong	2482	2179	88	43	2	2060	83	25	1
	Tuek Thla	2820	2457	87	23	1	2107	75	15	1
	Me Bon	2109	1531	73	67	3	1521	72	0	0
	Baray	1655	1256	76	27	2	1256	76	0	0
	Ta Kao	3739	2752	74	50	1	2754	74	4	0
	Prey Kandieng	2887	2308	80	60	2	2308	80	6	0
Sub-total	9	23316	18617	80	565	2	18184	78	294	1
Boeung Ream	Kakoh	3325	1023	31	536	16	609	18	81	2
Ta Soung	Ban Kam	1607	1320	82	111	7	1290	80	0	0
	Kampong Reab	532	220	41	100	19	220	41	100	19
	Pou Rumchak	778	662	85	25	3	648	83	55	7
	Prey Lvea	814	307	38	53	7	416	51	27	3
Sub-total	4	3731	2509	67	289	8	2574	69	182	5
Grant total	14	30372	22149	73	1390	5	21367	70	557	2

Source: *Commune Database 2021*

5. Conclusion

Cambodia has abundant water resources in general, but it has a little water in the dry season. The increased dry season rice farming in many provinces, following the increased rice export policy in Cambodia and the spill-over effects of rice trade in Vietnam has led to high demands for water for dry season rice farming. These have led to water shortage and conflicts over water among farmers in the farming provinces, and between sectors, for instance, fishery and rice farming.

Irrigation system development and improvement have improved water management and support to agricultural development. Rice farming areas have been expanded to around 2 million ha and rice farming has been increased from one rice crop to three rice crops a year. These have increased the high demand of waters for rice farming.

The irrigation System is physical infrastructure, which is imposed its structures on the physical landscapes. It then divides the land and waterscapes and blocks the flows and migration of fisheries in the floodplains and river systems in order to direct the irrigational flows to the rice fields. It divides the land and waterscape into blocs and plots that water could flow to and stay for the rice growing periods. Further, it has blocked the fish migrations between the rivers, floodplains, lakes and rice fields. However, there is no system in place to manage fisheries in the irrigation system. Fishery is often ignored in the irrigation management, as no expertise involved in the irrigation management. Thus, fishery productivity is low in the irrigation system and the rice fields where there are plenty of water.

The irrigation management has been decentralized toward to Farmer Water User Communities (FWUCs), promoting the water fee system among members of FWUCs. To do so, FWUCs and the irrigation schemes keep pumping water from rivers and lake system, where Community Fisheries (CFis) or Community Fish Refuges (CFRs) are established to protect fisheries and water resources. While CFis and CFRs work to protect water for fishery, FWUCs and the irrigation schemes work to extract water to irrigate the rice farming. These two systems are connected by water, but they are opposite in the approaches. Often, these two communities are competing for water and conflicting over water resources.

On the other hand, fishery and its productivity are undermined and affected by the agricultural practices, particularly the uses of agricultural inputs such as pesticides, fertilizers and chemical inputs to kill pests and herbs. These agricultural inputs are harmful to fishery and aquatic animals. Thus, even there are water, but there are not many fish and aquatic animals in the rice fields.

Water governance remain sectoral, technical and centralized, which have affected on the productivity of water, fishery and agriculture, and cost of the productions and it also has induced conflicts between sectors and among farmers. Water governance can be done through improving coordination between sectors and agencies. It also needs an integration of different sectors and agencies, and decentralization. Institutional integration should be strengthened to combine water, fishery, agriculture and water resource management into one management system down at the ground. The district agriculture, water resources and environment office should be strengthened to manage this integration.

List of figures

List of tables

References

Asian Development Bank (ADB) (2021). *Cambodia Agriculture, Natural Resources, and Rural Development Sector Assessment, Strategy, And Road Map*. Manila, Phillippines, 2021.

Asian Development Bank (ADB) (2004). *Proposed Revision of the Water Policy of the Asian Development Bank*; Asian Development Bank: Manila, Philippines.

Arias, M.E., Piman, T., Lauri, H., Cochrane, T.A. and Kummu, M 2014. Dams on Mekong tributaries as significant contributors of hydrological alterations to the Tonle Sap Floodplain in Cambodia. *Hydrol. Earth Syst. Sci.,* 18, 5303–5315. www.hydrol-earth-syst-sci.net/18/5303/2014/ doi:10.5194/hess-18-5303-2014.

Arias ME, Cochrane TA, Piman T, Kummu M, Caruso BS, Killeen TJ. (2012). Quantifying changes in flooding and habitats in the Tonle Sap Lake (Cambodia) caused by water infrastructure development and climate change in the Mekong Basin. *Journal of Environmental Management*, 112, 53-66.

Bann C. and Sopha L. (2020). *Fish Counts: increasing the visibility of small-scale fisheries in Cambodia's national planning*. IIED Working Paper. http://pubs. iied. org; 2020.

Cambodian Development Research Institute (CDRI) (2011). *Hydrological Analysis in Support of Irrigation Management: A Case Study of Stung Chrey Bak Catchment, Cambodia*; CDRI Working Paper Series No. 59; CDRI: Phnom Penh, Cambodia,p. 55.

Center for Agriculture Development Study (2009). *Inventory of Irrigation Schemes and Famer Water User Communities in Cambodia*; CEDAC and Water Program; CEDAC: Phnom Penh, Cambodia.

Chen A, Liu J, Kummu M, Varis O, Tang Q, Mao G, Wang J, Chen D. (2021). Multidecadal variability of the Tonle Sap Lake flood pulse regime. *Hydrological Processes* 2021, 35, 9, e14327.

Chua SD, Lu XX, Oeurng C, Sok T, Grundy-Warr C. (2022). Drastic decline of flood pulse in the Cambodian floodplains (Mekong River and Tonle Sap system). *Hydrology and Earth System Sciences* 2022, 26, 3, 609-25.

Dore, J. (2014). An agenda for deliberative water governance arenas in the Mekong. *Water Policy 16*, 194–214.

Dore, J.; Lebel, L.; Molle, F. (2012). A framework for analysing transboundary water governance com-plexes, illustrated in the Mekong Region. *J. Hydrol. 466–467*, 23–36.

Global Water Partnership (2002). *GWP in Action*; Global Water Partnership: Stockholm, Sweden.

FAO. 2021. FAO Database. Available online: http://www.fao.org/nr/water/aquastat/data/query/results.html (accessed on 12 October 202).

Fisheries Administration (2022). *Report on Status of Community Fisheries Assessment in 2018.* Community Fisheries Development Department (CFDD), Fisheries Administration (FiA): Phnom Penh, Cambodia, 2022.

Frenken K, (2011). editor. *Irrigation in Southern and Eastern Asia in figures*. Rome: Food and Agriculture Organization of the United Nations, 2011.

Hoang LP, van Vliet MT, Kummu M, Lauri H, Koponen J, Supit I, Leemans R, Kabat P, Ludwig F. (2019). The Mekong's future flows under multiple drivers: How climate change, hydropower developments, and irrigation expansions drive hydrological changes. *Science of the Total Environment*, 649, 601-9.

Hufty, M. (2011). Investigating Policy Processes: The Governance Analytical Framework (GAF).
Available online: https://ssrn.com/abstract=2019005.

Lebel, L.; Bastakoti, R.C.; Daniel, R. (2010). *CPWF Project Report: Enhancing Multi-Scale Mekong Water Governance*; Project Number PN50; CGIAR Challenge Program on Water and Food: Chiang Mai, Thailand, p. 91.

Lefebvre H. (1991). *The social production of space*. Malden, MA, Blackwell Publishing.

Liu J, Chen D, Mao G, Irannezhad M, Pokhrel Y. (2022). Past and future changes in climate and water resources in the lancang–mekong River Basin: Current understanding and future research directions. *Engineering*, 13, 144-52.

Ly, V. (2018. *The Baseline Assessment of the Effectiveness of Community Fisheries in Cambodia.* The Community Fisheries Development Department (CFDD), Fisheries Administration (FiA): Phnom Penh, Cambodia.

MOWRAM (2019). *Water Strategic Development Plan, 2019-2023*. MOWRAM: Phnom Penh, Cambodia.

Nang, P.; Khiev, D.; Hirsch, P.; Whitehead, I. (2011). *Improving the Governance of Water Resources in Cambodia: A Stakeholder Analysis—Understanding Stakeholders' Roles, Perceptions and Constraints for Effective Irrigation and Catchment Management and Development*; Working Paper Series No. 54; Cambodia Development Research Institute: Phnom Penh, Cambodia.

Nang, P.; Ouch, C. (2014). *Gender and Water Governance: Women's Role in Irrigation Management and Development in the Context of Climate Change*; Working Paper Series No. 89; Cambodia Development Research Institute: Phnom Penh, Cambodia.

National Institute of Statistics (NIS). (2022). *Cambodia Agriculture Survey (CAS) 2020.* Ministry of Planning: Phnom Penh, Cambodia.

Öjendal J, Mathur V, Sithirith M. (2002). *Environmental governance in the Mekong. Hydropower site selection processes in the Se Son and Sre Pok basins*. Stockholm Environment Institute: Bangkok, Thailand.

Ojendal, J. (2000). *Sharing the Good: Modes of Managing Water Resources in the Lower Mekong River Basin*; Göteborg University Department of Peace and Development Research: Goteborg, Sweden, 2000.

Ostrom, E. *Governing the Commons: The Evolution of Institutions for Collective Action*; Cambridge University: New York, NY, USA, 1990.

Perry, C.; Rock, M.; Seckler, D. (1997). *Water as an Economic Good: A Solution, or a Problem?* International Water Management Institute: Colombo, Sri Lanka, p. 24.

Ratner, B.D.; Cohen, P.; Barman, B.; Mam, K.; Nagoli, J.; Allison, E.H. (2013). Governance of aquatic agricultural systems: Analyzing representation, power, and accountability. *Ecol. Soc.* 2013, *18*, 59.

Rogers, P.; Alan, W.H. (2003). *Effective Water Governance*; TEC Background Papers No. 7; Global Water Partnership/Swedish International Development Agency: Stockholm, Sweden, 2003.

Royal Government of Cambodia (RGC) (2015). *Sub-Decree on Farmer Water User Community*. RGC, no. 73.

Royal Government of Cambodia (RGC). (2005). *Sub-decree on community fisheries*. No 25 OrNor Kror BorKor. Royal Government of Cambodia.

Savenije, H.H.G.; van der Zaag, P. (2002). Water as an economic good and demand management: Paradigms with pitfalls. *Water Int. 27*, 98–104.

Sithirith M. (2021). Downstream state and water security in the Mekong region: a case of Cambodia between too much and too little water. *Water* 2021, *13*, 6, 802.

Sithirith M. (2017). Water governance in Cambodia: From centralized water governance to farmer water user community. *Resources, 6*,3, 44.

Sokhem P, Sunada K. (2006). The governance of the Tonle Sap Lake, Cambodia: integration of local, national and international levels. *International Journal of Water Resources Development* 2006, 22, 3, 399-416.

Tortajada, C. (2010). Water Governance: A Research Agenda. *Int. J. Water Resour. Dev. 26*, 309–316.

Wokker C, Santos P, Bansok R. (2014). Irrigation water productivity in Cambodian rice systems. *Agricultural Economics* 2014, 45, 4, 421-30.

Authors

Mak Sithirith, Sok Sao, Sanjiv De Silva, Heng Kong, Chay Kongkroy, Tim Thavrin and Hy Sarun.

Citation

This publication should be cited as: Sithirith M, Sao S, Silva SD, Kong H, Kongkroy C, Thavrin T and Sarun H. 2024. Water-Land-Food Nexus: Water Governance for Fish Production and Rice Farming. Penang, Malaysia: WorldFish. Technical Report.

Acknowledgments

Funding support for this study was provided through CGIAR Initiative on Asian Mega-Deltas. This work was carried out with support from the CGIAR Asian Mega-Deltas (AMD) and Aquatic Foods (RAqFs) Initiatives. We would like to thank all funders who supported this research through their contributions to the CGIAR Trust Fund: *www.cgiar.org/funders*.

Design and production

Chua Seong Lee, Thavamaler Ramanathan and Sabrina Chong, WorldFish.

Photo credits

Front cover, Sean Vichet/WorldFish.

CGIAR is a global research partnership for a food-secure future. CGIAR science is dedicated to transforming food, land, and water systems in a climate crisis. Its research is carried out by 13 CGIAR Centers/Alliances in close collaboration with hundreds of partners, including national and regional research institutes, civil society organizations, academia, development organizations and the private sector. *www.cgiar.org*

To learn more about this Initiative, please visit *https://www.cgiar.org/initiative/asian-mega-deltas/*.

To learn more about this and other Initiatives in the CGIAR Research Portfolio, please visit *www.cgiar.org/cgiar-portfolio*

WorldFish

IWMI International Water Management Institute

CGIAR INITIATIVE ON Aquatic Foods

CGIAR INITIATIVE ON Asian Mega-Deltas