Journal of Rural and Community Development

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Citation:
Baldivieso Soruco, C. R., Bonatti, M., De Silva, S., Ou, P., Soeun, K. O., Neth, S., Sun, V., Rodríguez, T., Sean, V., Sithirith, M., Dubois, M. & Sieber, S. (2025). Disentangling community-based resource governance through knowledge systems mapping: Insights from community fish refuges in Rural Cambodia. *The Journal of Rural and Community Development*, *20*(2), 1–33.

Publisher:
Rural Development Institute, Brandon University.

Editor:
Dr. Doug Ramsey

ISSN: 1712-8277 © Authors
www.jrcd.ca

Disentangling Community-Based Resource Governance Through Knowledge Systems Mapping: Insights from Community Fish Refuges In Rural Cambodia

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Abstract

Inland fisheries in Cambodia are of great importance to the livelihoods of rural communities, as they provide sustenance and seasonal income for the local population. Community fish refuges (CFRs) are natural or human-made water bodies that hold water throughout the year, providing a dry-season sanctuary for aquatic life. Managed mainly by the local community, CFRs support diverse ecological and human functions, such as biodiversity repositories, including fish stocks, and provide water for irrigation, livestock, and domestic needs. These initiatives have been promoted by several organizations in Cambodia since the 1990s, showing positive ecological impacts and improving food security, especially for marginalized populations. However, the social dimensions of management, the role of local knowledge, and the underlying knowledge systems remain understudied. The objective of this study is to gain insight into the governance mechanisms of CFRs in relation to the local knowledge of management. Four CFR projects conducted by WorldFish and NGO partners between 2016 and 2021 in Central Cambodia were selected for the analysis. A participatory approach was employed using causal loop diagrams (CLDs) through focus group discussions (FGDs) with local stakeholders (n = 38). The methodological approach was based on three phases: exploratory interviews (n=23), causal-loop FGDs (n=4), and FGDs for data validation (n=4). Our study highlights the importance of context-specific and relational knowledge in CFR management, as well as the importance of institutional structures, power dynamics, and social differentiation in shaping knowledge access, distribution, and management. Social mobilization mainly involves village representatives mediating between villagers and external entities, with a certain degree of concentration of power within groups of stakeholders. Enhancing community governance through more inclusive, dialogue-based communication and potentially leveraging informal networks is recommended to channel social learning, considering the sociocultural context and challenges of decentralization in Cambodia.

Keywords: Aquatic food systems, causal-loop diagrams, collective action, community-based governance, knowledge systems

Démêler la gouvernance communautaire des ressources grâce à la cartographie des systèmes de connaissances : points de vue des refuges de poissons communautaires dans le Cambodge rural

Résumé

Au Cambodge, la pêche continentale revêt une grande importance pour les moyens de subsistance des communautés rurales, car elle assure la subsistance et un revenu saisonnier à la population locale. Les refuges communautaires de poissons (CFR) sont des plans d'eau naturels ou artificiels qui retiennent l'eau tout au long de l'année, offrant ainsi un sanctuaire pour la vie aquatique pendant la saison sèche. Gérés principalement par la communauté locale, les CFR soutiennent diverses fonctions écologiques et humaines, telles que les réservoirs de biodiversité, y compris les stocks de poissons, et fournissent de l'eau pour l'irrigation, le bétail et les besoins domestiques. Ces initiatives ont été promues par plusieurs organisations au Cambodge depuis les années 1990, démontrant des impacts écologiques positifs et améliorant la sécurité alimentaire, en particulier pour les populations marginalisées. Cependant, les dimensions sociales de la gestion, le rôle des connaissances locales et les systèmes de connaissances sous-jacents restent sous-étudiés. L'objectif de cette étude est de mieux comprendre les mécanismes de gouvernance des CFR en relation avec les connaissances locales de gestion. Quatre projets de CFR menés par WorldFish et des ONG partenaires entre 2016 et 2021 dans le centre du Cambodge ont été sélectionnés pour l'analyse. Une approche participative a été utilisée en utilisant des diagrammes de boucles causales (CLD) à travers des discussions de groupe (FGD) avec les parties prenantes locales (n = 38). L'approche méthodologique était basée sur trois phases : entretiens exploratoires (n = 23), groupes de discussion en boucle causale (n = 4) et groupes de discussion pour la validation des données (n = 4). Notre étude met en évidence l'importance des connaissances contextuelles et relationnelles dans la gestion des CFR, ainsi que l'importance des structures institutionnelles, des dynamiques de pouvoir et de la différenciation sociale dans l'élaboration de l'accès, de la distribution et de la gestion des connaissances. La mobilisation sociale implique principalement des représentants villageois faisant office de médiateurs entre les villageois et les entités extérieures, avec un certain degré de concentration du pouvoir au sein de groupes d'acteurs. Il est recommandé de renforcer la gouvernance communautaire grâce à une communication plus inclusive basée sur le dialogue et de tirer potentiellement parti des réseaux informels pour canaliser l'apprentissage social, compte tenu du contexte socioculturel et des défis de la décentralisation au Cambodge.

Mots clés : systèmes alimentaires aquatiques, diagrammes de boucles causales, action collective, gouvernance communautaire, systèmes de connaissances

1.0 Introduction

Fishing is an integral part of daily life for most rural Cambodians, whether in rivers, lakes, or seasonally flooded rice fields (RF). Inland fisheries are essential for subsistence and seasonal income (Freed, Kura, et al., 2020). However, these are declining due to habitat loss and environmental degradation—facing threats such as overfishing, negative impacts of hydropower dams, loss of habitat, pollution, increased mining, sedimentation, and climate change (Joffre et al., 2012; Phala et al., 2019). Addressing these challenges is crucial for enhancing fish availability to ensure sufficient food production while preserving biodiversity and ecosystem integrity. As rice production intensifies, the loss of naturally occurring wild aquatic species, which once played a vital role in supporting local food systems, further underscores the need for sustainable solutions (Freed, Kura, et al., 2020).

One way to enhance fish production while supporting the ecological diversity of aquatic food systems is to establish fish refuges, such as Community Fish Refuges (CFRs). These seek to improve rice field fisheries (RFF) productivity by protecting fish populations. CFRs are communal waterbodies in or near villages within the RFF system managed by local people with support from the Fisheries Administration (FiA) (Joffre et al., 2012; Miratori, 2015).

Cambodia, owing to its ecological and geographic conditions, has a rich history of water management (Klassen & Evans, 2020) and food culture rooted in the consumption of aquatic animals and rice (LeGrand et al., 2020; Yamamoto, 2016). Fish and rice are culturally preferred foods and essential for a healthy diet (Freed, Kura, et al., 2020). The supply of fish from rivers and lakes in Cambodia has historically been an important "social safety net" against famine (Sithirith et al., 2024, p. 121). Despite this, the management of RFF lacks fish protection systems such as CFRs, thus presenting a challenge for collective management and requiring a learning process to ensure effective management. Therefore, as CFRs introduce a new management and learning system for this type of integrated approach, we refer to them as *modern-day commons*, in line with how other scholars describe similar community fisheries initiatives in Cambodia (Kurien, 2017). This reflects the idea that CFRs, as multiple-use systems, are common goods that have not traditionally been managed as common-pool resources for fish conservation, but in a contemporary context, they require collective management to ensure sustainability.

Introduced in Cambodia in 1995 by the Asian Institute of Technology, the CFR approach received official endorsement in 2005 with the Royal Government of Cambodia's Declaration on National Fisheries Policy. Since 2007, the government has prioritized the development of CFRs initiatives as rural development projects and launched the "One Commune, One Community Fish Refuge" campaign. The implementation of CFR initiatives is consistent with the legal framework of community fisheries (Joffre et al., 2012; Phala et al., 2019).

In contrast to the coordination required for CFR management, water governance in Cambodia remains sectoral, technical, and largely centralized, with a predominant focus on irrigation. Although water management is decentralized to the provincial level, it remains centralized in terms of the allocation of financial and human resources. Consequently, sectoral policies and competing interests continue to impact the relationship between fisheries and water resources (Sithirith et al., 2024).

In this context, since the 1990s, CFR initiatives have shown positive ecological impacts and improved food security, particularly for marginalized populations

(Freed et al., 2020). They have received attention from the state and international funding channelled through WorldFish to local NGOs. Researchers have analyzed the socioeconomic aspects related to community members' awareness of CFR management and its socioeconomic impacts (Phala et al., 2019). Lessons from project implementation on technical and social design have been drawn and models of CFR governance have been proposed (Brooks et al., 2015; Joffre et al., 2012; Kim et al., 2019) as well as aspects of integrating nutrition and gender into CFR management (Shieh et al., 2019). However, less is understood about how local knowledge systems are able to evolve to meet the challenge of managing a multi-functional resource, the management of which often calls for mediating trade-offs for water between different food production systems. Thus, this study addresses a significant research gap—there has been no analysis of the knowledge systems involved in CFR management or the nature of these systems. It is essential to explore the transformations generated by this project in terms of local knowledge to gain a better understanding of the overall impact of CFRs on local practices and decision-making.

Therefore, this study examines local CFR governance mechanisms in relation to the transformation and application of local knowledge for effective and equitable CFR management, as well as its underlying drivers. To deepen this understanding, we explore two main research questions:

1. How do knowledge development and application shape CFR management outcomes? 1.1. What are the resulting management outcomes? 1.2. How is this knowledge facilitated or created?
2. How do institutional structures and actors shape the production and access to CFR-related knowledge? 2.1. Which institutional structures facilitate the production of CFR-related knowledge? 2.2. Who influences access to CFR-related knowledge, and through what mechanisms?

2.0 Theoretical Basis

2.1 Knowledge, Management, and Community Governance

This study reflects the approach of institutions for good governance, which emphasizes the importance of linking the design of incentives, rules, and sanctions to the principles of representativeness, participation, transparency, and accountability (Brooks et al., 2015; Steffek & Wegmann, 2021). The fields of development and governance of community projects have extensively explored the study and design of appropriate institutions that support these principles (Anderies et al., 2003; Ostrom, 2008). This approach has significantly influenced the politics of natural resource management (NRM), often leading to the establishment of multiple groups and committees within nested governance systems (Cleaver & Whaley, 2018). However, it is crucial to critically examine the nature and implications of such institutional building.

Within this framing, the notion of *knowledge transfer* is increasingly being challenged as knowledge and common sense are recognized as active constructions (Chakraborty et al., 2021; Nightingale, 2013; Zeng et al., 2017). Individuals with different epistemological backgrounds and life experiences possess different forms of knowledge, which lead local communities to perceive community issues through different lenses (Bonatti et al., 2021). Individuals develop explanatory power—the ability to understand, interpret, and articulate the

relationships between ecological processes and resource management—by actively engaging with their environment. This engagement includes observing ecological patterns, understanding nature and species-specific behaviour, and accessing and using the ecological system, all of which contribute to building localized food systems. Consequently, knowledge acquisition is influenced by geographic spaces alongside social-ecological and political dynamics associated with governance networks (Lamb, 2018; Sithirith, 2011).

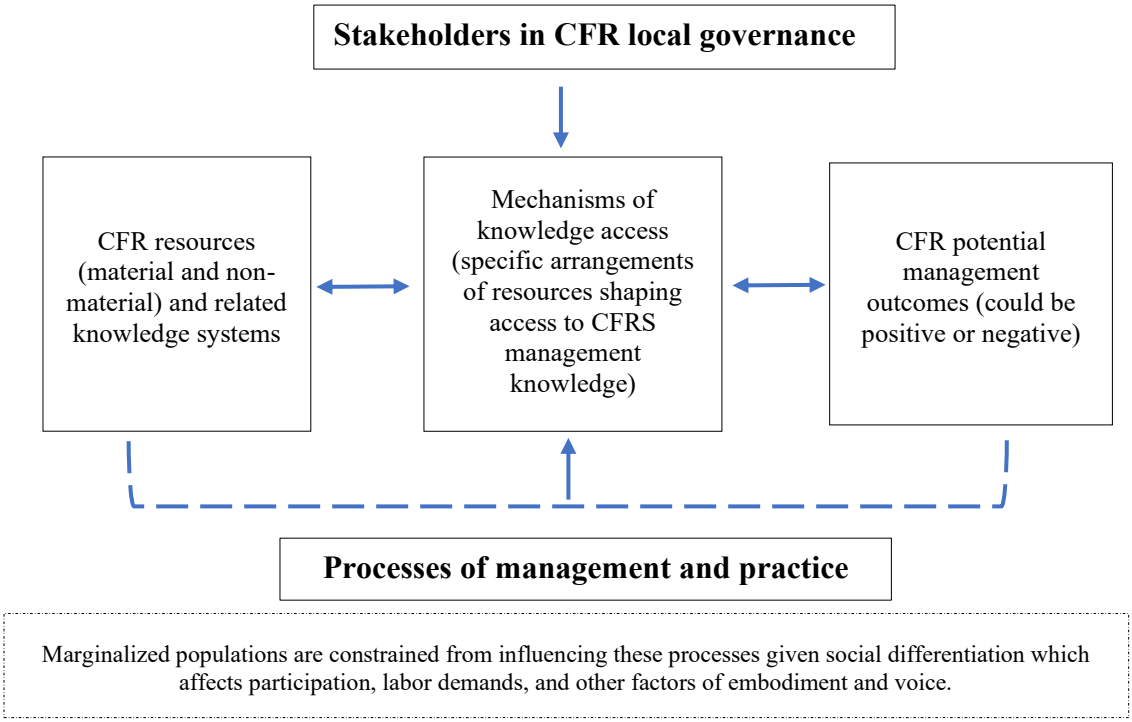
Our research builds on the interrelationship between collective action and collective learning processes for NRM, based on the premise that transformative community action can only materialize through reflective collective learning about the reality in need of transformation for the NRM challenge. The practice of dialogical communication in learning is crucial for defining strategies and promoting transformative change (Bonatti et al., 2019; Freire, 2020). Understanding collective action for ecological management across diverse knowledge systems requires recognizing the role of human perceptions in acquiring explanatory capacity through social-ecological interactions (Tengö et al., 2014).

NRM occurs within the space of social interaction and is shaped by ethical values, cultural norms, and social standards (Cleaver, 2012; Rist et al., 2007). Consequently, processes related to purposeful institutional design (Thiel et al., 2015), such as community-based governance implemented based on external ideals (even if collaborative), are subject to scrutiny by local communities (Gebara, 2019). This process is called institutional bricolage by critical institutionalists, bringing anthropological insights into the institutional economics sphere (Cleaver & Whaley, 2018). Bricolage refers to "processes by which groups of individuals consciously and unconsciously participate in reshaping institutional arrangements for managing… natural resources based on whatever tools or resources are readily accessible to them" (Bersaglio & Cleaver, 2018, p. 468. Hence, institutional formation entails adaptive processes whereby people inscribe configurations of rules, traditions, norms, and relationships with meaning and authority (Cleaver & De Koning, 2015). In this setting, this study questions social dichotomies related to knowledge—such as traditional knowledge and scientific knowledge or indigenous knowledge and Western knowledge (Agrawal, 1994, 2002)—instead considering their placement within overlapping, possibly combined, knowledge systems (Rivera Cusicanqui, 2018; Šūmane et al., 2018). Therefore, in this study, we use the notion of bricolage to understand institutions not only as outcomes of governance processes, but also as evolving bodies of knowledge shaped by diverse practices and learnings over time.

2.2 Framework for Analyzing CFRs Governance Through Knowledge

Franks & Cleaver (2007) formulate a framework for understanding water governance, which was subsequently adapted by Cleaver (2012) to describe resource governance. It is constructed as an interconnected process with varying practical results (Franks & Cleaver, 2007). We view frameworks as heuristic models and guides for thinking rather than descriptions of reality (Scoones, 2015). For the purposes of this manuscript, we take this existing framework and adapt it to fit our research purposes, presenting it here as Figure 1. We describe each of the categories below the figure based on the original version but adapted to fit our research context.

Figure 1. Framework for analyzing CFR governance.



Source: Adapted by the authors from the Franks & Cleaver (2007) framework for analyzing water governance and poverty.

CFR resources encompass a diverse range of both material and non-material assets. Framing resources in this broader context, the analytical scope expands to include not only tangible physical elements (material), such as infrastructure, tools, and natural resources, but also organizational structures (non-material), such as governance systems, community networks, and management practices. Together, these physical and organizational components reflect the underlying institutional frameworks that shape resource use and management. Among these resources, locally embedded knowledge systems play a crucial role, serving as a foundation for stakeholder behavior by shaping decisions, guiding practices, and influencing how available information is interpreted and applied.

CFR resources and knowledge systems translate into CFR potential management outcomes through mechanisms that facilitate access to knowledge. These mechanisms are influenced by the resources and knowledge systems within society as well as actions performed by stakeholders in the processes of CFR management. Mechanisms are context-specific arrangements that enable management and knowledge creation (e.g., building social capital for project implementation). These mechanisms are dependent on in situ social relationships and institutions. Stakeholders utilize the resources at their disposal to create the mechanisms, which are then practiced in the processes of CFR management. The term stakeholders is employed to encompass all actors with a stake in the management of the CFR. Marginalized populations, in particular, may encounter constraints in influencing these processes and accessing various forms of management knowledge owing to

social differentiation based on factors such as class, gender, age, and other aspects related to their embodiment and voice.

Outcomes may include institutional arrangements, such as governance arrangements and structures of power, practices pertaining to livelihoods, and access to resources. Management and practice are conscious and unconscious activities involved in negotiation, decision-making, and action. These changes influence the configuration of knowledge systems and resources as well as the mechanisms and outcomes of CFR governance.

3.0 Methodology

In this section, we begin by describing the CFR system to provide the necessary context for our methodological approach. We then explain our selection of the case study design, which is informed by the specific characteristics of the CFR system. This is followed by an outline of the phases of our empirical research, and we conclude with a discussion of our positionality and reflexivity.

3.1 Description of Community Fish Refuge (CFR) System

A CFR serves as a stock enhancement and fish protection measure designed to increase RFF productivity. This involves the creation of dry-season refuges for brood stock in seasonally flooded RFF. These refuges consist of human-made and/or natural water bodies that retain water throughout the year but are isolated from permanent natural water bodies during the dry season. During the flood season, these water bodies reconnect with larger flooded RF or natural water bodies using natural flood pulses. During the flood season, fish migrate back to the RF, where they are caught by local fishers. When the dry season arrives, fish inhabiting the flooded RF migrate to the CFR because of the low water level of the RF, remaining in the CFR until the next flood season. Fish use these refuges as spawning and feeding grounds (Joffre et al., 2012).

In Cambodia, access to RFFs is open and not restricted to the CFR owner (Kim et al., 2019). Thus, CFRs function as common-pool resources (CPRs)—common goods characterized by subtractability and a high difficulty of exclusion (McGinnis, 2011; Ostrom, 1990).

The CFRs in Cambodia are classified into four ecological categories (EC), as presented in Table 1.

Table 1. *The Categories of CFR*

EC1	**EC2**	**EC3**	**EC4**
Upland reservoirs	Waterbodies outside flood-prone areas for the Tonle Sap Lake floodplain	Waterbodies prone to flooding	CFRs within a large natural waterbody, particularly in the Tonle Sap floodplain

Source: Description of categories from the CFR manual, elaboration by Kim et al. (2019, p. 8).

3.2 Case Study Design Description

This study focuses on the management of CFRs as a single case study (Yin, 2018), aiming to provide an understanding of local CFR governance mechanisms in relation to local knowledge of resource management. The scope of the case study encompasses the province of Kampong Thom, considering its diverse ecological conditions within the same geographic region. Within this case, to ensure a diverse sample of systems, we analyze four embedded units, each representing one of the aforementioned ECs. These units were selected to capture a variety of management practices across different ecological and governance contexts. However, the aim is not to compare the units with one another, but rather to use them collectively to illuminate broader patterns and insights related to the overall management of CFRs. An overview of each site is provided in Table 2, with locations shown in Figure 2.

Table 2. *Characteristics of CFRs*.

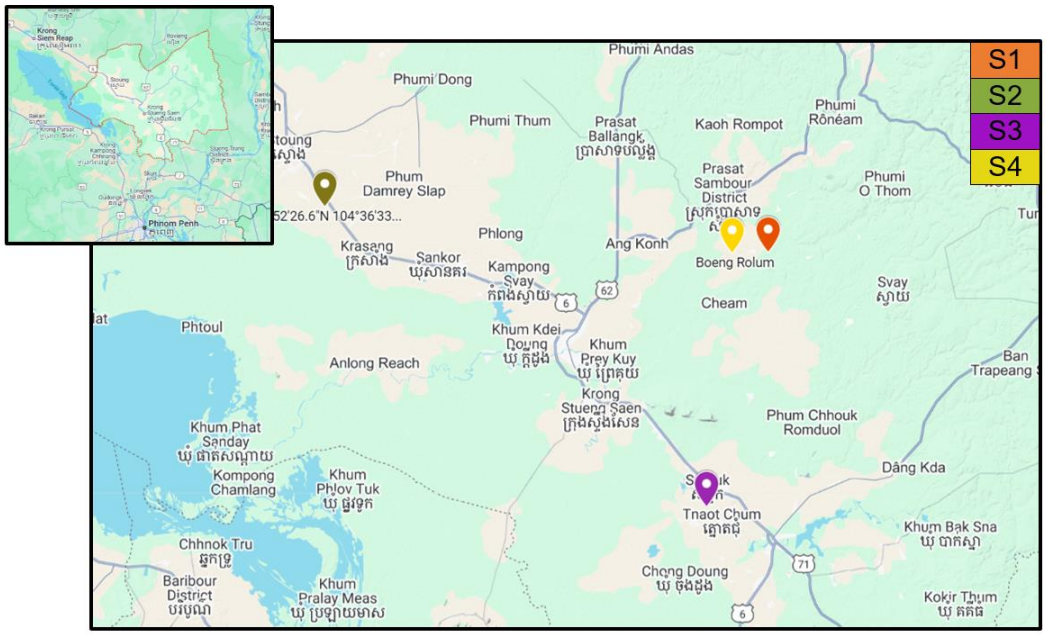
Category and name	**EC1: Ou Andeng (S1)**	**EC2: Trapaing Neang Noy (S2)**	**EC3: Boeng Banteay (S3)**	**EC4: Boeng Rolum (S4)**
Number of villages in the Zone of Influence (ZOI)	4	4	8	5
Number of households	923	1122	1830	756
Total number of committee people	9	7	9	9
% of women on the committee	22%	43%	33%	22%

Source: WorldFish, 2022.

These sites implemented the CFR initiative between 2016 and 2021 as part of the Feed the Future Cambodia Rice Field Fisheries II (RFF II) project (WorldFish, 2016). Our research team conducted an *ex-post* assessment of the project, focusing on activities related to the development of CFR management capacity, changes in biophysical attributes, and actions for managing both the CFR and RFF. The primary goal of our research is to provide an understanding of local CFR governance mechanisms, particularly how local knowledge of management has evolved and interacted with the project's phases and activities. For a detailed description of these activities, please refer to Table 3.

The sites were selected because, according to WorldFish, they had committees that developed good governance and sustainability practices for CFR management. The sites had active committees a year after this initiative ended, good relationships with local authorities, and established systems for collecting money to self-finance CFR costs (stopped since the Covid19 pandemic). All developed an action plan at the start of the project, received formal training workshops on management and nutrition, had patrolling systems, and held meetings at least every two months to discuss CFR issues. However, the representation of women still faces structural limitations (Shieh et al., 2019).

Figure 2: Study site locations: Kampong Thom, Central Cambodia.



Source: Authors' elaboration with Google My Maps: Sites of CLDs creation (Google, n.d.).

3.3 Empirical Research Description

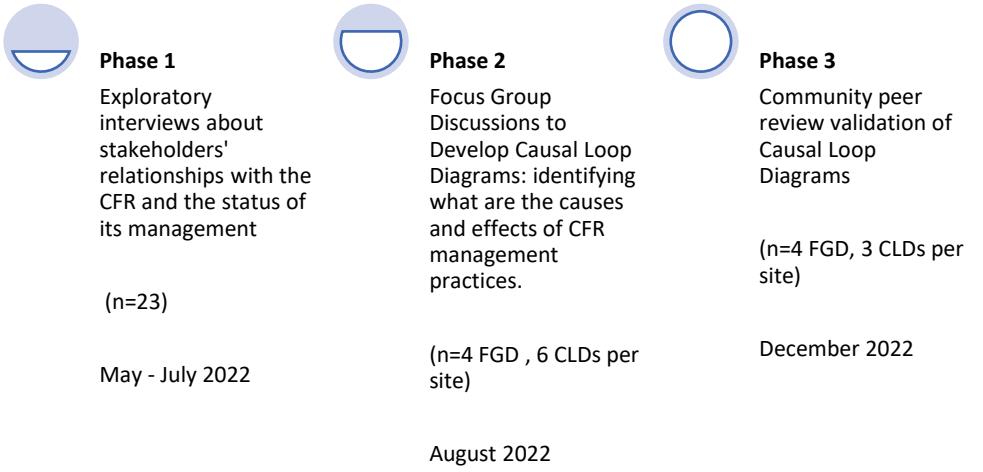
The empirical research for the on-site data collection was divided into three phases, as shown in Figure 3:

- **Phase 1**: Exploratory interviews with local representatives (n=23).
- **Phase 2**: Development of Causal Loop Diagrams (CLDs) through focus group discussions (FGDs) with the same interview participants, other representatives of the same organizations, and villagers invited by the CFRs committee (n=38).
- **Phase 3**: Validation of CLDs with the same participants through community peer review. Approximately 40 percent of the participants were women, and 60 percent were men.

To promote diversity in participation, the research team specifically invited women to take part in cases involving female stakeholders. However, this approach offers a narrow view of diversity and may limit a deeper understanding of broader community dynamics. However, practical, cultural, and fairness considerations led us to adopt this strategy. All methods were conducted in Khmer and facilitated by two Cambodian individuals with a background in fisheries from their university studies, who were also members of our empirical research team.

This paper is part of a broader research effort analyzing institutional dynamics in CFR management. A complementary study (Baldivieso Soruco et al., 2025) examines collective action within agency-constrained contexts, providing a wider institutional perspective that informs this work.

Figure 3. Empirical research description phases and outputs.



Source: Authors' elaboration.

3.3.1 Phase 1: Exploratory interviews. The interviewees were CFR committee representatives (CFRC), Commune Council (CC) representatives, village representatives (VR), water user group (WUG) representatives, and elders. Interviews were conducted in the interviewees' houses, with a few exceptions where the interviews were conducted in other locations. The names of the participants were kept confidential as per the research consent agreement. All participants were informed of the research purpose and what data would be used for.

During the exploratory phase, participants were asked about their involvement in the project, their expectations and motivations, their use of the CFR, and the challenges they faced in implementing it. The interview questions were designed to gather basic information about stakeholders' relationships with the CFR and the status of its management. This exploratory phase was instrumental in establishing the necessary working conditions and connections for future fieldwork. The validation of the interviews was conducted by assessing the consistency of responses over time across the three data collection phases and by presenting research findings to the WorldFish organization for further verification.

3.3.2 Phase 2: Focus group discussions for causal loop diagrams. To systematize the participants' knowledge systems, we collectively elaborated on CLDs in FGDs. The CLDs method is a tool of the Systems Thinking approach that is useful for mapping actors' hypotheses of system structures; that is, mental models of cause-and-effect relationships between variables. A CLD reveals the key elements (variables) of a system, the causal relationships between them (including polarity), and their effects expressed through feedback loops. It serves as a modeling technique to (1) facilitate data collection and (2) establish the foundation for understanding interrelated system variables (Herzog et al., 2022). The CLDs help unpack what lies in the actors' knowledge systems (Dhirasasna & Sahin, 2019). Thus, it serves to represent interactions between elements related to system behavior processes, expected future changes, and potential effects of stakeholder actions (Benavides et al., 2019; Del Río Duque et al., 2022). CLDs capture the complexity of causal processes but necessarily simplify interactions.

To develop CLDs, 27 cards were proposed indicating the CFR management actions. These were provided as *puzzle cards* and were preselected from the manual of the CFR project (Kim et al., 2019). As shown in Table 3, these are divided into three categories. Their purpose was to suggest building blocks that would motivate discussion about cause-and-effect relationships. Participants were free to choose whether to take the cards and work on others instead of connecting them in the form of a CLD. Figure 4 shows an example of a CLD created by mixing white puzzle cards and yellow cards, with participants contributing their ideas using the yellow cards. The guiding questions were: "What actions have triggered specific CFR management practices, and what are the causes and effects of those actions?"

Table 3. *Categorization of Actions Proposed for CLD Drawings in FGDs.*

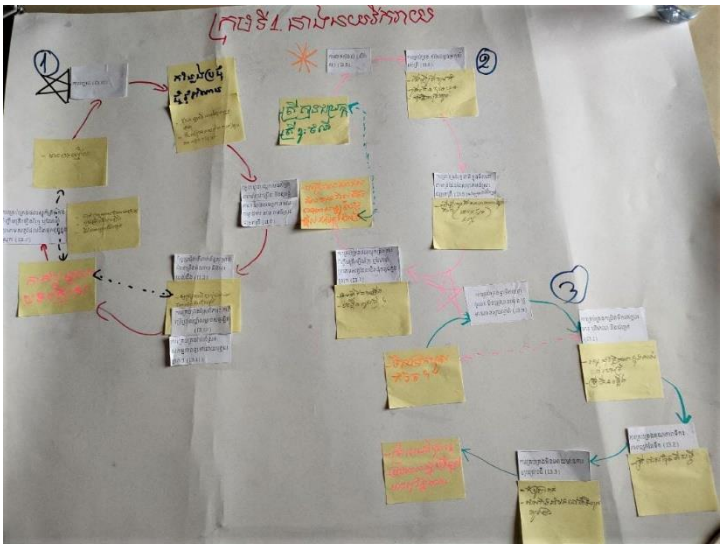
Stages	**Development of CFR management capacity (I1)**	**Bio-physical attributes (I2)**	**Management of the CFR and RFF (I3)**
Description	Actions related to awareness-raising and capacity building for multiple actors. Community capacity. Activities usually developed at the beginning of the intervention.	Actions related to the ways CFR and associated RFF environments can be improved to maximize their biodiversity and productivity. Physical changes in landscape and waterscape connected to the CFR pond.	Institutional capacity building for management of physical and social outcomes and transformations. Activities related to management of the resources after the I1 and I2.
Number of cards	4	11	12

* I1, I2, and I3 refer to the inputs proposed as the initial building blocks for CLDs.
Source: Adapted by the authors from the manual for the management of community fish refuges and rice field fisheries systems in Cambodia, by Kim et al. (2019)

The group of participants consisted of 10 people and lasted 3.5 hours. The group was then divided into two subgroups of five participants each. After each subgroup developed their respective CLDs, the members reconvened to share and discuss their findings with the other subgroup. The goal of this process was to compare findings, identify commonalities, and refine the CLDs through peer feedback.

To analyze the data resulting from this activity, the loops of each study site were merged and divided into three main loops corresponding to the stages of the CFR initiative's implementation, as shown in Table 3. These CLDs were then returned for community peer review, as described in Phase 3.

Figure 4: *Elaboration of CLDs (August 2022).*

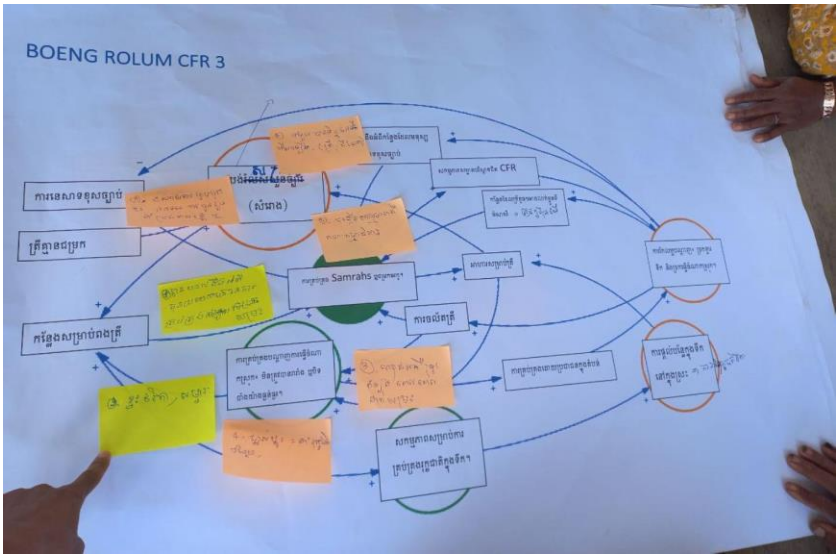


Source: Authors' picture from empirical data collection process.

3.3.3 Phase 3: Validation of causal loop diagrams. The validation took place four months after Phase 2 and lasted 3.5 hours. The same participants from Phase 2 were divided into two subgroups in a manner similar to the previous phase. During this session, participants reviewed the processes depicted in the proposed CLDs and participated in FGDs. This validation process was designed to enhance the rigor of the qualitative method by serving as a form of community peer review, where participants reflected on their prior work and engaged in interpretive discussions of the proposed CLDs (Hamilton, 2019).

Figure 5 illustrates how participants clarified the proposed CLDs during the FGD.

Figure 5: *Validation of CLDs (December 2022).*



Source: Authors' picture from empirical data collection process.

3.3.4 Processing and analysis of empirical materials. The interviews were analyzed using content analysis. For this, interviews were coded deductively using categories derived from the conceptual framework presented in Figure 1. Subsequently, they were refined and adjusted based on empirical data through an inductive approach. CLDs segments were coded using the same logic as in the interviews. Data analysis was performed using the NVIVO 12 software.

The results of the CLDs were summarized by the same person who facilitated the FGDs. These summaries were translated into English for analysis, and two rounds of English-Khmer proofreading were conducted to ensure that the translations were correct. CLDs digitalization was performed using VENSIM PLEx64 software.

3.4 Positionality and Reflexivity Statement

Our positionality and ethical position in this paper are grounded in reflexivity regarding the reasons for conducting research and for whom it is being conducted.

Our team of co-authors includes both Cambodian and non-Cambodian individuals. The research, design, analysis, and writing were primarily conducted by non-local researchers with expertise in social-ecological systems, pedagogy, and the sociology of development. These researchers have experience working on international development projects related to CFR management, with some having established relationships with stakeholders in Cambodia. The non-local co-authors approached the assessment of the existing development processes in the area as external observers of the CFR process itself. Their role was to offer evaluations of the project's outcome, with the goal of enhancing the project's benefits to people, particularly those in more disadvantaged positions within the power structure.

The local co-authors played a key role as mediators and supporters throughout the research process. They are divided into two groups. The first group supported the empirical research through translations and data analysis. The second group, consisting of individuals from the implementing organization of the CFRs, not just provided valuable insights into the project, reviewing the accuracy of the approach and empirical research, but also contributed to the selection of the study sites.

Furthermore, the CLDs were conducted as a participatory tool, designed not only as a means of data collection and analysis but as a pedagogical exercise that intended to benefit local villagers and foster an alternative manner of knowledge exchange between foreign researchers and the local population.

We acknowledge that there is a persistent epistemological imbalance between different types of knowledge, with certain forms affording greater epistemic value than others do. We acknowledge this imbalance and strive to engage with it critically throughout our research. In that regard, the local population who developed the CLDs were central to this research, providing essential knowledge on CFR management, which forms the foundation of this publication.

3.5 Operationalization of the Research Questions and its Outputs

For the purposes of our analysis, interviews provided information on management practices, CFR resources, stakeholders, and knowledge access mechanisms. CLDs provided information on potential outcomes, management practices, resources and mechanisms of access to knowledge. Table 4 provides a summary of our research questions and their correspondence to the framework categories, methods and results.

Table 4. Research Questions, Categories, Methods and Findings

Research questions		**Categories of conceptual framework**	**Results**	**Methods**
1. How do knowledge development and application shape CFR management outcomes?	1.1. What are the resulting management outcomes?	Outcomes	CFRs' resulting local knowledge *(4.1)*	CLDs
	1.2. How is this knowledge facilitated or created?	Processes	CFRs' management practices *(4.2)*	CLDs, Interviews
2. How do institutional structures and actors shape the production and access to CFR-related knowledge?	2.1. Which institutional structures facilitate the production of CFR-related knowledge?	Resources	Resources and knowledge systems.	CLDs, Interviews
		Stakeholders *(4.3)*	Institutional structures.	Interviews
	2.2. Who influences access to CFR-related knowledge, and through what mechanisms?	Mechanisms of access *(4.4)*	Mechanisms of knowledge access: mediation, access, and use.	CLDs, Interviews

Note: The numbers in parentheses correspond to the categories and subtitles in the results section.
Source: Authors' elaboration.

The Causal Loop Diagrams (CLDs) are part of the supplementary materials of this manuscript. In the results section, references such as CLDx, Sx denote specific diagrams presented in supplementary materials. For each study site, three CLDs were developed—CLD1, CLD2, and CLD3—the diagrams are labeled according to their respective site (e.g., S1 for Site 1, S2 for Site 2, and S3 for Site 3). Thus, CLD1, S1 refers to the diagram 1 of Site 1, and likewise for the other diagrams.

4.0 Results

This section is organized into four main sub-sections. We introduce the CFRs' resulting local knowledge after the CFRs' initiative, as well as the identified management practices. We then present the stakeholders and discuss their resources, knowledge systems, and institutional structures. Finally, we discuss mechanisms for knowledge access, considering mediation, access, and use of knowledge. Table 4 can be referred to in order to find its correspondence with the research questions underpinning this study.

4.1 CFRs' Resulting Local Knowledge

Our data reveals the existence of experiential, ecological, and social dynamic knowledge and awareness of management, which are part of the management knowledge systems, as described below.

Experiential knowledge is acquired through direct engagement with CFR management and through biophysical alterations. It encompasses insights into processes such as pond fencing and flood-resistant plant cultivation, along with expertise in water management and control equipment. It develops through direct involvement in CFR management and biophysical changes effected in the CFR (CLD1, S1; CLD2, CLD3, S3; CLD 2, S4).

Ecological knowledge integrates experiential learning with pre-existing knowledge and elucidates the intricate relationships between organisms and their environment, including the advantages of aquatic flora for fish and the behavioural patterns of various fish species. It is also acquired through direct involvement in the management and biophysical changes in the CFR (CLD3, S1; CLD3, S2; CLD3, S3; CLD 1, CLD2, S4).

Social dynamics knowledge embraces the CFRC's adeptness to foster collaboration, community cohesion, and knowledge dissemination among members, facilitating enhanced communication with fellow villagers and the identification of areas vulnerable to illegal fishing. It encompasses the capacity gained by the CFRC to collaborate effectively, foster a sense of community, and facilitate the transfer of knowledge between members (CLD1, S4; CLD2, S1; CLD3, S4; stakeholders S3 and S4, December 10, 12, 2022).

Finally, there is an awareness of CFR management processes, including budgetary needs for developing management and planning actions, the installation and management of eco-shelters and brush parks for fish, fishing laws and accepted fishing gear, evaluation and reflection on CFRC elections, as well as the organization of roles within the CFRC (CLD3, S1; CLD1, S2; CLD3, S3; CLD1, S4; stakeholders S2, December 18, 2022).

4.2 CFRs' Management Practices

The outcomes of CFR management are developed here as actions that people take to manage their CFR, observe information, engage in patterns of interaction, and realize outcomes (McGinnis, 2011). We identify seven main management practices based on the information provided by local actors. However, this is not an exhaustive list of project activities but rather a systematization of the practices emphasized by interviewed stakeholders and people who contributed to the CLDs during our empirical research for this paper. These practices are:

1) Cleaning and provisioning. People implement measures to enhance environmental quality in CFR surroundings, including waterways and fish migration gates, enabling fish to find hiding places from predators (CLD 3, S4). Actions to care for CFR are partly triggered by training courses involving a diverse range of stakeholders (CLD2, S1). The installation of fences to protect the necessary vegetation and prevent waterbody access represents another measure to enhance water quality (stakeholder S4, July 12, 2022).

2) Stakeholders conduct ecology management by considering aquatic plant management to support beneficial plants and achieve a balanced environment for fish reproduction. Brush park installation helps create fish habitats, reducing illegal fishing (CLD1, S1). Additionally, they release fish into the CFR to support ecosystem sustainability (CLD1, S1; CLD2, CLD3, S3; stakeholder S1 and stakeholder S2, July 11 and July 14, 2022).

3) Patrolling against illegal fishing. Illegal fishing is related to the use of instruments that are not allowed by law in CFR conservation zones and electrofishing. The CFR committee employs a graduated sanction process, ranging from informative actions to the involvement of external agents. Engagement in patrolling is contingent upon the availability of financial resources for patrolling teams and equipment (CLD1, S1; stakeholders S2, S3, and S4; July, 2022).

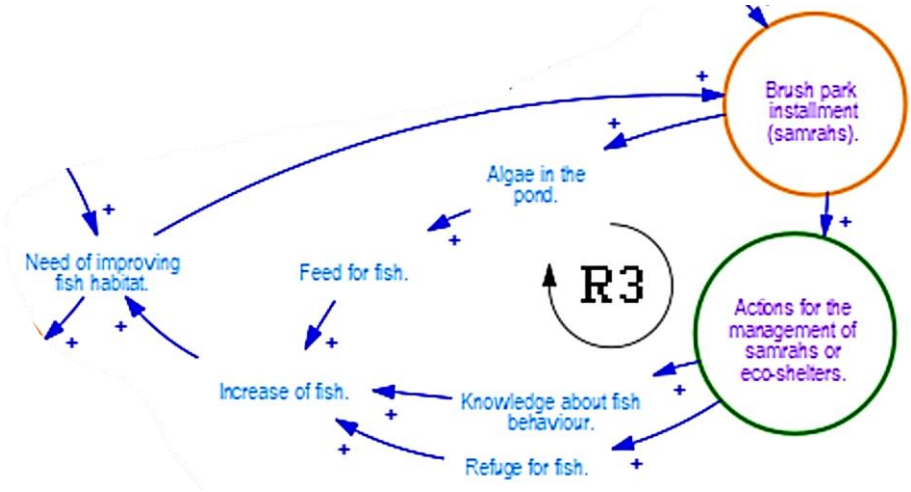
4) Fundraising initiatives, including the placement of donation boxes in pagodas during significant Khmer and village festivals. Previously, funds were collected through voluntary donations; however, disruptions to fundraising efforts were attributed to the impact of the COVID-19 pandemic (stakeholders S1, S2, S4, July, 2022). Other funding mechanisms include financial contributions from CC members to the CFR and solicitations to affluent individuals who visit villages (stakeholders S3 and S4, July, 2022).

5) Water management, which includes the regulation of water levels to ensure that they do not drop below its accepted limit. This is achieved through the opening of water channels for facilitating and regulating outflow, regulations on water distribution during dry-season, reporting of any potential misuse of water to the CC, and collection of voluntary funds if needed for managing the water body and improving its conditions.

6) Educational processes directed to other villagers. Education about the fisheries law have led to dissemination of information about fishing gears to all people (CLD1, S4). Awareness activities are carried to socialize the importance of the CFR for the community.

7) Perceiving biophysical changes. CFR management necessitates constant human-environmental interactions, which results in the observation of changes in ecosystem dynamics. This symbiotic relationship between practice and knowledge is exemplified in Figure 3, which is a segment of one of the CLD2 of S2 demonstrating social-ecological learning.

Figure 3: *Reinforcing loop: perception of biological changes associated with CFR-related actions*.



Source: CLD2, S2.

4.3 Stakeholders

4.3.1. Resources and knowledge systems. People across sites indicate a shared commitment to safeguarding their environment to ensure a prosperous future, including commitments to establishing a lasting legacy, maintaining a clean environment near the CFR, contributing to community well-being through enhancing their fishpond, developing human resources, improving livelihoods, protecting nature, preserving fish populations, safeguarding fish species, and preserving ecological knowledge (CLD1, S1; CLD3; S2; CLD1, CLD2, S3; CLD1, CLD2, S4).

Knowledge systems related to aquatic food systems that existed before the project include agrobiodiversity knowledge and water management. Stakeholders reported a lack of knowledge regarding fish sanctuaries and fish conservation. Agrobiodiversity knowledge happens in a dynamic context where knowledge of fishing practices is also subject to change. Fishing was based on traditional tools used in lakes, rivers, and RF; however, over time there has been a transition to modern equipment that allows for greater catch efficiency. Stakeholders refer to different types of fishing gear, showing knowledge about fishing practices and the importance of fishing in the local culture. It is identified that there was existing local knowledge about fish biodiversity and aquatic plant species (CLD 3, S3), which fostered the desire of villagers to protect them (CLD1, CLD 3, S4). This awareness led to their interest in participating in the management of fish sanctuaries (CLD3, S4).

Cambodia has a rich history of water management, driven by its geographical location and the cyclical patterns of rain and drought, often resulting in extreme climatic events. Consequently, water management is an NRM priority. Water engineering, which involves the design and construction of physical infrastructure, is exemplified by the ancient water management systems of the Angkor period (9th to 14th century), more recent interventions like the construction of open canals during the Khmer Rouge time for increasing rice field productivity (1975-1979), and modern large-scale water irrigation schemes for agriculture (since 1990) (Sithirith, 2022). These engineering interventions reflect more Westernized approaches to

water management. In contrast, community-based systems also exist in Cambodia, such as the Metuk water management system described by Sithirith (2022). In our research sites, communities had already engaged in water management practices before the introduction of the CFR, indicating the existence of experiential knowledge with respect to water management.

Stakeholders believe that prior to the establishment of the CFR project, there was limited management capacity and technical knowledge for fish conservation. The establishment of the CFRC filled this management gap for this community resource (CLD1, S1; CLD1, S4). As one interviewee points out, "In the past, villagers were free to fish wherever they wanted. Today, however, they understand the importance of complying with regulations and therefore refrain from fishing in designated protected areas" (stakeholder S3, July, 2022).

4.3.2. Institutional structures. The collective overseeing the waterbody management is the CFR Committee. This organization is composed of:

> A group of 5-10 local volunteers who are elected by the community living in the ZOI of the CFR. They are the responsible for managing and improving the CFR and providing protection from illegal fishing, with support from the local authorities and Fisheries Administration Cantonment" (Kim et al., 2019, p. 7).

The committee comprises the following roles: Committee Chief, Deputy Chief, Secretary, CFR Patrolling Team, and Awareness-raising/Information Sharing Team (Kim et al., 2019).

The CFRC representatives are elected by villagers and village representatives (VR), with great influence from the commune council (CC) (stakeholders S1, S2, S3, S4, July, 2022). The process of engaging villagers and doing awareness raising is through the CC chief (stakeholder S2, July 14, 2022). Collaborative planning for communities, requires that the CCs and external organizations like WorldFish, initiate and implement projects related to community development (stakeholders S1, S2, S3, S4, July, 2022).

Individuals assuming management roles in the CFR hold positions in other management bodies within the villages, typically taking on three to four positions. According to the interviewed stakeholders, 45% of the leaders in management positions of the four sites indicated they are simultaneously part of the CFRC and the Water User Group Committee (WUGC). Both roles have synergistic effects on waterbody management; as stakeholders indicate that their responsibilities include managing community ponds, fish sanctuaries, and water resources by opening and closing sluice gates, repairing damaged gates, and managing water flow (stakeholder interviews, June and July 2022).

Regarding involvement of villagers in CFR-related meetings, monthly community meetings are attended by village representatives—who are part of the CC—and villagers, with a composition of 70 percent women and 30 percent men. This is influenced by men delegating their attendance to women due to work commitments (stakeholder S1, July, 2022). Villagers that lack farmland are less actively engaged in the project (stakeholder S4, July 2, 2022). Villagers participate in various

activities, including restoring aquatic plants, and planting seedlings in response to the CFRC calls (stakeholder S2, July, 2022).

Participation is shaped by social differentiations that reflect societal norms, influencing decision-making processes and individuals' capacity for agency. In the study sites, gender roles are clearly delineated, with men predominantly occupying leadership and decision-making positions. The division of labor is also gender-based, with men primarily involved in activities such as patrolling, while women manage finances, cooking, and household chores. It is important to note that this study adopts a reductionist perspective on gender, treating it as binary (man/woman) due to the prevailing social structures across the study sites.

There are also significant disparities in education, as it is believed that women's financial stability is hindered by a lack of education, despite the perception in some villages that women perform better economically. In terms of age, elderly individuals face challenges in participating in activities due to physical limitations compared to younger participants. Additionally, socioeconomic factors such as distance or lack of farmland may hinder some villagers' ability to fully participate in community activities.

4.4 Mechanisms of Knowledge Access

4.4.1. Mediation. Mediators facilitate access to information mechanisms and shape how it is accessed. Thus, as brokers, they influence the ways in which actors with unequal power relations and diverging interests interact (Koster & van Leynseele, 2018). This study identifies that CFRCs serve as the mediating organization between the rural population and state organizations and NGOs. CFRC representatives are those who have the role of mediation in this community-based initiative, granting them a strategic advantage as community-based representatives (Schultz, 2017). However, CC leaders do not just mediate discussion scenarios between CFRC and WUGC (S4 and S2) but also support coordination of activities with external agents to send plans to the FiA and support activities strengthening CFR committee capacities (S3, S2, S1).

The mediation in the implementation of the CFR project is inherently relational and varies depending on the stage of the process, guided by stakeholder engagement. Local NGOs and WorldFish play an important role in this process, mediating between government officials and local communities. They facilitate learning and awareness sessions, especially in the early stages of project implementation. WorldFish is one of the pioneer and expert organizations of CFR projects in Cambodia (Ou et al., 2024), they developed knowledge on fisheries conservation, fish related nutrition, management knowledge, and technical implementation for biophysical changes, which was socialized to local communities as part of project implementation (Joffre et al., 2012; Kim et al., 2019). In this context, not all villagers have access to the same kind of information, the community-based representation (CFRC) has access to management knowledge and is part of the stakeholder network. General villagers take part in awareness-raising processes and other learning spaces as described below.

4.4.2. Access and use of knowledge. One of the main mechanisms for accessing knowledge about CFR management is through interactions with external agents such as WorldFish and local NGOs. There is coordination and collaboration with state

and provincial bodies, such as the Fisheries Administration at the provincial and cantonment levels, particularly concerning fisheries laws, water resource management, and support for community projects. These organizations undertake various activities, including livelihood improvement programs, CFR-related education, infrastructure development, and community empowerment initiatives.

Stakeholders indicated that villagers gain knowledge about CFRs through different channels: (1) Training sessions on child and women's nutrition and the importance of fish; (2) Educational programs on illegal fishing and fisheries law; and (3) Awareness campaigns on CFRs importance and appropriate fishing equipment. In addition to these meetings, the CFR committee participates in (1) Capacity building meetings, during which they were encouraged to involve community members in the process; (2) Evaluation and assessment meetings; and (3) Experiences and knowledge exchange with other CFR committees from different provinces in Cambodia.

CFRC members indicate that they utilize the information they acquire to disseminate the fisheries laws and CFR regulations to fellow villagers (CLD2, S1; CLD2, S2). The trainings help them implement their community initiatives and facilitate collaboration with their communities. Furthermore, they implemented disciplinary measures in order to instruct people about new regulations, with the aim of deterring illegal fishing (stakeholders S2, S3 and S4, July, 2022).

5.0 Discussions

Our discussion examines both knowledge as content—information that is transmitted—and knowledge as process, which entails observing, discussing, and interpreting new information within specific ways of knowing and institutional frameworks (Berkes, 2009; Lin et al., 2021). This distinction aligns with our research objectives, allowing us to explore how CFR-related knowledge is generated, facilitated, and accessed within governance mechanisms.

5.1. Knowledge Creation from CFR Management Practices: Situated and Relational Processes

In this paper, knowledge is disaggregated according to the manner of acquisition (experiential knowledge) and the manner of its use with regard to managing different dimensions of a CFR's ecology and use. We reflect that such knowledge is situated and relational to answer to our question on how knowledge is created.

5.1.1 Relational processes for CFR management. Knowledge is relational because it is created from the quality of the relationships between involved actors (Bruckmeier & Tovey, 2008). In that sense, we identify that management practices demonstrate that individuals engage in a range of actions to conserve aquatic resources and manage the CFR ecosystem. These actions involve a larger group of villagers, whether it is a collective activity (cleaning and provisioning actions), a collective response to management processes (financing), or a process of interaction to learn new practices from external agents (education).

The knowledge identified stems from everyday management practices conducted by the local population. However, it may also be passed down through secondhand stories. In Cambodia, where oral and narrative culture is deeply entrenched, the influence of language and the power of the spoken word play a crucial role in

shaping knowledge. Oral culture holds both epistemological and historical significance, thus making it an invaluable tool for information dissemination (Din, 2020; Rivera Cusicanqui, 2018). The awareness-raising efforts spearheaded by the project could potentially enhance this process, enabling individuals to share factual information, experiences, and views (Lin et al., 2021). Awareness-raising efforts are a key component of the CFR project led by WorldFish and the FiA, meant as knowledge transfer practices designed to address local knowledge gaps.

This study acknowledges the potential of oral culture and secondhand stories may be underestimated within this study due to certain limitations. The process of translations from Khmer to English, along with time constraints that restricted deeper engagement with village dynamics, created gaps that limited interactions with other types of epistemologies of knowledge present at the study sites. Furthermore, informal communication networks within the villages were not explored in this research.

5.1.2. CFR as a space for situated knowledge. The concept of situated knowledge is derived from feminist epistemologies (Haraway, 1988; María et al., 2012), which reflect the existence of multiple perspectives anchored in a specific time and place. It is not just linked to the ecological landscape, it is produced, shared, and maintained from a cultural system (Berkes et al., 2000). People's knowledge and behaviors are shaped by their interactions with local nature, particularly within the CFR area, through evolving management practices. These practices include provisioning, patrolling, ecological management, water management, and the perception of biological changes, which require constant social-ecological interaction for making adjustments to the management regime. The CLDs capture knowledge complexity, including knowledge of agrobiodiversity existing before the project and how it interacts with social structures, which helps ensure that knowledge transferred from outside of the community is integrated and defined on the basis of what already exists (Zeng et al., 2017). Further, the CLDs provide a perspective of the management knowledge areas, offering an understanding of the surface of the *knowledge iceberg*: there are deeper knowledge systems and broader bases on which the selected knowledge is grounded, such as traditional knowledge systems.

5.2. Institutional Structures: Implications for CFR Management and Community Engagement

The institutional structures that facilitate production of CFR-related knowledge include local structures in place, local resources, and organizations resulting of the purposeful institutional design of this community-based initiative. We discuss the impact of institutional structures on the generation of knowledge and how this has implications for the governance of CFRs.

5.2.1. Local structures in place and resources. This study identifies that the position of subjects within the social sphere of the villages ultimately determines their access to knowledge. Typically, people with experience in public management and connections to stakeholders that have prevailing positions of authority within local government structures will be part of new management organizations, such as the CFRC. This has the advantage of facilitating communication between stakeholders who already know each other, thus reducing transaction costs, meaning the time and effort people need to build new networks and social capital in which trust plays a key role (Lien et al., 2021; Ostrom et al., 2008). Furthermore, the presence of individuals

within the CFRC who possess bureaucratic and management experience provides a significant advantage. Nonetheless, it limits the access of others who are not part of already existing managerial groups to take part in new management positions and their contributions to knowledge systems and underlying learning processes. The CC is central in determining who sits on the CFRC; thus, while the project aims to foster community engagement and establish election processes for CFRC representatives, these efforts are often constrained by existing appointment procedures. This study highlights that, despite the challenges of local elections in rural Cambodia (Eng & Ear, 2016), CFRC elections can provide a platform for villagers, benefitting from discourses and ideas around diverse experiences, needs, and perceptions. However, this study reveals that the distinction between appointment and election is still unclear in this context, given the great influence of the CC.

Furthermore, there are difficulties for women taking up leadership positions in the CFRC, as reflected in their low representation. Simply increasing the number of women would not guarantee equality or fair representation of marginalized groups (Lau et al., 2021). Numerous social factors influence the status of women in management, including gender norms and education (Shieh et al., 2019). Other factors that influence stakeholders' engagement in CFR's management include age and socioeconomic status. However, despite prevailing social inequalities, the CFRs are successful, supporting those who are more socioeconomically disadvantaged (Freed, Barman, et al., 2020; Freed, Kura, et al., 2020; Ou et al., 2024); thus, contributing to the conservation of the "social safety net" of rural populations (Sithirith et al., 2024, p. 121).

In this respect, we reflect on how institutional structures play a role in mediating the creation of knowledge alongside the fact that institutions are important for the functioning of the CFR ecosystem because knowledge is situated and relational. If the institutional design of the CFR does not challenge the direction of decision making but rather reinforces what is already in place (Baldivieso Soruco, et al. 2025), this the democratization of knowledge of management and the possibilities of agency in decision making is affected.

5.2.2. Institutional design of the CFR. The CFR is implemented by means of a purposeful institutional design based on a single design organization represented by the CFRC (Thiel et al., 2015). It is not a community-initiated organization, but a project that entails community-based principles (Anderies et al., 2003; Ostrom, 2008). However, institutional change is not alien to the stakeholders: the NRM forms before the project and the social relations on the ground do affect the results of this institutional design. The process of institutional formation is characterized by institutional bricolage; thus, "components from different origins are adapted to perform new functions" (Cleaver & Whaley, 2018, p. 6). The CFRC, as a mediator, assumes a pivotal character, serving as the nexus where the bricoleurs converge. Individuals that occupy a CFRC position are enabled to participate in the institutional creation processes that lead to knowledge creation on management. Given that management knowledge is disseminated through institutional channels, only certain stakeholders are able to engage in bricolage and be bricoleurs. Following Sehring's (2009) approach, we understand bricolage as a non-teleological process in which actors both influence and are influenced by institutional structures as they reinterpret and adapt them. In our study, institutional bricolage is linked to path dependency, meaning that the CFRC is embedded in pre-existing institutional

arrangements characterized by power centralization. This also shapes the channels through which knowledge flows.

The institutional design for CFR implementation includes several dimensions of learning. These dimensions range from management and financing to fishing gear and nutrition. There is a positive attitude toward the implementation of the project and its results. However, the channels through which information is disseminated and collective action is convened are unidirectional, originating from the management center (CC, VR, and CFRC). This is evidenced in the way educational processes and information dissemination are conceived. These are *awareness-raising* activities and *dissemination* of laws. Thus, CFRCs could benefit from the establishment of alternative forms of communication that facilitate the inclusion of non-empowered voices. This could potentially enhance the creation of collective learning processes (Bodin, 2017). Moreover, following the ideas of Paulo Freire, a social change toward a sustainable world is driven by a broad awareness that involves a wide range of social actors engaged with processes of critical thinking on their realities (Freire, 1985).

Nevertheless, we are aware of the difficulties this poses for local implementers, especially when participation is constrained by the lack of a culture to speak out and the everyday need for local villagers to make their livelihood. This challenge is further compounded by a deeply ingrained respect for authority and a clear division of labour between the people and the state, where the public tends to adhere to state policies and directives. These dynamics are reinforced by both a hierarchical culture and the enduring legacy of prolonged conflict, which has perpetuated a system where authority is unquestioned and labour is strictly divided (Chheat, 2013; Lee, 2021).

The above identified challenges also relate to Decentralization and Deconcentration (D&D) reforms that started in the 1990s in Cambodia. D&D emphasizes the improvement of local decision-making mechanisms and public administration, a tendency in line with community-based NRM, given that theoretically, it aims to improve governance, community participation, and accountability of governing local needs (Vanny et al., 2024). However, it has proven to be a constrained context for decentralization and bottom-up community governance, given the ongoing concentration of power and resources at the highest levels due to the mixing of local governance structures and politics (Eng & Ear, 2016). This has resulted in continued uncoordinated resource management with limited intersectoral collaboration. This conflicts with the needs of CFR management, which necessitates closer integration between the Ministry of Water Resources and Meteorology (MOWRAM) and the Ministry of Agriculture, Forestry, and Fisheries (MAFF) (Sithirith et al., 2024). The state delegation of responsibilities from the national level contrasts with what is identified in this study. This may be in part due to elite control processes at the village level, but also to the fact that water and fisheries management responsibilities are seen as cojoined, with resource management integrated, as built on the holistic local knowledge that people have of their ecosystems. This represents a difference between local and national levels; local stakeholders see roles as interrelated and integrated for the multi-purpose nature of the CFRs. We emphasize the holistic nature of this knowledge as it emerges through a bricolage process. As demonstrated in the CLDs, management practices and outcomes reflect a blending of diverse knowledge sources—experiential, ecological, and social dynamics, as well as an understanding of CFR management processes. This adaptive approach to CFRC management inherently relies on existing institutions and knowledge systems.

6.0 Conclusions

Community Fish Refuges are "modern-day commons," similar to other community fisheries initiatives in Cambodia that introduce innovative approaches to the collective use and management of environmental resources in areas where fish conservation has not traditionally been practiced (Kurien, 2017, p. 65). However, they also pose challenges in developing effective management strategies and fostering collective action to ensure their sustainability.

CFR represent a combination of a resource, a community utilizing it, alongside a set of norms and rules for its management, leading to community-based governance (Ostrom, 2009). CFRs are designed to have community-governance, incorporating educational tools and participatory approaches that not just foster social capital through the establishment of rules-in-place but also strengthens social cohesion among resource managers within communities. Additionally, these approaches promote network capital by enhancing collaboration and coordination among local stakeholders and organizations involved in the implementation and management of CFRs.

Our findings reveal holistic ecological knowledge that integrates various elements of CFR management and previously existent social-ecological learnings. Previously existent knowledge involves traditional knowledge derived from water and agrobiodiversity management for food systems, even in the absence of explicit knowledge and practice of fish conservation. Thus, knowledge is situated and dependent on the existing contextual conditions and ecological settings. This shows that, for the continuity of the project and the proper conservation of the CFR ecosystem, traditional ecological knowledge is an important asset that must be preserved and supported.

The way local resource management processes evolve is contingent upon the interplay of local power dynamics and institutional structures, making knowledge relational. These factors determine who has access to management positions and the flow of knowledge. Existing structures may reinforce existing inequalities, yet they also facilitate communication and resource management through established networks (Cleaver, 2012). Thus, institutional bricolage is observed, whereby new resource management processes, information, and networks are linked to local structures and existing local knowledge. Individuals already affiliated with the state's inner circle of management assume new roles. Those engaged in the management of water resources also oversee the management of fisheries. These bricoleurs utilize the existing roles and organizations to shape their own roles and assume new responsibilities. Consequently, social mobilization could concentrate in the group designated as community-based representative and mediator between villagers and external entities, and their direct local state superiors.

Although this study does not examine informal communication networks, our observations indicated that communication between the CFRC and fellow villagers is primarily based on information sharing and awareness-raising (Baldivieso Soruco et al., 2015). The interviewed stakeholders were motivated by the project's positive ecological outcomes (Freed, Barman, et al., 2020); however, new collective resource management practices still need further integration and the development of more dialogue-driven communication channels. This study highlights a key tension for CFR governance: while CFRs provide important benefits, their management remains concentrated in the hands of a few, limiting broader participation. This

dissonance reflects a reality in which community-based resource management coexists with entrenched power structures that shape decision-making and knowledge flows. While the CFR implementation framework aims to promote inclusive governance, existing hierarchies can constrain these efforts. This highlights the need to critically assess how knowledge creation and authority are linked within CFRs alongside the implications for long-term sustainability, given existing institutional dynamics. This conclusion also highlights the role of institutional bricolage as a process that can enable change, while also perpetuating social structures that do not support greater democratization of knowledge (Baldivieso Soruco et al., 2015).

Our research identifies ways to improve governance in CFRs by establishing horizontal communication channels and participatory processes (Alves et al., 2021) that include marginalized groups in dialogue with political representatives, such as the CFR committee. This approach aligns with the findings of Horning et al. (2016), who note that, in rural areas, centralized governance structures often marginalize peripheral stakeholders, highlighting the need for more collaborative governance models. The CFR committee is, in fact, a pillar of community governance. and it can be seen as a seed for the further democratization of the NRM if spaces for dialogue are promoted. Creating social learning channels will need to account for the cultural context, existing social differentiations, the failures and challenges of decentralization in Cambodia, and local politics. To be effective, funding organizations must consider appropriate timelines that allow for real social change rather than focusing solely on the number of projects implemented or measurable goals. A shift toward social and environmental sustainability requires long-term commitments that recognize both the importance and complexity of democratizing knowledge in CFR governance and the institutional dynamics at play.

Finally, this study suggests that CFRs could benefit from investigating the potential benefits of informal communication networks and oral epistemologies for social learning. It would not only be valuable to examine the knowledge differentiations among various social groups but also to assess the influence of sociocultural factors on local resource governance from a local research perspective. Furthermore, we encourage future research to explore how existing knowledge and practices address the various dimensions of the CFR management challenge, with a focus on identifying both strengths and gaps within the knowledge system.

7.0 References

Alves, J. M., da Silva Souza, F. N., Sieber, S., Vergara, F. E., & Bonatti, M. (2022). Assessment of land use relations and the sustainability of agricultural systems: Considering different views to foster social learning. *Journal of Land Use Science, 17*(1), 368–385. https://doi.org/10.1080/1747423X.2022.2099592

Agrawal, A. (1994). *Dismantling the divide between Indigenous and scientific knowledge.* Workshop in Political Theory and Policy Analysis. https://dlc.dlib.indiana.edu/dlc/bitstream/handle/10535/4201/Dismantling_the_Divide.pdf

Agrawal, A. (2002). Indigenous knowledge and the politics of classification*. *International Social Science Journal, 54*(173), 287–297, https://doi.org/10.1111/1468-2451.00382

Anderies, J. M., Janssen, M. A., & Ostrom, E. (2003). *Design principles for robustness of institutions in social-ecological systems*. https://hdl.handle.net/10535/1777

Baldivieso Soruco, C. R., De Silva, S., Gleich, P., Yan, Y., Dubois, M., Sieber, S., & Bonatti, M. (2025). Realizing collective action in agency-constrained contexts: The case of the Community Fish Refuges in Cambodia. *Frontiers in Environmental Science, 12*. https://doi.org/10.3389/fenvs.2024.1417971

Benavides, R. A. M., Gaona, R. C., Guerrero, H. S., Patiño, L. G., & Atzori, A. S. (2019). Sustainable feedbacks of Colombian Paramos involving livestock, agricultural activities, and sustainable development goals of the agenda 2030. *Systems, 7*(4), 52. https://doi.org/10.3390/systems7040052

Berkes, F. (2009). Indigenous ways of knowing and the study of environmental change. *Journal of the Royal Society of New Zealand, 39*(4), 151–156. https://doi.org/10.1080/03014220909510568

Berkes, F., Colding, J., Folke, C. (2000). Rediscovery of traditional ecological knowledge as adaptive management. *Ecological Applications, 10*(5), 1251–1262. https://doi.org/10.1890/1051-0761(2000)010[1251:ROTEKA]2.0.CO;2

Bersaglio, B., & Cleaver, F. (2018). Green grab by bricolage - the institutional workings of community conservancies in Kenya. *Conservation and Society, 16*(4), 467–480. https://doi.org/10.4103/cs.cs_16_144

Bodin, Ö. (2017). Collaborative environmental governance: Achieving collective action in social-ecological systems. Science, 357(6352). https://doi.org/10.1126/science.aan1114

Bonatti, M., Borba, J., Bundala, N., Löhr, K., Ito, L. H., Rybak, C., & Sieber, S. (2021). Food insecurity and malnutrition in rural Tanzania: Mapping perceptions for social learning. *Ecology of Food and Nutrition, 60*(6), 765–784. https://doi.org/10.1080/03670244.2021.1907747

Bonatti, M., Borba, J., Schlindwein, I., Rybak, C., & Sieber, S. (2019). "They came home over-empowered": Identifying masculinities and femininities in food insecurity situations in Tanzania. *Sustainability, 11*(15), 4196. https://doi.org/10.3390/su11154196

Brooks, A., Kim, M., Sieu, C., Sean, V., & Try, V. (2015). *A characterization of community fish refuge typologies in rice field fisheries ecosystems*. Penang, Malaysia: WorldFish. Handbook 2015-37. https://digitalarchive.worldfishcenter.org/server/api/core/bitstreams/c8639e18-29d6-4913-ae85-8966b3df8370/content

Bruckmeier, K., & Tovey, H. (2008). Knowledge in sustainable rural development: From forms of knowledge to knowledge processes. *Sociologia Ruralis, 48*(3), 313–329. https://doi.org/10.1111/j.1467-9523.2008.00466.x

Chakraborty, R., Gergan, M. D., Sherpa, P. Y., & Rampini, C. (2021). A plural climate studies framework for the Himalayas. *Current Opinion in Environmental Sustainability, 51*, 42–54. https://doi.org/10.1016/j.cosust.2021.02.005

Chheat, S. (2013). Democratic governance and local politics in Cambodia. *Panorama - Insights into Asian and European Affairs*, 97–111. Singapore: Konrad-Adenauer-Stiftung. https://www.researchgate.net/publication/319629105

Cleaver, F. (2012). *Development through bricolage*. Routledge. https://doi.org/10.4324/9781315094915

Cleaver, F., & De Koning, J. (2015). Furthering critical institutionalism. *International Journal of the Commons, 9*(1), 1–18. https://doi.org/https://doi.org/10.18352/ijc.605

Cleaver, F., & Whaley, L. (2018). Understanding process, power, and meaning in adaptive governance: A critical institutional reading. *Ecology and Society, 23*(2), 49. https://doi.org/10.5751/ES-10212-230249

Del Río Duque, M. L., Rodríguez, T., Lora, Á. P. P., Löhr, K., Romero, M., Castro-Nunez, A., Sieber, S., & Bonatti, M. (2022). Understanding systemic land use dynamics in conflict-affected territories: The cases of Cesar and Caquetá, Colombia. *PLoS ONE, 17*(5), e0269088. https://doi.org/10.1371/journal.pone.0269088

Dhirasasna, N., & Sahin, O. (2019). A multi-methodology approach to creating a causal loop diagram. Systems, 7(3), 42. https://doi.org/10.3390/systems7030042

Din, D. (2020). Cambodian Identity, Culture, and Legacy. In D. S. Udom, B. J. Murg, O. Virak, & M. Renfrew (Eds.), *Cambodia 2040* (pp. 12–37). Phnom Penh, Cambodia: Konrad Adenauer Stiftung.

Eng, N., & Ear, S. (2016). Decentralization reforms in Cambodia. Journal of *Southeast Asian Economies, 33*(2), 209–223. https://doi.org/10.1355/ae33-2f

Franks, T., & Cleaver, F. (2007). Water governance and poverty: A framework for analysis. *Progress in Development Studies, 7*(4), 291–306. https://doi.org/10.1177/146499340700700402

Freed, S., Barman, B., Dubois, M., Flor, R. J., Funge-Smith, S., Gregory, R., Hadi, B. A. R., Halwart, M., Haque, M., Jagadish, S. V. K., Joffre, O. M., Karim, M., Kura, Y., McCartney, M., Mondal, M., Nguyen, V. K., Sinclair, F., Stuart, A. M., Tezzo, X., … Cohen, P. J. (2020). Maintaining diversity of integrated rice and fish production confers adaptability of food systems to global change. *Frontiers in Sustainable Food Systems, 4*. https://doi.org/10.3389/fsufs.2020.576179

Freed, S., Kura, Y., Sean, V., Mith, S., Cohen, P., Kim, M., Thay, S., & Chhy, S. (2020). Rice field fisheries: Wild aquatic species diversity, food provision services and contribution to inland fisheries. *Fisheries Research, 229*. https://doi.org/10.1016/j.fishres.2020.105615

Freire, P. (1985). *The politics of education: culture, power, and liberation*. Bergin and Garvey Publishers.

Freire, P. (2020). Pedagogy of the oppressed. In P. Freire (Ed.), *Toward a sociology of education* (pp. 374–386). Routledge.

Gebara, M. F. (2019). Understanding institutional bricolage: What drives behavior change towards sustainable land use in the eastern amazon? *International Journal of the Commons, 13*(1), 637–659. https://doi.org/10.18352/ijc.913

Google. (n.d.). *Sites of CLDs creation* [Google My Maps]. Retrieved May 6, 2025, from https://www.google.com/maps/d/u/0/edit?mid=1EVLk1pipmJ9kCbER2kTNYSg9XqE5aX0&usp=sharing

Hamilton, J. B. (2019). Rigor in qualitative methods: An evaluation of strategies among underrepresented rural communities. *Qualitative Health Research, 30*(2), 196–204. https://doi.org/10.1177/1049732319860267

Haraway, D. (1988). Situated knowledges: The science question in feminism and the privilege of partial perspective. *Feminist Studies, 14*(3), 575–599. http://www.jstor.org/stable/3178066

Herzog, L., Tanguay, L., Beisner, B. E., Pahl-Wostl, C., Audet, R., & Schlüter, M. (2022). Studying human-nature relations in aquatic social-ecological systems using the social-ecological action situations framework: How to move from empirical data to conceptual models. *Ecology and Society, 27*(3). https://doi.org/10.5751/es-13268-270307

Horning, D., Bauer, B. O., & Cohen, S. J. (2016). Community development watershed governance for rural communities: Aligning network structure with stakeholder vision. *The Journal of Rural and Community Development, 11*(2), 45–71. https://journals.brandonu.ca/jrcd/article/view/1453

Joffre, O., Kosal, M., Kura, Y., Pich, S., Thuok, N. (2012). *Community fish refuges in Cambodia - Lessons learned*. The WorldFish Center, Phnom Penh, Cambodia. https://digitalarchive.worldfishcenter.org/server/api/core/bitstreams/f8defcd8-5d0c-4210-8429-e3d51d5d4f8a/content

Kim, M., Mam, K., Vichet, S., Brooks, A., Thay, S., Hav, V., & Gregory, R. (2019). A manual for community fish refuge-rice field fisheries system management in Cambodia. *WorldFish.* https://worldfishcenter.org/publication/manual-community-fish-refuge-rice-field-fisheries-system-management-cambodia

Klassen, S., & Evans, D. (2020). Top-down and bottom-up water management: A diachronic model of changing water management strategies at Angkor, Cambodia. *Journal of Anthropological Archaeology, 58*. https://doi.org/10.1016/j.jaa.2020.101166

Koster, M., & van Leynseele, Y. (2018). Brokers as assemblers: Studying development through the lens of brokerage. *Ethnos, 83*(5), 803–813. https://doi.org/10.1080/00141844.2017.1362451

Kurien, J. (2017). *Community fisheries organizations of Cambodia. Sharing processes, results and lessons learned in the context of the implementation of the SSFF Guidelines*. FAO Fisheries and Aquaculture Circular No. 1138. Food and Agriculture Organization of the United Nations.

Lamb, V. (2018). Who knows the river? Gender, expertise, and the politics of local ecological knowledge production of the Salween River, Thai-Myanmar border. *Gender, Place and Culture, 25*(12), 1703–1718. https://doi.org/10.1080/0966369X.2018.1481018

Lau, J. D., Kleiber, D., Lawless, S., & Cohen, P. J. (2021). Gender equality in climate policy and practice hindered by assumptions. *Nature Climate Change, 11*(3), 186–192. https://doi.org/10.1038/s41558-021-00999-7

Lee, S. Y. (2021). Understanding everyday peace in Cambodia: Plurality, subtlety, and connectivity. *Journal of Peacebuilding and Development, 16*(1), 24–38. https://doi.org/10.1177/1542316620974371

LeGrand, K., Borarin, B., & Young, G. M. (2020). Tradition and fermentation science of *prohok*, an ethnic fermented fish product of Cambodia. *Journal of Ethnic Foods, 7*(1). https://doi.org/10.1186/s42779-019-0027-1

Lien, A. M., Dew, T., Ruyle, G. B., Sherman, N. R., Perozzo, N., Miller, M., & López-Hoffman, L. (2021). Trust is essential to the implementation of adaptive management on public lands. *Rangeland Ecology and Management, 77*, 46–56. https://doi.org/10.1016/j.rama.2021.03.005

Lin, E., Sprunger, C. D., & Hwang, J. (2021). The farmer's battlefield: Traditional ecological knowledge and unexploded bombs in Cambodia. *Agriculture and Human Values, 38*(3), 827–837. https://doi.org/10.1007/s10460-021-10195-0

María, M., Cruz, A., María, D., Reyes, J., & Cornejo, D. M. (2012). Conocimiento Situado y el Problema de la Subjetividad del Investigador/a [Situated knowledge and the problem of researcher subjectivity]. *Cinta Moebio, 45*, 253–274. www.moebio.uchile.cl/45/cruz.html

McGinnis, M. D. (2011). Updated guide to IAD and the language of the Ostrom workshop: A simplified overview of a complex framework for the analysis of institutions and their development. *Policy Studies Journal, 39*(1), 169–183. https://doi.org/10.1111/j.1541-0072.2010.00401.x

Miratori, K. (2015). *Good governance of rice field fishery management*. WorldFish.

Nightingale, A. (2013). Fishing for nature: The politics of subjectivity and emotion in Scottish inshore fisheries management. *Environment and Planning A, 45*(10), 2362–2378. https://doi.org/10.1068/a45340

Ostrom, E. (1990). *Governing the commons*. Cambridge University Press. https://doi.org/10.1017/CBO9780511807763

Ostrom, E. (2008). *Design principles of robust property-rights institutions: What have we learned?* [Workshop abstract]. http://ssrn.com/abstract=1304708http://www.indiana.edu/~workshop

Ostrom, E. (2009). Collective action theory. In C. Boix, & S. C. Stokes (Eds.), *The Oxford handbook of comparative politics* (chapter 8). Oxford University Press. https://doi.org/10.1093/oxfordhb/9780199566020.003.0008

Ostrom, E. (2008). Building trust to solve common dilemmas: Taking small steps to test an evolving theory of collective action. In S. Levin, (Ed.), *Games, groups, and the global good.* Springer. https://doi.org/10.1007/978-3-540-85436-4_13

Ou, P., Sean, V., Sun, V., Chhy, S., Lim, N., Mam, S., Phin, P., Eng, K., Samon, C., & Gregory, R. (2024, March 13). *Guidelines for stocking community fish refuge systems*. WorldFish. https://hdl.handle.net/10568/140748

Phala, C., Sarin, T., Suvedi, M., & Ghimire, R. (2019). Assessment of community fish refuge management practice in the Siem Reap Province of Cambodia. *Environments, 6*(1). https://doi.org/10.3390/environments6010001

Rist, S., Chidambaranathan, M., Escobar, C., Wiesmann, U., & Zimmermann, A. (2007). Moving from sustainable management to sustainable governance of natural resources: The role of social learning processes in rural India, Bolivia and Mali. *Journal of Rural Studies, 23*(1), 23–37. https://doi.org/10.1016/j.jrurstud.2006.02.006

Rivera Cusicanqui, S. (2018). *Un mundo ch'ixi es posible : ensayos desde un presente en crisis* (1st ed.) [A ch'ixi world is posible: Essays from a president in crisis. Tinta Limón.

Schultz, O. J. (2017). The micro-politics of small-scale fisheries governance in South Africa: A case study of community-based political representation as a form of brokerage. *Maritime Studies, 16*(7). https://doi.org/10.1186/s40152-017-0060-x

Scoones, I. (2015). *Sustainable livelihoods and rural development*. Practical Action Publishing. https://doi.org/http://dx.doi.org/10.3362/9781780448749

Sehring, J. 2009. Path dependencies and institutional bricolage in post-Soviet water governance. *Water Alternatives, 2*(1), 61–81.

Shieh, J., Eam, D., Sok, S., Long, H., Try, V., Sean, V., Sun, V., Ou, P., & Freed, S. (2019, August). *Integrating nutrition and gender into Community Fish Refuge-Rice Field Fisheries system management: A practitioner's guide.* Phnom Penh: Cambodia: WorldFish Cambodia. https://digitalarchive.worldfishcenter.org/bitstream/handle/20.500.12348/4870/d9214e70c009d77a6005ef55bee725ab.pdf?sequence=2

Sithirith, M. (2011). *Political geographies of the Tonle Sap: Power, space and resources* [Unpublished doctoral dissertation]. National University of Singapore.

Sithirith, M. (2022). Water security and Indigenous water management practice: A case study of the Metuk water management in Cambodia. *Journal of Ecology & Natural Resources, 6*(3), 1–15. https://doi.org/10.23880/jenr-16000300

Sithirith, M., Sao, S., de Silva, S., Kong, H., Kongkroy, C., Thavrin, T., & Sarun, H. (2024). Water governance in the Cambodian Mekong Delta: The nexus of Farmer Water User Communities (FWUCs), Community Fisheries (CFis), and Community Fish Refuges (CFRs) in the context of climate change. *Water, 16*(2), 242. https://doi.org/10.3390/w16020242

Steffek, J., & Wegmann, P. (2021). The standardization of "good governance" in the age of reflexive modernity. *Global Studies Quarterly, 1*(4), ksab029. https://doi.org/10.1093/isagsq/ksab029

Šūmane, S., Kunda, I., Knickel, K., Strauss, A., Tisenkopfs, T., Rios, I. des I., Rivera, M., Chebach, T., & Ashkenazy, A. (2018). Local and farmers' knowledge matters! How integrating informal and formal knowledge enhances sustainable and resilient agriculture. *Journal of Rural Studies, 59*, 232–241. https://doi.org/10.1016/j.jrurstud.2017.01.020

Tengö, M., Brondizio, E. S., Elmqvist, T., Malmer, P., & Spierenburg, M. (2014). Connecting diverse knowledge systems for enhanced ecosystem governance: The multiple evidence base approach. *Ambio, 43*(5), 579–591. https://doi.org/10.1007/s13280-014-0501-3

Thiel, A., Mukhtarov, F., & Zikos, D. (2015). Crafting or designing? Science and politics for purposeful institutional change in Social-Ecological Systems. In Environmental Science and Policy (Vol. 53, pp. 81–86). Elsevier Ltd. https://doi.org/10.1016/j.envsci.2015.07.018

Vanny, M., Adnan, M., Sok, V., Choeun, K., & Neau, S. (2024). Local implementation of decentralization policies in Cambodia. Innovative: Journal of Social Science Research, 4(4), 5642–5655. https://doi.org/10.31004/innovative.v4i4.13700

WorldFish. (2022). *Internal report of finalization of second phase of the Feed the Future Cambodia Rice Field Fisheries II (RFF II) project in Kampong Thom Province.* Phnom Penh, Cambodia.

WorldFish. (2016). Feed the future Cambodia rice field fisheries II. *WorldFish*. https://worldfishcenter.org/project/feed-future-cambodia-rice-field-fisheries-ii

Yamamoto, S. (2016). Ethnic fermented foods and beverages of Cambodia. In J. Tamang (Ed), *Ethnic fermented foods and alcoholic beverages of Asia* (pp. 237–262). New Delhi: Springer. https://doi.org/10.1007/978-81-322-2800-4_10

Yin, R. K. (2018). Case study research and applications design and methods (6th ed.). Sage Publications.

Zeng, L., Chatti, D., Hebdon, C., & Dove, M. R. (2017). The political ecology of knowledge and ignorance. The Brown Journal of World Affairs, 23(2), 159–176. https://ssrn.com/abstract=3007687