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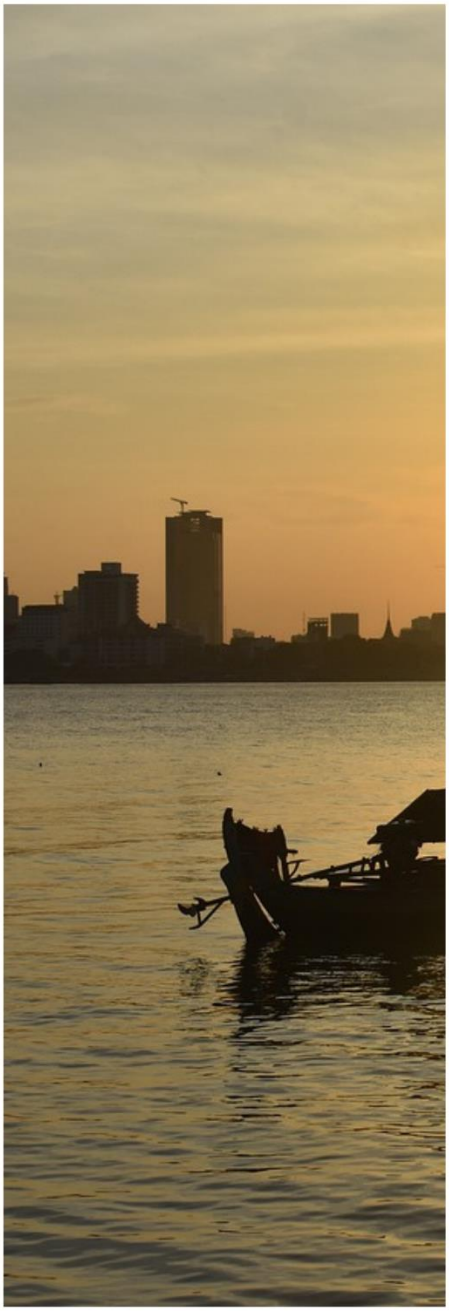
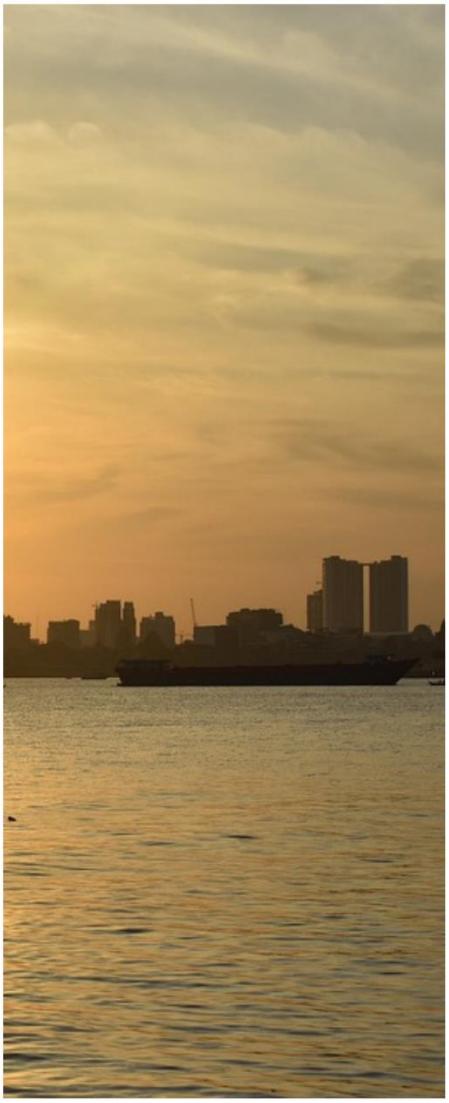
The NGO Forum on Cambodia

ROSA LUXEMBURG STIFTUNG
SOUTHEAST ASIA – HANOI OFFICE

Impacts of a Low Flow of Water from the Mekong River to Tonle Sap Lake on the livelihoods of Different Communities and Natural Environments





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Research Study on "Impacts of a Low Flow of Water from the Mekong River to Tonle Sap Lake on the Livelihoods of Different Communities and Natural Environments"

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ABSTRACT

Tonle Sap Lake (TSL) is the largest freshwater lake in the Mekong River Basin (MRB) and Southeast Asia. It is connected to the Mekong River (MR) through the Tonle Sap Lake (TSL). The MR flows into TSL in early or late June but usually in mid-June. These phenomena are influenced by a 'flood pulse', which transforms both the physical and human landscapes of the Tonle Sap, submerging vast areas during the wet season and exposing those areas in the dry season. The flood pulse of TSL is being changed following the construction of many hydropower dams in the Mekong River Basin, the urban expansions along the Mekong, Bassac, and Tonle Sap Rivers and around TSL in Cambodia, and sand mining in the Mekong River Basin. Furthermore, a climate challenge has occurred in the Mekong River Basin (MRB) and Cambodia, contributing to changing rainfall between the wet and the dry season—more rains in the wet season and droughts in the dry season.

The NGO Forum on Cambodia has commissioned a study of the impacts of the changing water flow from the MR to TSL on the environments and livelihoods of different communities around the lake. The study reviews the literature, analyzes the hydrological data of TSL between 2010 and 2023, and conducts three case studies of communities in TSL to demonstrate the impacts of hydrological change on the environment and livelihoods of local communities. First, the study looks at the case study of Kampong Khleang, a water-land-based community in TSL in Siem Reap Province, to document the impacts and effects of lower water levels on livelihoods. Second, the study examines Kampong Loung—a water-based community in TSL in Pursat Province to carry out the data collection and monitoring of fish catch and livelihoods in this community. Third, we study the changes in fish catch, hydrology, and livelihoods in the Rohal Soung Village—a land-based community in the Ek Phnom District, Battambang Province.

The study concludes that the average water level in TSL in the dry season dropped to about 1.37m and in the wet season to about 7.60m between 2010 and 2023. The volume of TSL has dropped between 35-40% and 50%. The monthly water volume of 2019, 2020, 2021, 2022, and 2023 is smaller than the long-term average (LTA) volume of 1997-2019. The water volume of TSL from 2023 up to September 2023 has reduced by 50% compared with the LTA average. Between 2017 and 2023, the dry season inundation decreased by 10-15%, while the wet season inundation (WSI) decreased by 30-45%, lower than the LTA average. These have affected fishery, the lake's natural resources, and the livelihoods of local communities. Fish catch has reportedly dropped in all studied communities, contributing to lower incomes. Migration has increased in fishing communities, and so do indebtedness. The Royal Government of Cambodia (RGC) has made concerted efforts to address issues faced by fishing communities in the lake. However, some issues remain challenging and need strong coordination between local, national, and regional actors to address them.

ACRONYM

ATTZ	Aquatic/terrestrial transition zone
CFi	Community Fishery
CNMC	Cambodia National Mekong Committee
FiA	Fishery Administration
FiAC	Fishery Administration Cantonment
HH	Household
LBC	Land-based Community
LTA	Long-term average
MAFF	Ministry of Agriculture, Forestry and Fishery
MCM	Million Cubic Metter
MOWRAM	Ministry of Water Resources and Meteorology
MRB	Mekong River Basin
MR	Mekong River
MRC	Mekong River Commission
NGOF	NGO Forum on Cambodia
NGO	Non-governmental Organization
NTFP	Non-timber Forest Product
OAA	Other Aquatic Animal
PDoE	Provincial Department of Environment
PDoWRAM	Provincial Department of Water Resources and Meteorology
RF	Reverse Flow
RGC	Royal Government of Cambodia
TSA	Tonle Sap Authority
TSL	Tonle Sap Lake
TSR	Tonle Sap River
WBC	Water-based Community
WLC	Water-land-based Community

CONTENTS

1. INTRODUCTION

Tonle Sap Lake (TSL) is the largest freshwater lake in the Mekong River Basin (MRB) and Southeast Asia. The lake connects to the Mekong River (MR) via the Tonle Sap River (TSR), and it has an exceptional water regime (Kummu et al., 2014)[1]. The lake covers 2,500-3,000 km^2 in the dry season with an average water level of 1.30m. However, the size of TLS increases to 13,000-15,000km^2 in the wet season with a water level of 10-11m, following the reverse flow of water from the MR to TSL (Kummu et al., 2006)[2]. These phenomena are influenced and driven by a 'flood pulse,' which transforms both the physical and human landscapes of the Tonle Sap, submerging vast areas during the wet season, exposing those areas in the dry season, creating inundated forests with unique species adapted to the rhythms and cycles of the pulsing ecosystem, and providing habitats for many species of flora and fauna (Lambert, 2006).

The flood pulse of TSL is being changed following the construction of many hydropower dams in the Mekong River Basin. The upstream hydropower dams jeopardize the connectivity between the upstream and downstream Mekong River systems. Furthermore, the urban expansions along the Mekong, Bassac, and Tonle Sap Rivers and around TSL in Cambodia undermine the connectivity of the Mekong River and TSL. In addition, mining and hydropower developments around TSL make the links between TSL and its tributaries fragmented. These developments transform the functions and the connectivity of the Mekong-TSL-floodplain system. The disconnectivity produces the discontinuity of flow and the reverse water flow from the Mekong River to TSL. Also, it would disrupt the flow of nutrients and the migration of fish species between the MR and TSL.

Furthermore, a climate challenge has occurred in the Mekong River Basin (MRB) and Cambodia, contributing to changing rainfall between the wet and the dry seasons—more rain in the wet season and droughts in the dry season. Climate change may increase the annual Mekong River flow by 15% from 2036 to 2065 compared with 1971–2000, particularly in the wet season, but the dry season flow would be reduced by 2.18 percent (Keskinen *et al.*, 2009). The Mekong Dam Monitor (MDM) predicted that the weather predictions for the rest of the wet season in 2023 would be drier than usual due to El Nino impacts. The low water level of the lake has had adverse impacts on the livelihoods of different communities, especially on agricultural production, fishing, and collection of NTFPs.

Consequently, the change in the hydrology of the Mekong River in recent years has influenced the flood pulse and the reversed flow of Tonle Sap Lake, which affected the ecosystem functions and the lake's productivity. The flood pulse and hydrological regime have become unpredictable, in which, in some years, water-based villages were not flooded at all, and the dry season lake's waterbody was shrunken during the dry season of 2019-2021. The MRC reported the critical condition of Tonle Sap Lake during these three-year periods as the delay in the reverse flows. In 2023, NGOF reported about the changing environment, culture and how communities give up fishing activities and clearing the flooded forests for agricultural land impacting many fish species

[1] Kummu M, Tes S, Yin S, Adamson P, Józsa J, Koponen J, Richey J, Sarkkula J. 2014. Water balance analysis for the Tonle Sap Lake–floodplain system. Hydrological Processes. 28(4):1722-1733.

[2] Kummu M, Sarkkul J, Koponen J, Nikula J. 2006. Ecosystem management of the Tonle Sap Lake: an integrated modeling approach. *International Journal of Water Resources Development*, *22*(3), pp.497-519.

and other aquatic resources (NGOF, 2022)[3]. Furthermore, due to the scarcity of resources, some community members migrate elsewhere for alternative jobs (NGOF, 2021)[4].

Thus, this study is designed to examine the social and ecological changes of the Tonle Sap Lake and riverine communities following the changes in the hydrology and the flood pulse of TSL. Furthermore, it quantifies the main ecological impact of the lake as a result of the low water flow condition from 2019 and beyond. On the other hand, it also conducts a deep dive into the impacts on livelihoods of communities around the lake and generates possible strategies and measures to minimize and mitigate the impacts in the future.

1.1 Objectives

Overall Objective: The study's main objective is to examine the impacts of the low water flow in Tonle Sap Lake on the livelihoods of different communities, the socio-ecological transformation, and the coping strategies of different communities.

Specific Objectives: To realize the above objective, the study is to undertake the following activities:

1. To quantify the main ecosystem changes of the lake as a result of the low water flow condition from 2019 and beyond.
2. To conduct a deep dive into the impacts on the livelihoods of the different communities.
3. To understand the social-ecological transformations of environment and human system in Tonle Sap Lake.

1.2 Scope of Study

To achieve the above objectives, the study focuses on the low flow of the hydrological regime of TSL beyond 2019-2021 as to compare the impacts between low flow and high flow of TSL. The second scope of the study is to examine the impacts of changing hydrological flow regimes and flood pulses on communities in TSL: (1) water-based, (2) land-based, and (3) water-land-based. Notably, it studies how changes in hydrological flows and flood pulses induce changes in fishing practice, fish catch, changing in rice farming practices, and the clearance of flooded forest for rice farming and migration.

The study duration was less than 50 working days, including research design, data collection, and report writing. However, the extension would be considered upon the available time. The study also focuses on three main variables of agriculture and fisheries: water and crop relationship, water and fish landing relationship, and water and off-farm job relationship.
To deliver these outputs, the study answers the following research questions:

1. What are the changes in the hydrology of TSL over the last ten years?
2. What are the impacts of hydrological changes on the flood pulse of TSL? How is the change in the flood pulse?
3. What are impacts of hydrological changes on the fishery and fish catch?

[3] NGOF (2022) Impact study of Tonle Sap Lake's Tributary Functions.

[4] NGOF (2021) People migration to climate change

4. How these changes—hydrological changes and change in fish catch—have affected the livelihoods of communities in TSL?
5. What changes are happening in TSL communities—land-based, water-based and water-land-based communities?
6. Is there a migration from the TSL communities following these changes?
7. What are the long-term solutions to address these changes in TSL?

2. CONCEPTUAL FRAMEWORK

Tonle Sap Lake (TSL) is connected to the Mekong River via the Tonle Sap River. The river-lake-floodplain connectivity and the hydrological regime of the river system, particularly the reverse flows of water from the Mekong River to TSL in the wet season and the returned flows from TSL to the Mekong River in the dry season, produce the flood pulse of TSL and shape the flood pulse in different forms: predictable and unpredictable, and long and short duration. The flood pulse is also driven by the lateral overflow of water between the river/lake and the floodplain, zoning the river-floodplain area into an aquatic/terrestrial transition zone (ATTZ), which prevents prolonged stagnation and allows rapid recycling of organic matter and nutrients, thereby resulting in high productivity. The flood pulse is the driving force responsible for the existence, productivity, and interaction of living and non-living organisms in river-lake floodplain systems throughout the year (Junk et al., 1989[5]; Lambert, 2006[6], 2013[7]).

In the wet season, the flood pulse occurs when water inundates a floodplain in TSL. Flooding of the floodplain brings about a transfer of biomass from the terrestrial to the aquatic phase; considerable inputs of mostly inorganic sediments in the lake water flush into the floodplain; and are deposited there; terrestrial habitats are flooded; large amounts of biomass decay, and large amounts of inorganic and organic matter deposited during the terrestrial phase are mobilized by the overlaying water; terrestrial organisms migrate into non-flooded habitats or show adaptations to flooding; and aquatic organisms are flushed or migrate into the floodplain. In the dry season, the water level falls in the lake; water stored in the floodplain with any dissolved and suspended matter enters the lake; the floodplain falls dry and becomes colonized by terrestrial organisms; large amounts of water-borne organic carbon become stranded and incorporated in the terrestrial food webs; aquatic organisms move to permanent water bodies or show adaptations to periodic drought and floodplain pools become isolated from the parent lake and develop specific physical and chemical characteristics and specific species assemblages. The cycle of flooding and drought in the Tonle Sap lake-floodplain ecosystem is the main force determining ecosystem productivity (Lambert, 2006, 2013). Primary production associated with the ATTZ is much higher than that of permanent water bodies in unmodified systems (Lambert, 2006, 2013). Fish yields and production are strongly related to the extent of the accessible floodplain, whereas many fish species use the main river as a migration route. Floodplain fisheries have an average potential fish production rate

[5] Junk WJ, Bayley PB, Sparks RE. 1989. The flood pulse concept in river-floodplain systems. Canadian special publication of fisheries and aquatic sciences. 106(1):110-127.
[6] Lamberts D. 2006. The Tonle Sap Lake as a productive ecosystem. International Journal of Water Resources Development. *22*(3):481-495.
[7] Lamberts D. 2013. The role and significance of the flood pulse in the functioning and management of the Tonle Sap ecosystem, Cambodia.

of 2.5-4 times that of tropical lakes and reservoirs on an annual mean water surface area basis (Bayley, 1991)[8].

The flood pulse shapes culture, lifestyle, and social processes, in which water is essential for agriculture, energy production, transportation, and many other activities that sustain human life. It is not only human society but also ecosystems that rely on water and rapidly deteriorate in its absence, thus endangering the livelihoods and resources they provide (). The flood pulse of TSL shapes three communities in TSL, living reliant on water, aquatic resources, and farming: (1) water-based community, (2) water-land-based community, and (3) land-based community. A *water-based community (WBC)* consists of floating homes that form the 'floating villages'. The Floating village floats and moves from one location to another on water. *A water-land-based community* (WLC) is a stand-stilt community where people live six months on land and six months over water in TSL. Their houses are built on stilts about 6–8m above the ground, which could stand in water. *A land-based community* (LBC) is in a zone 6m above sea level (asl) between National Roads 5 and 6 (Sithirith, 2011)[9]. The flooding water from TSL does not submerge the community areas. People living in land-based communities are engaged in farming and fishing.

Many studies highlight the hydropower and irrigation developments in the Mekong Basin affecting the hydrological regime, the flooding area and its duration, and the flood pulses of TSL (Lauri et al., 2012[10]; Kallio and Kummu, 2021[11]; Sithirith, 2021[12]). Several studies present a drastic decline in reverse flow, water level, flood pulse, flooded areas, and flood duration between 1960 and 2019 (Lin and Qui, 2017[13]; Ji et al., 2018[14]; Wang et al., 2020[15]; Yun et al., 2020[16]). Specifically, Chua et al. (2022)[17] presented a drastic decline in flood pulse in TSL, in which an average annual reverse flow from the Mekong to TSL decreased by 56.5 %, from 48.7 km^3 in 1962–1972 to 31.7 km^3 in 2010–2018 (Chua et al., (2022), and further down to 18.83 km^3 in 2019-2020, below long-term reverse flow volume (MRC, 2020)[18]. These have impacted TSL's fishery, biodiversity, environment, and humans.

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[8] Bayley PB. 1991. The flood pulse advantage and the restoration of river-floodplain systems. Regulated Rivers: Research & Management. 6(2):75-86.

[9] Sithirith M. 2011. Political geographies of the Tonle Sap: Power, space and resources (Doctoral Dissertation, National University of Singapore, Singapore).

[10] Lauri H, de Moel H, Ward PJ, Räsänen TA, Keskinen M, Kummu M. 2012. Future changes in Mekong River hydrology: impact of climate change and reservoir operation on discharge. Hydrology and Earth System Sciences. 16(12):4603-4619.

[11] Kallio M, Kummu M. 2021. Comment on Changes of inundation area and water turbidity of Tonle Sap Lake: responses to climate changes or upstream dam construction? Environmental Research Letters. 16(5):058001.

[12] Sithirith M. 2021. Downstream state and water security in the Mekong region: A case of Cambodia between too much and too little water. Water. 13(6):802.

[13] Lin Z, Qi J. 2017. Hydro-dam–A nature-based solution or an ecological problem: The fate of the Tonlé Sap Lake. Environmental Research. 158:24-32.

[14] Ji X, Li Y, Luo X, He D. 2018. Changes in the lake area of Tonle Sap: Possible linkage to runoff alterations in the Lancang River? Remote Sensing. 10(6):866.

[15] Wang Y, Feng L, Liu J, Hou X, Chen D. 2020. Changes of inundation area and water turbidity of Tonle Sap Lake: responses to climate changes or upstream dam construction? Environmental Research Letters. 15(9):0940a1. https://doi.org/10.1088/1748-9326/abac79.

[16] Yun X, Tang Q, Wang J, Liu X, Zhang Y, Lu H, Wang Y, Zhang L, Chen D. 2020. Impacts of climate change and reservoir operation on streamflow and flood characteristics in the Lancang-Mekong River Basin. Journal of Hydrology. 590:125472.

[17] Chua SDX, 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. 26(3): 609-625.

[18] Mekong River Commission (MRC). 2020. Situation Report: Hydrological Conditions in the Lower MR Basin in January-July 2020. MRC: Vientiane, Laos.

Thus, this study examines these impacts on the environment and the human system and identifies the transformation that takes place in the lake. The study employs the above conceptual framework to analyze the changes in the flood pulse and its impacts on fishery, biodiversity, and livelihoods. The livelihood frameworks are utilized to analyze how the change in the flood pulse has affected the livelihood assets: (1) natural, (2) physical, (3) human, (4) social, and (5) financial, mainly, how changes in water flows affect the natural resources such as fish, biodiversity and other natural resources; the physical infrastructure such as schools, roads and others; the social and cultural dimensions of communities around the lake; and also the incomes. The study also analyzes the policy and institutional frameworks influencing these assets in the context of changing hydrological flows and natural resources in the lake, and what strategies the human system has developed to build their strategies in addressing these changes.

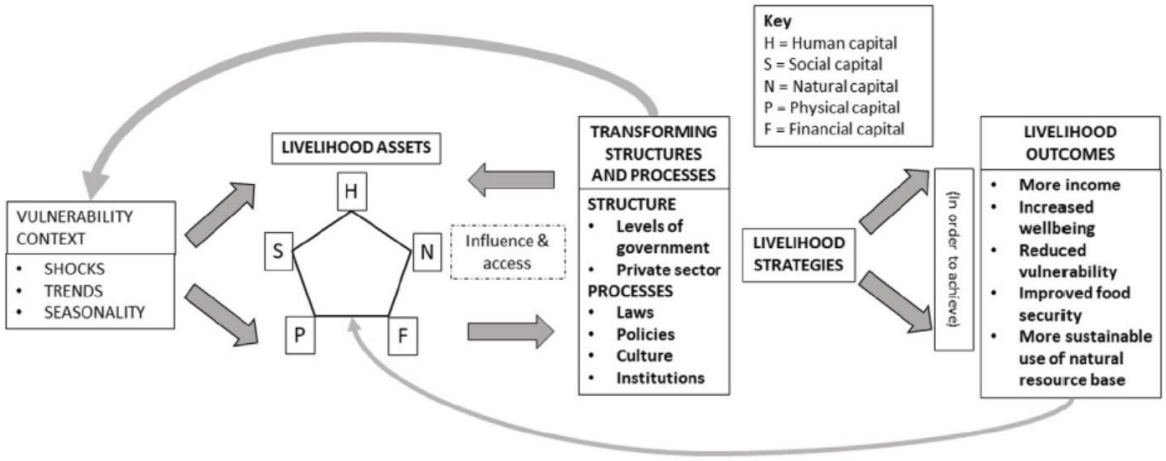

Figure 1. Livelihood Framework of the 21st Century (Natarajan et al., (2022)[19]

3. METHODOLOGY

The study employs the above conceptual frameworks to analyze the impacts of the hydrological changes in TSL on fishery, environments, and community livelihoods around the lake. The analysis is supported by the data and information collected by the study team in sites proposed below in TSL.

3.1 Location

The study was conducted in three sites in TSL to study the impacts of hydrological changes of TSL on fishery, rice farming, livelihoods, and communities. First, we select one village in Kampong Khleang namely Muk Wat, which is a water-land-based community (WLC) in TSL in Siem Reap Province to work with local communities to collect data and monitor the fish catch and the changes in livelihoods. Second, we select the Phum Pir village in Kampong Loung—a water-based community in TSL in Pursat Province as a second site to carry the data collection and monitoring of fish catch and livelihoods in this community. Third, we study the changes in fish

[19] Natarajan, N., Newsham, A., Rigg, J., & Suhardiman, D. (2022). A sustainable livelihoods framework for the 21st century. *World Development, 155*, 105898.

catch, hydrology, and livelihoods in the Rohal Soung Village—a land-based community in the Ek Phnom District, Battambang Province.

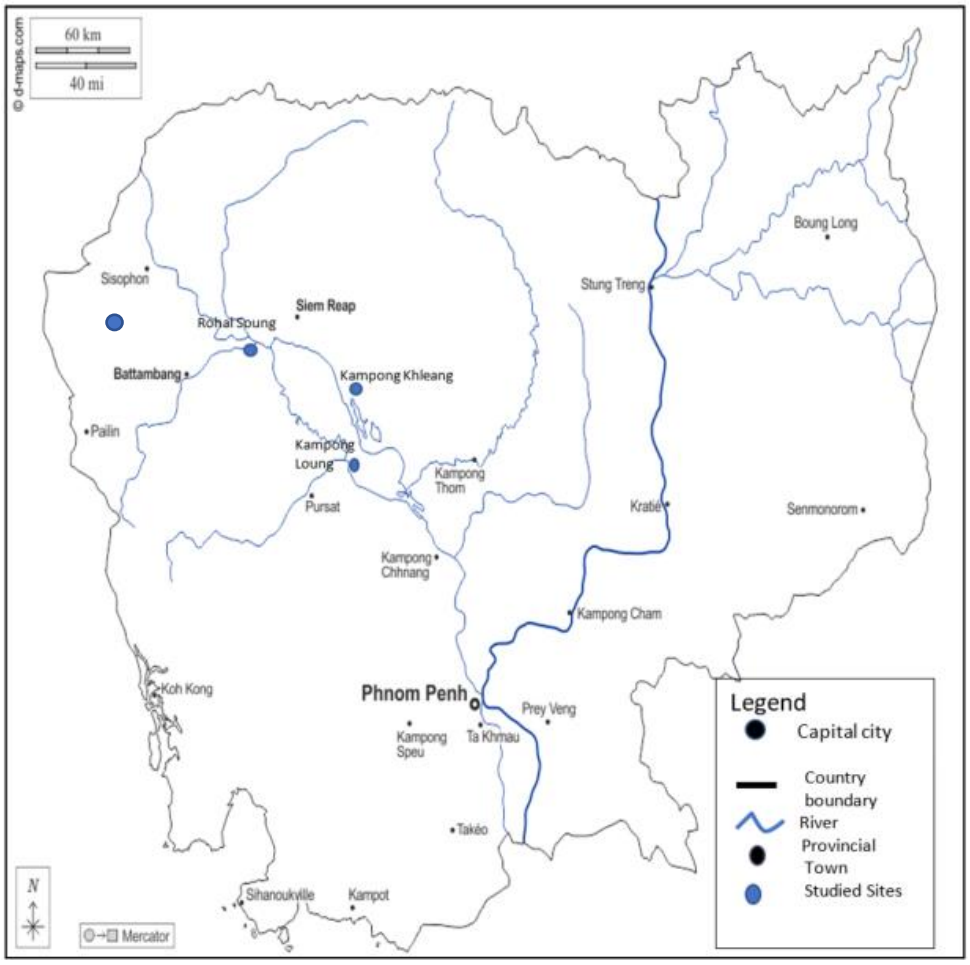

Figure 2. Map of the Study Areas in Tonle Sap Lake (TSL)

The study focuses on the impacts of the hydrological changes on fish catch, agriculture, culture, and livelihoods of different communities in TSL. This study supports the design of the interventions to prevent future changes that could affect TSL and the livelihoods of people dependent on the lake resources. This study is part of the project to promote the space of dialogue with youth, civil society, and relevant duty bearers to discuss alternative development models for a socially just and ecological transformation.

3.2 Data Collection

Under the scope and the research questions stated in the TOR, to achieve the above-stated objectives, the study employs qualitative and quantitative research methods to collect and analyze data on hydrological changes, fish catch, changes in agriculture, livelihoods and culture of TSL

communities. To do so, the study team collected both primary and secondary data on the proposed sites in Tonle Sap Lake.

a) Secondary Data Collection

The study team collected the secondary data from different sources. It included the hydrology of TSL, water level, inundated area, the fish catch, the fish catch by different communities, community fishery, the changes in rice cultivation in TSL, the clearance of flooded forest for agriculture, policy and legislation, and legal frameworks concerning fishery management, fish catch, and utilization, and the migration. Secondary data were collected from various archive sources at the national, provincial, and local levels. Government agencies, Provincial Government Offices, donors, and NGOs are rich sources of documents, books, and research papers. The study team conducted the literature reviews, which consisted of relevant existing documents, policies and other water resources papers and documents, as well as the climate change impacts related to the Tonle Sap flow regime and farming application in various Tonle Sap household's livelihoods were meaningfully conducted prior to verifying the fact findings in the assessment. Based on the existing documents, project reports, and consultations with the NGOF team, we reviewed the relevant documents regarding Tonle Sap in-flow and out-flow, the climate change caused discharge and water Tonle Sap ecosystem, natural disasters, and flood area of Tone Sap – focused on what links, impacts that led to livelihoods of the three communes, what policies and strategies of the government were implemented and what gaps existed in responding to water flow and farming systems. Moreover, while reviewing the current state of the flow regime and reservoir attached to the Tone Sap, we designed a study plan – identifying either qualitative or quantitative approaches, key informants and migrants, data collection and analytical methods, and reporting structure.

The study team reviewed the secondary data. The outcome of the secondary data review was the trends of hydrology in TSL, the correlation between hydrological change and fish catch, and the changes in agricultural practices and livelihoods in communities in TSL.

b) Primary Data Collection

The study team collected the primary data in the selected sites on the criteria of best practices in fish catch, water level in Tonle Sap Lake and livelihood activities. The proposed samples were 1) representative families or households affected by flood and drought in each community of the three selected study areas; 2) government officials from the communes where study locations were selected and interviews conducted using structured questionnaires; 3) Sample size were classified into a group of farmers, group of fisheries, and the group of business; and 4) Non-Governmental Organization (NGOs) working to promote the climate-related water management, agriculture, or fisheries were approached to widely discuss the livelihoods of the local households and their interventions in the study area. Then, the number of samples was determined via formula as clarified below and subject to be discussed with the NGOF team.

The primary data collected include:

- Hydrological changes in TSL
- Geography, the location, culture, livelihoods

- fish catch in both wet and dry seasons
- water level in the wet and dry seasons;
- inundated areas over ten years period,
- Stakeholder involvements in recognizing and verifying the data collected
- Local community contributions.

Primary data were gathered through key informant interviews (KIIs) and focus group discussions (FGDs).

- ***Key Information Interviews (KIIs)***

Key informant interviews were conducted with knowledgeable persons from the Fishery Administration (FiA), Fishery Administration Cantonments (FiACs), Provincial Department of Environments (PDoEs), Provincial Department of Water Resources and Meteorology (PDoWRAM)/MoWRAM, Commune Councilors in the selected sites, NGOs, RCC members, and key representatives of local communities. More specifically, the research team conducted the KIIs with NGOs who work with local communities to monitor the fish catch and water level at each site for in-depth studies. Local community representatives who engaged in the monitoring were interviewed in-depth.

The KII questions were developed in consultation with the team of the NGO Forum. The lists of interviewees from the sites in the Tonle Sap Lake were finalized with NGOF after the final discussion with the consultant team. For key informants, since the target participants at the sub-national level (i.e., samples) were unique and specialized, a non-probability sampling technique were applied and we based our sampling decisions interchangeably on the mixture of three main techniques – Purposive, Convenient, and Snowball Samplings to assure the most correct participants engaged in the discussions and interviews:

- Questions/questionnaires are developed, finalized and tested based on different samples i.e., key informants, households…
- Formal and in-depth interviews with key informants i.e., commune/district/provincial authorities/groups
- Semi-structured interviews with sampled households in the three locations

- ***Focus Group Discussion (FGDs)***

To further complement the findings from the KIIs, qualitative data were collected through Focus Group Discussions (FGDs). Three Focus Group Discussions (FGDs) were conducted with local communities at the study sites. One FGD was conducted at each site, with the participation of at least 5-8 people to discuss the work and progress according to water level changes, fish catch declines and livelihood opportunities. Participants who were included in the FGDs include community members who engaged in fishing and water level monitoring, members of community fisheries and other community members, and women who were involved in fishing activities at the household levels. Focus group discussions (FGDs) focused on agricultural farming, fishing activities, and other livelihood activities.

3.3 Data Analysis

Qualitative and quantitative analytical approaches were used to analyze the primary and secondary data. It required a few sample sizes to be conducted in the interviews, except for the KIIs and the FGDs. The consultant team used the Excel Sheet to analyze qualitative and quantitative data collected from primary and secondary sources. The data was entered into Excel sheets and processed into percentages, figures, and a table. Percentage, fact, and figure were supported by qualitative information.

These data were analyzed using the livelihood conceptual frameworks above to assess the impacts on the livelihood assets, including the natural, social, capital, human and financial assets. It also analyzes how different communities adapt their livelihood strategies in response to changes in hydrological regimes and socio-ecological changes.

3.4 Timeframe

Although valuable data in the study sites are available, getting access to it took constant communication to build trust before these agencies would share it. The consultant team collected data, FGDs, and interviews between September and October 2023. The report was first validated with the stakeholders the study team interviewed to clarify and update the information in the report. The report was then launched on 23 October 2023 by the NGO Forum on Cambodia with the participation from government and non-government agencies. The Consultant Team was later updated and included final comments and inputs from concerned stakeholders before the end of 2023.

4. RESULTS AND DISCUSSIONS

4.1 Tonle Sap Lake and Its Impacts by Hydropower and Climate Change

Tonle Sap is characterized by both a river and a lake system. Tonle Sap River (TSR) connects the MR to TSL and the surrounding floodplain. The MR and the tributaries discharge a large volume of water annually to the lake and the sea. The TSL system comprises the permanent water lake, the floodplains, and the watershed area (Kummu & Sarkkula, 2008; Kummu et al., 2014). The water volume of TSL is estimated at about 83.1 km^3. In the wet season, water from the Mekong River contributing 53.5% of total water volume in TSL, the lake's tributaries contributes 34%, and the precipitation 12.5%. The lake absorbs large volumes of floodwaters and reduces flooding along the Mekong River (Kummu et al., 2014). The water flows from the Mekong River, bringing 72% of sediments to TSL, providing rich nutrients for fish and biodiversity, and fertilizing the agricultural lands along the Mekong River and Delta. In the dry season, from November to March, when the water level in the Mekong River is lower than that of the Tonle Sap Lake, TSL outflows its water to the Mekong mainstream through the Tonle Sap River, estimated at 82km^3, of which 84% via Tonle Sap River and 13% via evaporation. The water volume of TSL in the dry season is estimated at 4.5 km^3 (Kummu et al., 2014). This process is called a 'flood pulse,' which drives the inundation and productivity of the lake, particularly the fishery and livelihoods of communities (Lamber, 2006).

The functions, productivity, and livelihoods depend on the water flows (discharges) from the Mekong River to TSL and vice versa. Enough water enters TSL and its floodplains, and the secured volumes inundate the floodplain areas. The water flow and the volumes from the MR keep TSL functioning uniquely, beating as the heart of the MRB. The secured reverse flow provides the secured volume of water to TSL that inundates the floodplain areas over a specific duration, allowing the living organism to reproduce and grow in the lake. With nutrients, the regular natural flows in the lake, enough volume of water, and good quality of water make the hearth and the geo-body healthy and high productivity in biodiversity and freshwater fisheries. This pulsing system, together with a large floodplain, high levels of biodiversity, and annual sedimentation plus nutrient fluxes from the Mekong, makes the lake one of the most productive freshwater ecosystems in the world (Kummu et al., 2006; Lamberts, 2006).

The annual 'flood pulse' (timing, modality, speed, height, duration) is essential to fisheries productivity and fish migrations in the Lower Mekong Basin and Tonle Sap system (Rainboth, 1996; Poulsen et al., 2002). About 500 fish species (van Zalinge & Thouk, 2000)[20], out of 758-1,200 fish species in the MRB (Rainboth, 1996[21]; Baran, 2005[22]) reside in freshwater bodies in Cambodia, of which 280 fish species inhabit TSL (Wright et al., 2004)[23]. About 200 billion fish eggs and fries are carried downstream by the Mekong currents in the wet season and swept into the inundated floodplain areas of TSL, where conditions are ideal for the rapid growth of young

[20] Van Zalinge N, Thuok N. 2000. Fisheries Management Issues in Cambodia. Contribution to the MRC Program for Fishery Management and Development Cooperation Technical Symposium 7-8 December 1998. Phnom Penh: MRC Secretariat.
[21] Rainboth WJ. 1996. FAO species identification field guide for fishery purpose. Fish of the Cambodian Mekong, Rome, 265.
[22] Baran E. 2005. Cambodian inland fisheries: facts, figures and context. WorldFish: Phnom Penh.
[23] Wright G, Moffat D, Wager J. 2004. Establishment of the Tonle Sap Basin Management Organization: Tonle Sap Basin Profile. Phnom Penh: Asian Development Bank and Cambodian National Mekong Committee (CNMC).

fish. The flooded land provides the nutrients for fish to grow in the lake (Thouk, 2009)[24]. In addition, 23 migratory species move downstream from the lake (Thanh Be et al., 2007)[25].

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TSL naturally comprises three ecological functioning zones—the terrestrial, the floodplain, and the aquatic. The terrestrial zone covers a large land area—rice fields and a flooded forest area. The floodplain is an area where it is flooded for six months and dry for another six months. However, the aquatic zone is an area where it is covered year-round by water (Bailleux, 2003).

The 'flood pulse' of TSL influences how people live in the lake and use its resources to sustain their livelihoods. The human in TSL has organized their settlements in three different categories, located in three different ecological zones: land-based, water-based, and water–land-based communities. The land-based community (LBC) is a community situated on land year-round. Community members are farming and fishing, depending on the distance between the lake and the community. The water-based community (WBC) refers to a floating community, whereby the community is floated year-round on water, and fishing is a primary occupation of community members. The third community category is a water–land-based community (WLC), whereby the community is physically located for six months on the water and six months on land. These communities are in the ecological zone, affected by seasonal water levels (Sithirith, 2011).

The development of hydropower in the Mekong River Basin (MRB), urbanization in the wetland areas around TSL, and climate change have disrupted the connectivity of the Mekong River and TSL. Hydropower dams have disrupted the flow and volumes and undermined the connectivity between the MR and TSL. Between 1993 and 2020, China built 65 dams along the Lancang River and its tributaries, of which 11 hydropower dams are on the mainstream. Furthermore, China has

[24] Thouk N. 2009. Community fish refuge husbandry in lowland agriculture ecosystem. Doctoral dissertation, Doctoral thesis, Build Bright University.
[25] Thanh BT, Sinh Bach T and Miller F. (eds). 2007. Challenges to Sustainable Development in the Mekong Delta: Regional and National Policy Issue and Research Needs. Bangkok: Stockholm Environment Institute (SEI), Thailand.
[26] Van Zalinge N, Thuok N. 2000. Fisheries Management Issues in Cambodia. Contribution to the MRC Program for Fishery Management and Development Cooperation Technical Symposium 7-8 December 1998. Phnom Penh: MRC Secretariat.
[27] Rainboth WJ. 1996. FAO species identification field guide for fishery purpose. Fish of the Cambodian Mekong, Rome, 265.
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[31] Thanh BT, Sinh Bach T and Miller F. (eds). 2007. Challenges to Sustainable Development in the Mekong Delta: Regional and National Policy Issue and Research Needs. Bangkok: Stockholm Environment Institute (SEI), Thailand.

planned to build an additional 12 dams on the mainstream Lancang River that could generate 21,310 MW with a storage capacity of 47,644 MCM (Qingsheng, 2020). In the LMRB, 132 hydropower projects proposed, planned, and built on the tributaries—25 hydropower dams are operational, 13 hydropower dams are under construction, 23 hydropower dams are licensed, and 74 hydropower dams are planned. Eleven hydropower dams are proposed on the mainstream MR, of which two were built (MRC, 2017). Some 42 hydropower dams are planned in the 3S river basin—three hydropower dams were built on the Sekong River, eight on the Sesan River, and seven on the Srepok River—and 23 hydropower dams are under the planning process (Constable, 2015; Piman et al., 2016; Piman et al., 2013). Five hydropower dams have been proposed around the lake—2 in the Stung Sangker River, 2 in the Stung Pursat River, and one in the Stung Sen River, with a total installed capacity of 5073 MW and a storage capacity of 20,555 MCM (MRC, 2009; Urban et al., 2018).

TSL, like another river basin, is facing threats from climate change. Climate change has caused heavy rains and flooding in the wet season and severe droughts in the dry season in TSL (Nuorteva et al., 2010; Keskenen et al., 2015). Between 2019 and 2021, the water level in the lake was critically low in its history. Wang et al. (2020) argue that this low water level is due to climate change, not the hydropower dams. Similarly, Ji et al., (2018) confirm that the operation of dams in the Lancang River does not primarily account for the inundated area reduction in TSL during the flood season. Also, Frappart et al., (2018) present significant correlations between the lake's surface water volume and rainy season rainfall in the MRB, and the TSL's hydro-climatic extremes have a connection to climate change.

4.2 Hydrological changes—Flow, Volume, Inundation

4.2.1 Water Level

Normally, water flows from the Mekong River to Tonle Sap Lake from May to July. In 2023, the reversed flow from the Mekong River into the Tonle Sap began between 06 and 10 July 2023. The water level in TSL rises slowly between July and September 2023. The study team examined the water level in three locations in the Lake: (1) Kampong Loung, Pursat Province; (2) Chong Kneas in Siem Reap Province; and (3) Preak Toal in Battambang, and found that the water level is still low, estimated around 5m in September in Kampong Loung, representing the entire lake. Based on the data collected from three sites, the average water level trend has decreased in the past 13 years.

In 2023, the water level of the TSL is significantly down. Climate Change, low precipitation, loss, and forest cover degradation in the catchment areas could cause this. In Prek Toal, compared to the same periods in the previous years, the water level in September 2023 is lower than that of the last year, about 2m. The water level in the TSL depends very much on the release of water from the upstream dams of the Mekong mainstream.

In Pursat Province, there are three tributaries of the TSL: Stung Pursat, Stung Svay Daun Keo, and Stung Maam. The hydrological regime varies from year to year. In some years, the water flooded upstream. In 2022, at this particular time, the water level in the TSL is around 8.00m, but for this year (2023), the water level is 4.50m.

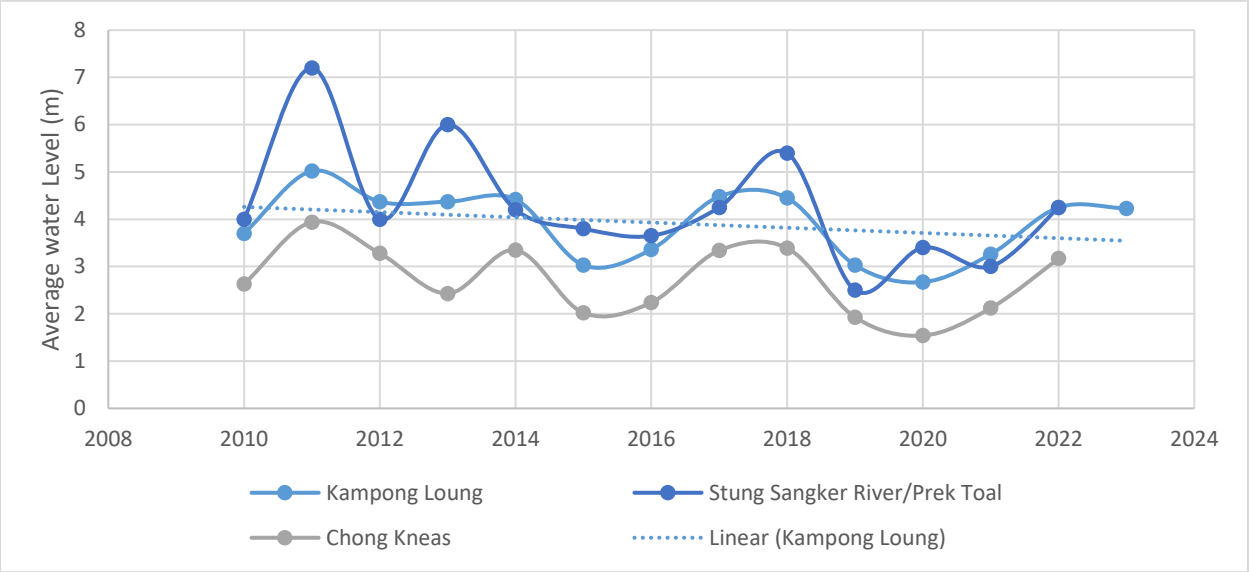

Figure 3. Water level in the studied areas in TSL

4.2.2 Flows and Reverse Flows

When water levels along the Mekong River rise at the end of the dry season, the Mekong River inflows return to the Tonle Sap Lake, called the "reverse flow (RF)". This phenomenon usually takes place from the end of May to July. Figure 4 shows the seasonal changes of the outflow and the inflow/reversed flow of the TSL compared with the flows of 2020, 2011, and 2022 and their LTA level (1997- 2022). In 2019, the RF started until the first week of August, three months later. The total RF volume to TSL was estimated at 31.48 Km^3, critically lower than the long-term average (LTA) of TSL (40-42 Km^3). In November 2019, the water level in the lake started dropping immediately, reaching below the critical level in December 2019 and continuing in January and February 2020.

In the 2020s, the RF of TSL took place intermittently. The first RF started on 7 July and ended on 15 July, with a total volume of just 0.21 Km^3, significantly delayed (about two weeks later than in 2019 and 40 days later than the 1997–2017 average). The second RF occurred in the last week of July or early August 2020, resulting in an accumulated RF volume of 12 Km^3. The third and fourth RF events occurred in late September and the third week of October 2020. The RF finally stopped in the last week of October. The total volume of the RF in 2020 was only 18.89 Km^3 or about 44% of the acceptable annual volume of 43 Km^3 (average condition for 1997–2005). As a result, at the end of October 2020, TSL experienced extreme drought conditions, and the RF was at its lowest record since 1997.

In 2021, the RF took place three times. The first RF started on 28th May and ended on 1st June 2021; the second RF resumed on 15th June and ended again on 1st July 2021. The third RF occurred again on 13th July and ended on 15th August 2021. It shows that up to mid-August 2021, the water volume of TSL is higher than the levels in 2019 and 2020 during the same period. However, the water volume of TSL has been considered low compared with the LTA level.

In 2023, the reversed flow (RF) from the Mekong River into the Tonle Sap began between 06 and 10 July 2023. Up to September 11, 2023, the inflow into the Tonle Sap Lake was most likely caused by inflows and rainfall from the catchment area.

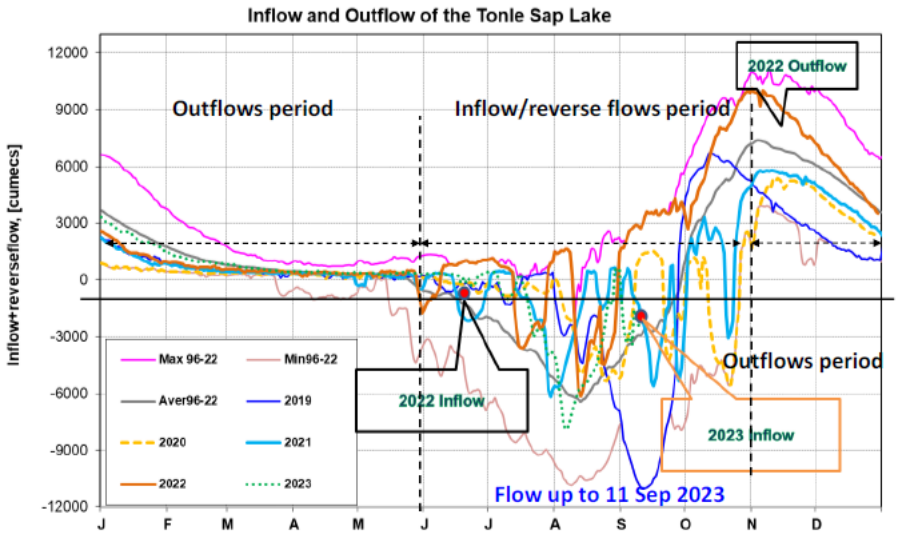

Figure 4. Inflow of outflow in TSL (MRC, September 11, 2023)

4.2.3 Volume

In the wet season, water from the MR, tributaries, and rainfalls flow into TSL, estimated at 83.1 km^3, of which the MR contributes 53.5%, the lake's tributaries 34%, and the precipitation 12.5%. The lake absorbs large volumes of floodwaters and reduces flooding along the MR. The lake size has increased from covering 2500 km^2 in the dry season to 11,000-13,000 km^2 in the wet season (Kummu et al., 2014). In the dry season, from November to March, when the water level in the MR is lower than the lake, the TSL outflows its water to the Mekong mainstream through the Tonle Sap River. The lake size has reduced to around 2500 km^2 with a dry season volume of about 1.5 km^3 (Sithirith, 2015; Kummu et al., 2014; Kummu et al., 2006; Kummu & Sarkkula, 2008).

Figure 5 presents monthly flow volumes by year between 2018 and September 2023 flowing into TSL, compared with the long-term average (LTA) of volume entering into TSL. The average dry season monthly volume of TSL is 4,166 MCM (4.16 km^3), measured between 1997 and 2019. The wet season monthly volume is 49,698.19 MCM (50km^3). Compared with the volume of water estimated by Kummu et al., (2014), the volume of TSL has declined. Also, looking into the monthly water volume entering TSL, Figure 5 shows that monthly volumes of 2019, 2020, 2021, 2022, and 2023 are smaller than the LTA average volume of 1997-2019. The water volume of the Tonle Sap Lake from 2023 up to September 2023 has reduced by 50% compared with the LTA average (about 50%), during the same period. Thus, flow alterations in the mainstream could have a direct impact on the Tonle Sap Lake water levels and its hydrology. However, the monthly water

volume in 2022 increased above the monthly water volume of 2021, 2020 and 2019, still it is lower than the TLA average.

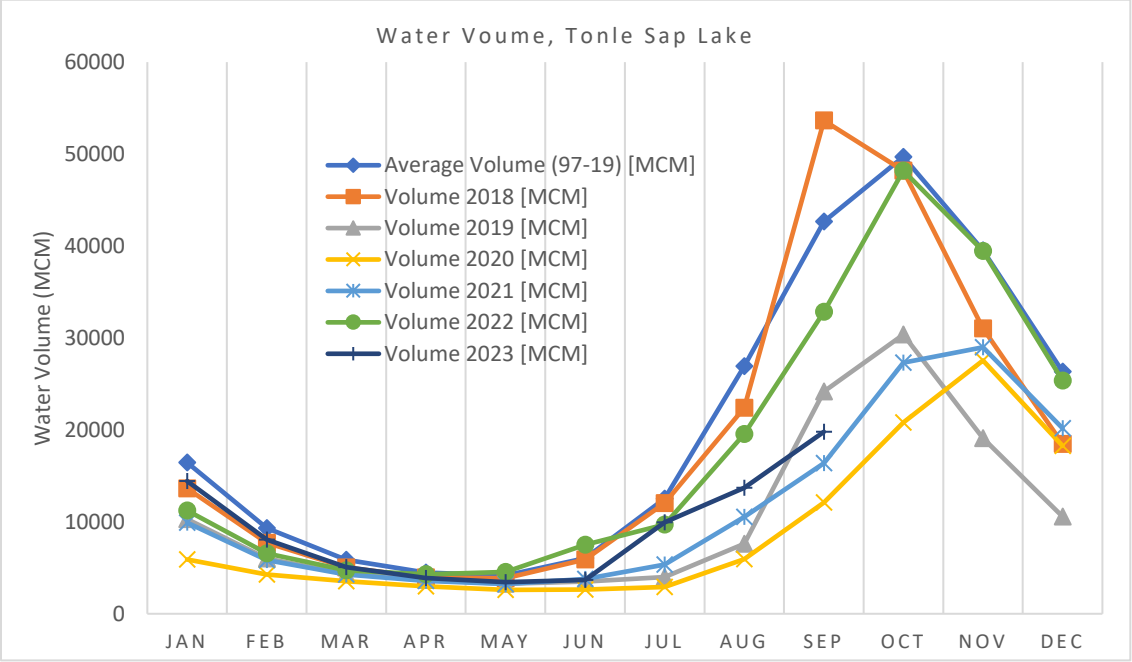

Figure 5. The Volume of TSL

4.2.4 Inundation

The average dry-season lake area was 2,922 km^2 between 1997 and 2012. During the wet season, the dry season lake increases four times, to about 11,955.41 km^2. However, the inundation in TSL varies within and between years, depending on the flows and volumes of water from the Mekong River to TSL.

Recently, more hydropower has been built and operated in the upper Mekong River Basin. The operation of these dams has altered the hydrological regime of the lake. Furthermore, climate change and infrastructure developments in the MRB and Tonle Sap Region have increased the water level fluctuation in the MR and TSL. Figure 6 shows the declining inundated areas in TSL between 1997 and 2012. Between 2017 and 2023, the dry season inundation decreased by 10-15%, while the wet season inundation (WSI) decreased by 30-45%, lower than the LTA average of inundation.

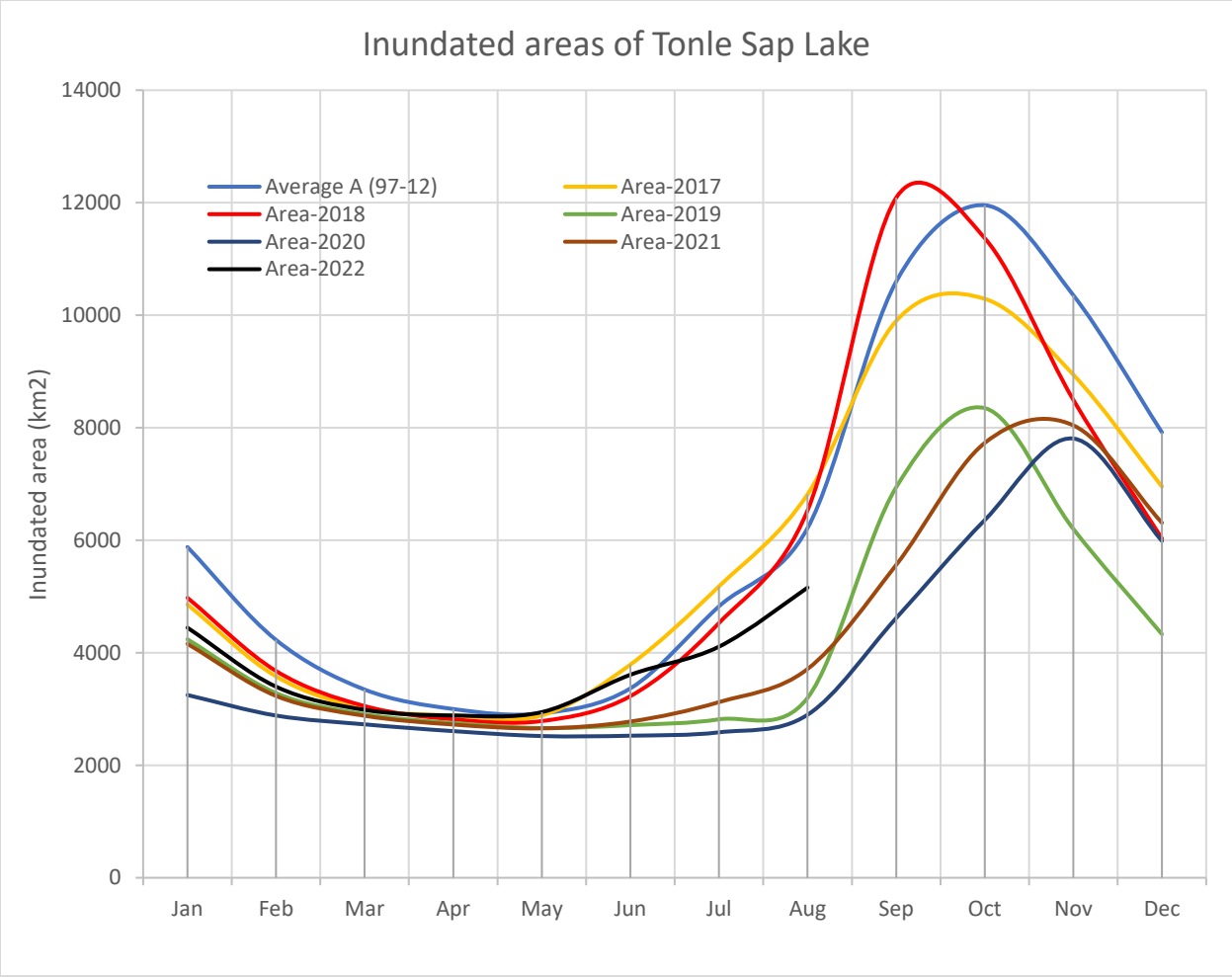

Figure 6. The inundated areas around Tonle Sap Lake between 2017 and 2020.

In 2022, with the increased water volume, the inundated areas increased to 100% in May and June, but for the rest of the year, only 75-95% of the lake's area inundated. Also, as of September 2023, the water level was still 1.5-2m lower than in 2022, and based on this, it is estimated that only about 53% of the lake area is inundated. The ground verifies these facts check in Kampong Loung site during the study that the Commune Office is a stand stilt, usually submerged during the wet season, particularly from August to October every year. However, the Community Office was not underwater in the last 5-10 years. In Kampong Khleang, as of September 2023, this community should have been in water already with a water level of 3.5-4m deep, as a water-land-based community, but water from TSL has not reached the community area yet in 2023, and the entire community is still on land.

4.3 Fishery and Biodiversity—Catch and Productivity

The changes in the RF from the MR to TSL between 2018 and 2020 and the reduction in the inundation around the lake degrade the lake's productivity. The fish production in Cambodia reached 856,400 tons in 2021, down by 8.5 percent from 936,300 tons in 2020. Further, inland fish

production in Cambodia dropped from 535,005 tons in 2018 to 413,200 tons in 2020. The Dai fishery production in TSR declined from 16,975 tons in 2018 to 9,900 tons in 2020. The decline in inundated areas around the lake, the low volumes of floodwaters entering the lake, the degradation of fish habitats due to lower water levels, and the destruction of flood forests between 2018 and 2020 contributed to changes in fish catches in TSL.

The annual fish catch from TSL accounts for 250,000 tons. However, between 2018 and 2020, it dropped from 291,260 tons in 2018 to 144,635 tons in 2020--a 50% reduction. The decline of fish production in TSL is associated with the lowering water level, volume, inundated areas, and flood duration. Of course, it cannot deny other factors that contributed to the decline in fish catches in TSL, such as the destruction of flooded forests, illegal fishing, and the disappearance of some fish species. It also demonstrates the decline in fish catch by provinces in TSL. In Siem Reap, Kampong Chhnang, and Kampong Thom provinces, fish catch has contributed significantly to the provincial economies and livelihoods of communities around TSL. However, they recently experienced a drop in fish catch. The reductions in fish catches have transformed the human connection with the lake.

There is an increase of small fish in the catch, such as *Trey Bandol Ampov*, *Trey Riel*, and *Try Chrologn Moan*, which are small and low prices. Even fishermen who catch large quantities of small fish still do not get a reasonable price, 2,500-3000 riel per Kilogram. There is a decrease in large fish in the catch, which has happened since 2000. Some significant and high-value fish species have disappeared, such as *Trey Kantrap Khla*, *Trey Krayear*, *Trey Prolung*, *Trey Dang Kteng*… etc. Some species are getting rare, such as *Trey Proma*, *Trey Damrey*, *Trey Sanday*, *Trey Kcheung… etc.*, and they are expensive. Among the species under immense fishing pressure and dwindling numbers is the striped catfish Pangasianodon hypophthalmus, which is now endangered as per the IUCN due to its decreasing numbers in the Tonle Sap Lake, the Cambodian Mekong River, and the Chao Phraya River in Thailand (Campbell et al., 2022; Vidthayanon & Hogan, 2013). The increased small fish and reduced large fish in the catch indicate declining fish productivity in TSL.

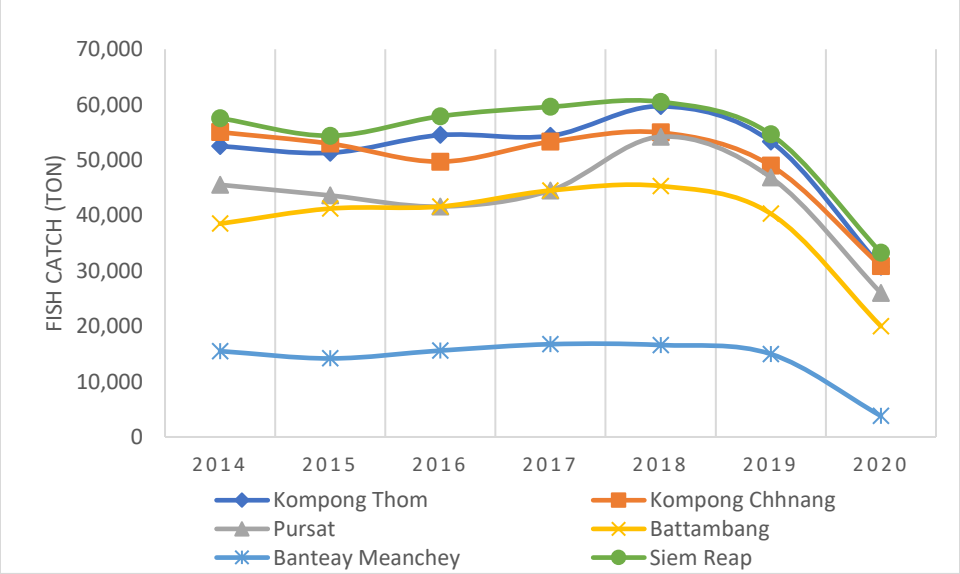

Figure 7. Fish catch in Tonle Sap Lake between 2014 and 2020

The changes in hydrological regimes of TSL have also impacted on biodiversity, such as birds and other wildlife. The bird eats fish, and when, there is a lower water level in the lake, there are fewer fish, impacting the food webs of birds. The encroachment of flooded forest has resulted in clearing flooded forest for agriculture, causing flooded forest fires of hundred hectares every in the lake.

4.4 Human Impacts—Livelihoods of Communities in Tonle Sap Lake

The natural ecological system of TSL influences livelihoods and how people use the lake's resources. Due to the geographical location and the hydrological regime of the lake, the study classifies the communities into three different types: (1) land-based community; (2) water-based community; and (3) water-land-based community (Sithirith, 2011). About 2 million people live in these communities, who rely on lake resources and organize their societies based on the flood pulse. The flood pulse is very important to people living in the region. People have lived with rising and falling water for generations. They have unique solutions to live with the influence of Tonle Sap Lake.

The changes in hydrological regimes of the Mekong River and TSL have affected the livelihoods of local communities living in three different categories of communities mentioned above. The study examines the above changes in (1) Kampong Loung—a water-based community located in TSL in Pursat Province; (2) Kampong Khleang—a water-land-based community located in TSL in Siem Reap Province; and (3) Prek Norin/Rohal Soung—a land-based commune in the floodplain areas of TSL in Battambang Province. The study examines the impacts of hydrological changes on the livelihoods of the above communities in terms of human, social, physical, financial, and natural impacts, and how communities respond to these changes in their capacity and support from government agencies.

Table 1.The livelihoods of communities in Tonle Sap Lake

Livelihood Indicators	Water-based: Kampong Loung	Water-land-based: Kampong Khleang	Land-based: Rohal Soung
Human	• 1449 households (hhs) with 5950 people; Vietnamese—340 hhs— • 5 floating villages—village no.5 is a Vietnamese village.	• 2,588 hhs with 11,815 people living in 10 villages. • ID Poor: 668hhs • Indebtedness hhs—800hhs	• 3,900 hhs—17,120 persons. The population under 18 years old is 11,303 persons. • 10 villages—farming 90% and fishing 10%.
Physical	• Floating and mobile community following the rising and falling water level. • Floating houses • Floating path—5-6km. • About 7km from National Road No. 5. • Four primary schools • Area 4,200ha	• Commune area—20,021ha • Ten water-land-based villages with stand-stilt housing, 7-8m above the ground. • In the dry season, the community is on land, in the wet season, the village is in water for six months. • Located deep in the TSL floodplain about 20km from National Road No. 6. • One village is not flooded.	• Land-based community • It is influenced by water from TSL and the Stung Sangker River. • Farming field— (1) Sreleu and (2) Srekroam.
Social	• Vietnamese—340hhs—Vietnamese Buddhist temple—01 in village no.5. • Cham living in village no.4. • Khmer—Majority • Four Buddhist temple for Khmer • Migration	• Majority is Khmer • Few Vietnamese households. • Many are Buddhist with 04 Buddhist temples. • 01 secondary school.	• Majority is Khmer • Buddhism—90%. • Farming is the main livelihood activity. • 01 primary school.
Financial	• Fishing as main occupation—85%. • Income is from fishing—30,000-50,000 riel/day • Fish catch—7-8kg/day/hh. • Indebtedness—90% of total population	• Fishing—85% • Chamcar—field crop—10% • 5%--petit traders/workers. • Migration—500 pers. • Indebtedness—800 hhs. • Fish catch—15-20kg/day	• Farming is the main occupation—85% • Fishing is secondary—10%. • Migration—30% • Indebtedness—65-70%. • Rice farming is 2 times/years with 5 tons/ha.
Natural	• Tonle Sap Lake • Fishery resources • Water resources • Water level and floating communities. • Water pollution	• TSL as fishing grounds for the entire commune. • Rice in fishery, flooded forest, and water. • Community is relying on fishing	• Tonle Sap—sources of fish and water. Water is for rice and fish. • Sangker River is also a source of fish and rice. Rice in fertile soil. • Fish is declined and less fish,

4.4.1 A Water-Based Community—A Case of Kampong Loung Floating Community

Geography

The Tonle Sap is home to several water-based villages or in other word, a floating village. Kampong Loung is a water-based community in TSL. It is a floating community located on the western shore of TSL, on water space, covering a total area of about 4,200ha, in the Krakor District, Pursat province. Kampong Loung commune is bordering to Ansar Chambark of Kampong Chhnang Province to the downstream and to Kandeang District, Pursat Province to the upstream. It is very remote from the District and Provincial Towns, about 7 km from the Krakor district center.

Water Level

Water level in Kampong Loung is considered as a water level of TSL. Water level in the lake starts to rise in May and it reaches the peak level in October. Usually, at the end of the rainy season, the water stays still for a particular period of time until the raining ended, and then, the water level starts going down. It is apparently that for the last 10-15 years the hydrological regime of TSL has changed and water level is lower as compare to that of the last 40-50 years. During that period, it was apparent that the flood was big and there were plenty of fish. Nowadays, it is hard to see or predict the hydrological regime, even though there is a modernized system, it is still not possible to predict the hydrological regime correctly both in wet and dry seasons.

At present, the water level has just suddenly risen and after a short time, it is suddenly going back. Water has risen for about 10-20 days in recent years and stopped rising. Usually, in the middle of the river, the water depth in the dry season is up to the human neck, but nowadays, it is around the chest or waist. Also, the water seems warm, and subsequently, fish and OAAs have no habitats, leading to fewer fish and OAAs, adding up the fishing of every family for their livelihoods. Generally, the number of people living here has declined (per. Comm. With Keo Sovannareth, 17 September 2023).

The hydrological regime and water level in TSL have altered drastically in the last 10-15 years. Figure 8 provides detailed information on the water level variation between 2010 and 2022. The trend of water level in TSL shows a decline between 2010 and 2023. May is a month of lowest water level in TSL. The average water level in May measured between 2010 and 2022 is about 1.37m. The deepest water level in the dry season was found in May 2022 of 1.75m and the lowest water level was 1.02m in May 2016. The water level in the dry season in TSL has dropped from 1.52m in May 2018 to 1.32m in May 2019, and then to 1.09m in May 2020. It has increased to 1.31m in May 2021, and then 1.75m in May 2022, but decreased to 1.37m in May 2023.

In the wet season, the average water level measured between 2010 and 2023 is 7.60m. However, the deepest water level in TSL in the wet season was 10.8m in October 2011 and the lowest water level was 5.28m in October 2020. Since then, it has been dropped significantly. The water level of the lake in the wet season dropped to 8.52m in October 2018; then to 6.68m in October 2019 and 5.28m in October 2020. It started increasing to 6.26m in October 2021 and then 8.48 in 2022, but it dropped again to 5.73m in September 2023. Overall, the water level in TSL is varied from year to year and has dropped significantly in the last 15 years.

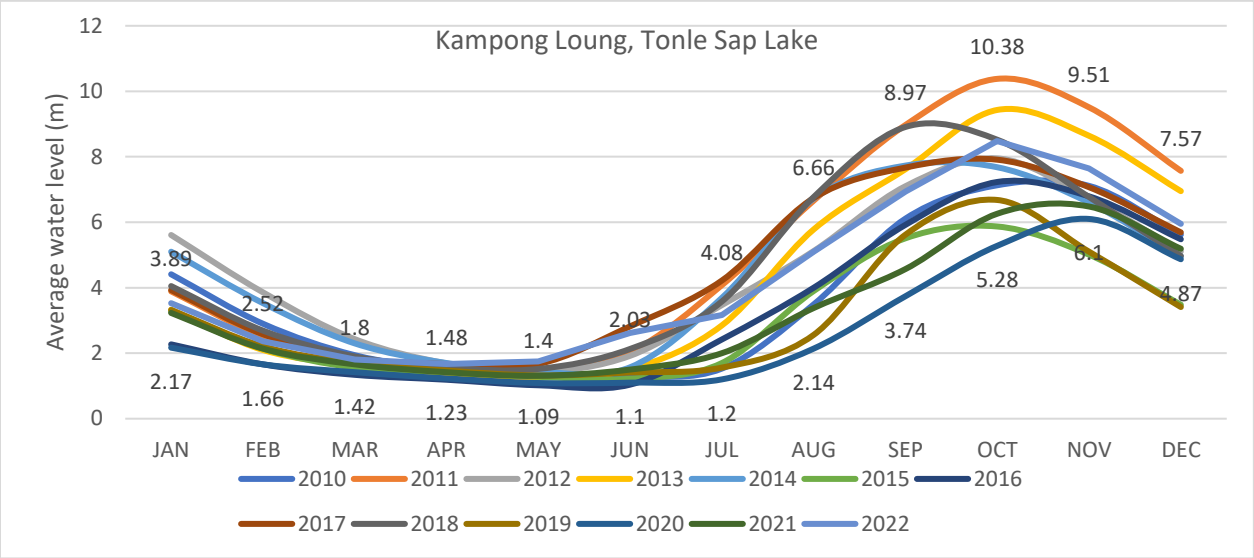

Figure 8: The Monthly water level in Kampong Loung 2010-2023 (MRC & 2023)

The Commune Office used to be flooded by the rising water from TSL in the last 10-15 years ago. The road access to the Commune Office was also flooded in the wet season, following the rise of water level in TSL. Access to the Commune Center was mainly by boats during the wet season. The floating houses of Kampong Loung community were floated and moved to settle surrounding the Commune Office in the peak event in October every year.

At present, the floods of TSL does not reach the Commune Office. These have happened in the past 5-10 years. The Commune Office becomes a land-based office and the floating houses have not come nearby due to the lower water level in TSL. These have changed the waterscapes and the way in which the floating communities access to land-based office, where boats are their main transportations.

Kampong Loung Commune Office, Photo no.1 took in September 2023, Photo no.2 took in October 2014

People

Kampong Loung Commune has five villages, namely Village 1, 2, 3, 4, and 5, and most of them are floating villages, except Village no.4 homed to 514 families as a land-based village. Indeed, Village No. 4 used to be located on the water in the wet season and on land in the dry season, but for the last 10-15 years, water has not inundated Village No. 4 anymore and it is located entirely on land nowadays. Kampong Loung as a commune is home to more than 1,449 households in 2023 with a total population of about 5950 people. It is a fascinating floating commune as an ethnically mixed space with its unique human territoriality associated with rising and falling water levels. Living in floating villages, those families are mixed communities with Khmer and ethnic people, mostly Khmer, Khmer Islam, Vietnamese (not much), and Chinese, living together and practicing different occupations, from trading in goods to fishing and netting; most of them are fishers. About 340 Vietnamese households live in village No. 5, and most of them are living as either fishermen or fish traders.

Table 2. Population in Kampong Loung

Villages	Total number of families	Total Population	Above 18 years old of national migration	%	Above 18 years of international migration	%
1. Village no.1	202	814	9	1	0	0
2. Village no.2	172	679	37	5	7	1
3. Village no.3	201	965	0	0	16	2
4. Village no.4	497	1984	288	15	51	3
5. Village no.5	377	1508	32	2	1	0
Total	1449	5950	366	6	75	1
Source: Commune Database 2021						

Kampong Loung is the largest floating community in TSL. It is considered a ‘floating town’ of the Tonle Sap. Access to this community is mainly by boats, and a few local grocery shops are moving according to the water level up and down, the primary school was seen on the water too, as a petrol station set on the local floating house, a pagoda hands in hands with a floating church, and even a floating health center and floating fish landing port. The only difference from a ‘normal’ village is that the entire village life is happening on floating houses and boats. A stroll through the village is only possible with a boat. Kampong Loung is a village whose life is floating on the Tonle Sap Lake and moving up and down depending on water availability.

Floating and Mobility

As a floating town, Kampong Loung floats and moves. There are four types of floating houses—boat, ferry floating, bamboo rafting, and pen floating homes. The floating community floats vertically and horizontally. First, they float vertically between a water level of about 1m above sea level (asl) in the dry season to 10m asl in the wet season—the average floating height is around 7.6m. Second, Kampong Loung floats and moves horizontally or laterally as the water level rises in the lake between an area about less than 6m above sea level (asl) to an area about 8-10m asl.

As a result, the Kampong Loung community floats and moves upward as the water level in TSL rises from the lowest position of 1m asl in May to the highest position of 10m asl in October over 3-4m long. In November, when water level in TSL recedes, the entire floating community starts floating and moving back to its original position in the lake in January or February and stay still there until May. Annually the Kampong Loung Community moves back and forth for about 5-6km. They also move location at the seasonal extremes (MRC, 2023). While they float and move, they park their floating houses at several locations. Often, their parking spaces are socially constructed, and in many cases, villagers compete over the parking spaces for their houses.

Thus, the vertical floating mobility in 2019 was between 1.32m and 6.68m, and in 2020, between 1.09m and 6.1m. In 2021, the vertical floating mobility was between 1.32m and 6.48m; and in 2022 was between 1.67m and 8.48m. Given the short distance of the vertical floating mobility, the

horizontal mobility of the entire floating community of Kampong Loung was shorter, estimated at about 3-4km only between 2019 and 2022 (Figure 8). These suggest that Kampong Loung was confined longer in the areas of lower water levels with many floating houses and the increased level of water pollution in the area. The lack of sanitary facilities and systems in Kampong Loung raises the high risk of increasing human waste discharged into the lake, which is a source of drinking water for lake residents. Kampong Loung is highly polluted, affecting human health, sanitation, and drinking water when the water level is low.

Fisheries

Water and fish form a fundamental basis of the livelihoods of communities in Kampong Loung. During the fishing season, farmers from neighboring communes complete the rice harvesting, and move down to the lake with a large bag of rice to exchange for fish to make a fermented fish known as '*prahok*.' In Cambodia, most people love to eat *prahok* as an essential ingredient in their food. The *prahok* business is deeply intertwined with the fish-rice economy and local food culture. Indeed, the air is thick with the pungent aroma of *prahok* in many settlements of Kampong Loung. There are two types of *prahok*: boneless and bony *prahok*. Fishers from floating communities catch fish and sell fish for rice at the Kampong Loung. Fishers from many floating communities take their fish catches to Kampong Loung. Thus, Kampong Loung becomes a local and regional 'marketplace' for fishers from many floating communities.

As densely populated areas with fishing as a primary occupation, villagers struggle with fishing. Fishing is putting pressure on declining fisheries resources. Fish catch has dropped to around 3-5kg/day for large fish in the high fishing season with the increased fishing efforts, compared to 10-15kg/day during 2000-2015, about 15 years ago. Some fishers spend up to 40,000 riels fishing in TSL per trip, including the fuel cost and bait, however, on some days, they do not get fish and lose the bait. The fish caught from the Dai Fisheries in Tonle Sap River comprised ten species, making up 90% of catches, mostly of small fishes.

At present, fish catch has been declined. First, fish catch is composed of small fish species with low values. Currently, some fishing households can catch up to 70kg/day. It seems a lot, but they are small fishes, which cost between 300-400 reals per kilogram. Before, the small fishes were only used for animal feeding. However, nowadays, people also consume small fish due to declining fisheries. There are many factors causing fish and OAAs reduction (e.g., water regime, unpredictable rise and recession, climate change, and human factors). Second, some fish species

have disappeared, and that contributes to the low composition of large fish in the catch, making the low-value catches.

However, there are fewer fishers than before because the fish catch is getting lower, and some fishermen switch their occupations to do something else. Young people, who used to work with their parents on fishing now go to work in factories. The decline in fishing has occurred across Cambodia's inland fishing areas. In the Tonle Sap region, fisher families decreased by 17 percent over the same 10-year period. One fisherman, Chhim Chea said “Since I was born, I never saw low water and fewer fish like now. My last resort is to leave this hometown again to find jobs to repay loans.” Mr. Koy Prom, 63 years old, a fisherman in Kampong Loung said for this generation, I could cast two nets and get a boat of fish, but at present, it takes fishers from sunset till the morning, and they cannot even 10 kg of fish (per. Comm, with Mr. Chhim Chea, and Mr. Koy Prom, Kampong Loung, 15 September 2023).

The fishing population in Kampong Loung has dropped. In 2010, the total number of households was 1,203, with 6,145 people. However, the population census in 2019 shows that the total number of families was only 1228, with the total number of people reduced to 5,050 (The Commune Database (CDB), Ministry of Interior (MoI), 2020). Migration for urban employment has increased, accounting for 6% of national migration and 1% of international migration, and thus, it reduces the fishing population in Kampong Loung. Vietnamese villagers have reported the returns of some Vietnamese families to Vietnam for employment as more jobs were created in Vietnam. Village no.4 has the highest percentage of migration, accounting for 15% of national migration and 3% of international migration (Table 2).

Gender

Apart from ethnic diversity, Kampong Loung has a dynamic role of women in fishing, fish processing and trading. About 51% of its population is women, with fishing as a primary occupation. Fishing is a daily activity and fish catch sustains the incomes and food of the fishing households. Women play a central role in making incomes and food security for their household members. Men go fishing every day and are often accompanied by women and children, depending on the size of the fishing boats. As houses are on the water for the entire day and year, fishing households go fishing at night and return in the morning to sell their fish. Like other fishing households, women take their fish catch to sell to fish traders in Kampong Loung sooner rather than later, as they have no cold chains to keep the fish. For other households, they process fish to more value with the intention of getting a good price.

The study team observes that there are mobile petite shops, selling vegetables, fresh and cooked foods, drinks, and non-eatable items, operated by women on boats, moved from floating houses to floating houses for non-stops. There are both Khmer and Vietnamese women who are active in the petit trades on the floating mobility in Kampong Loung, creating the largest floating town of TSL. These illustrate the active roles of women in the communities outside the fishing activities.

However, fish catch has dropped, and fishing is no longer livable for fishing households. Thus, many fishing households are struggling to get incomes to sustain their living. As a consequence, many young people from the Kampong Loung Community have migrated to work in the garment

industries set up in Krakor District. Based on the discussion with the Commune Chief of Kampong Loung, more and more young female members of fishing households above 18 years work in these factories and earn USD180-250 a month. These have triggered the effects of our migration to seek employment outside the fishing industry. However, this is still an early signal and it is too soon to assess the impacts.

4.4.2 A Water-Land-Based Community (WLC)—A Case of Kampong Khleang Community

Geography

There are several water-land-based communities (WLCs) in TSL. Kampong Khleang is one of the WLCs located on the eastern shore of TSL in Sotr Nikum District, Siem Reap Province. Kampong Khleang is located about 60km from the Provincial Town of Siem Reap. A road of about 15km connects Kampong Khleang to the National Highway no.6. It is located right inside the floodplain close to the lake. The total area of the Kampong Khleang Commune is 10,999ha, of which the residential land covers 6% of the total land areas, 4% of rice land in the commune (it is the dry season rice land), and 59% of the total lands as Chamcar (crop fields). These areas are fully flooded in the wet season and become the fishing grounds.

Table 3. Geographical location of Kampong Khleang

Areas/Items	Number	%
Total Land Area of Commune/Sangkat (ha)	10,999	100
Area of Residential Land (ha)	614	6
Total dry-season rice land in the commune(ha)	386	4
Area of Chamkar Land in the Commune (ha)	6532	59
Rice production in dry season (MT)	1351	n/a
Source: Commune Database 2021		

Figure 7. Map of Kampong Khleang

Water Level

Kampong Khleang is influenced by the changing water regime in TSL. The water level in TSL in Siem Reap is measured at the Chong Kneas station. Since Kampong Khleang is part of TSL in Siem Reap, water level in Chong Khneas is also equated to the water level in Kampong Khleang. Based on this reference, the water level in Chong Kneas station in Siem Reap fluctuated drastically between 2010 and 2023.

Also, figure 3 illustrates that the water levels in both the wet and dry seasons have declined over the past 12 years between 2010 and 2023. These declining water levels in Chong Kneas are consistent with the declining water flow and volumes from the MR to TSL. These declines have affected the livelihoods, fishery, and environments in the Kampong Khleang community. In the wet season, the highest water level in Chong Kneas is in October. Between 2010 and 2023, the average water level in October was 6.95m. The lowest water level in Chong Kneas in October was 3.87m in 2022, and the highest was 9.29m in 2011. A heavy flood in Cambodia in 2011 affected all provinces, including Siem Reap Province and Kampong Khleang. However, since 2011, the water level in Chong Kneas has been dropping. At the time of the study (17 September 2023), the study team witnessed that there was no inundation in Chong Khneas, Kampong Phlouk, and Kampong Khleang, which generally, all areas mentioned above are inundated during September, partly because there was a low flow of water from the MR to TSL. In Kampong Khleang, during September 2023, the entire community was not underwater, which is unusual. However, about one month later, in mid-October 2023, the entire Kampong Khleang community was reported under water about 4-5m. The drastic changes in water level and volume in Kampong Khleang are partly

linked to the release of water upstream of the Mekong River and the heavy rainfalls in the catchment areas around TSL.

Nevertheless, the lowest water level is found in the dry season in May. The average water level in Chong Kneas in May is estimated at 0.35m. The highest water level in May was 0.67m in 2022, and the lowest was 0.02m in 2020. Between 2010 and 2023, the lowest water levels were 0.02m in 2016 and 2020. The TSL experienced a prolonged drought in 2015-2016, leading to the state emergency declaration by the RGC for a water shortage. Also, TSL experienced the lowest reverse flow of water from the Mekong to TSL for the first time in its history in 2019-2020.

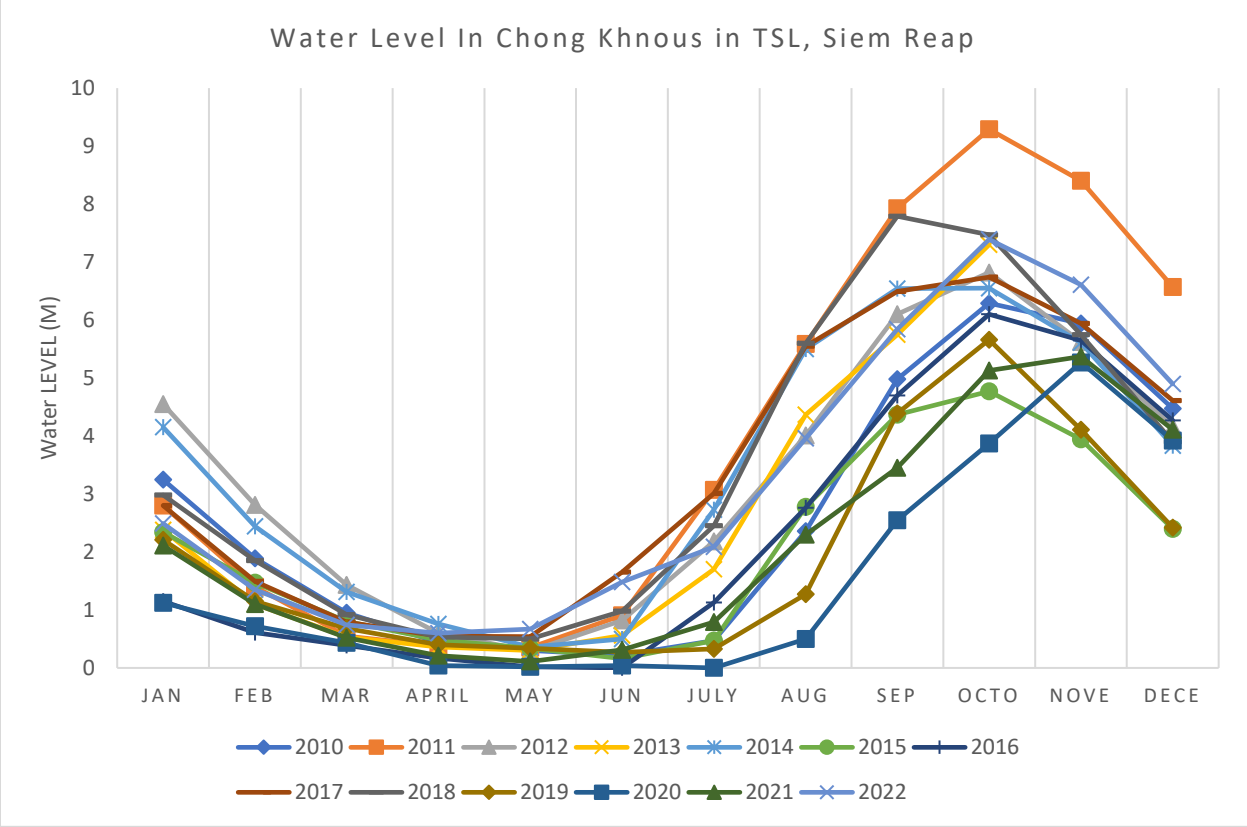

Figure 8. Water levels in Chong Kneas between 2010 and 2022

People

Kampong Khleang is home to about 2,588 households with a total population of 11,815 persons living in 10 villages, of which the female population constitutes about 50% of the total population. Among ten villages, the rising water level in TSL usually submerges nine villages, and only one village is not submerged by the peak flood. However, at the time of this study in September 2023, all There 09 villages were not inundated for the first time.

Villagers live on stilt houses for six months on land and another six months in water. Their houses are built on stilt about 7-8m above the ground. Fishing is a primary occupation. About 85% of the population are fishing, 10% in Chamcar or cropping, and 5% as petit traders and wage laborers.

Table 4. The Population of Kampong Khleang

Villages	Total number of families	Total Population	No. of people above 18 years old migrating nationally	%	above 18 years old migrating internationally	%
1. Preaek Sramaoch	394	1785	79	4	32	2
2. Spean Veaeng	208	843	22	3	8	1
3. Ta Uor Sa	158	584	27	5	9	2
4. Phsar Khleang	313	1528	155	10	40	3
5. Chamkar Yuon	207	1013	44	4	6	1
6. Ta Chranieng	405	1952	3	0	32	2
7. Ou Ta Puk	312	1416	30	2	5	0
8. Cheay Chet	137	591	20	3	4	1
9. Muk Wat	229	1124	78	7	7	1
10. Roteang	225	979	51	5	25	3
Total	2,588	11,815	509	4	168	1
Source: Commune Database 2021						

In June, the water level in Kampong Khleang starts rising and inundating up to only half of the commune area. However, water has arrived irregularly in the last 10-15 years in Kampong Khleang. Despite that, for the last three years (2020 – 2022), during September every year, water has inundated all the roads in Kampong Khleang, and people must use boats to travel.

Muk Wat Village in Kampong Kheang in October 2014.

As compared to the previous year, as of 17 September 2023, the water level in Kampong Khleang was lower than 4.8m, which is still lower than that of 2022, about 2.5m. Usually, the water level should be more profound than 5m by September. Between May and September, all areas around Kampong Khleang and all villages should have been under water for about 5-6m, but not for this year, 2023. At the time of the study in September 2023, the entire Kampong Khleang had not been flooded, and people walked from house to house and village to village. The study team reached the community by car, which was impossible during the previous September.

Based on the observations by the Commune Councilors in Kampong Khleang, the water level rose irregularly. At the time of this study, water rose about 0.05 m per night. In August 2023, the water level rose to around 3m, but in September 2023, it only rose about 1m. The causes of these kinds of changes could be climate change, hydropower development upstream of the MR in China, and Lao PDR. People have also learned that this year, 2023, the water flow in Chaktomomuk is faster than in the other years.

Muk Wat Village in Kampong Khleang in September 2023 (Photos took in September 2023)

Muk Wat Village in Kampong Khleang in September 2023 (Photos took in September 2023)

Fisheries

The changes in water regimes cause a reduction in fish and OAAs. At this time of the year, the size of the fish should be big enough for fishing, but for this year, 2023, all fishes are still fingerling/small, for instance, *Trey Real*, which is still tiny. During this month, some fish species lay eggs according to the level of water and the inundated areas. However, because of lower water levels in the lake, water does not submerge the wetlands and flooded forest areas. Therefore, some fish species such as Trey Chpin, Chhlang, Chhdor, and Climbing pert could not find flooded forests or wetland habitats to lay eggs. Instead, they lay their eggs in the mud before water comes. When the water level is shallow, other predators eat them. When the water rises, the spawning muds are inundated, leading to the fish eggs hatched lately and fingerlings growing slowly. Thus, it is vulnerable to harsh environments.

Villagers in Muk Wat Village in Kampong Khleang Commune report the decline in fish catch following the lower water level in TSL and the shrinking flooded areas in Kampong Khleang. They say that in 2023, there is little water in the areas around Kampong Khleang; thus, there is not enough water for fish to grow. The bigger the flood is, the larger the quantity of the catch would be. Due to a shortage of fish and OAAs, people caught small fish and fingerling, and this situation has been started in 2009 so far. The daily fish catch is around 15-20kg/day, but mostly small fish in the catch, which has low value and is not expensive. The increase in small fish in the catch has happened since 2009, and small fish were used to make the fertilizers.

In Kampong Khleang, FiA has established two community fisheries (CFis). The Kampong Khleang CFis covers 19,796, comprising nine villages, and Prey Sromoch CFi covers 574ha, comprising only one village. They are vulnerable to encroachment, given the lower water level. There is also increasing illegal fishing by offenders from neighboring communes. These have affected fisheries resources inside the CFis.

Migration and Indebtedness

At present, people go fishing, and they get a small catch. Fishery resources are scarce, and the catch comprises tiny fish or fingerlings used only for human consumption and animal feeding. It is also observed that where people do farming using pesticides and weedicides, fish and OAAs are affected. Based on the commune database 2021, about 5% of the population in Kampong Khleang migrates to find work at national and international levels. Phsar Khleang and Muk Wat have the highest percentage of migrations, accounting for 10% and 7%, respectively (Table 4). As of the end of 2022, more than 500 people had migrated out of the commune for jobs outside the fishing areas, such as construction. After the national election in July 2023, up to 1,000 people had migrated out of the commune for employment.

According to the registration of the Commune, people in between 700 to 800 households out of 2,800 are in debt. With the intervention by the commune authority, micro-finances and banks have conducted meetings with the debtors and introduced facilitated measures for application.

Gender

Women constitute 50% of the total population, and fishing is the main livelihood activity, where women play an essential role in fishing. In the wet season, Kampong Khleang is surrounded by water, like an open sea, and travel is mainly by boat. Man goes fishing every day, as fishing is the source of daily food and income. Also, the fishing area is located about 5-10km from their homes. Women actually go fishing with their husbands, bringing along with them the children, as no one looks after them while fishing. In many cases, fishing households go fishing at night times and they come back in the morning. When arriving home in the morning, women classify fish for marketing and some for processing. Some women trade their fish catch to middlemen who come to buy fish in the villages, but some women have their fish catches to sell in the Kampong Khleang market, located at the center of the Commune. Women also are responsible for making daily food for their families with the fish they catch from the rivers.

In the dry season, water recedes in the Kampong Khleang area and the whole community is situated on the dry land. The fishing area is located in TSL, which is very far from Kampong Khleang. Reaching the fishing area would take time and travel a few hours to get there by oxcarts in the old days, but by motorbikes at present. Many fishing households from Kampong Khleang travel to the lake and stay fishing there for a few days before returning home, but some fishing households would stay fishing there for a week to months. Thus, some fishing households bring most of the family members including wives and children, but leave behind the aged people. In this case, some children would miss school during the fishing period.

Women have more roles and responsibilities at the household and community levels. The decline in water levels and fish catch has impacted both men and women, but women are more vulnerable than men. Climate change further affects women and children, including drought and heavy floods. The decline in fish catch has made women more worried than men, at least finding food for their family members.

Facing such a situation, many young women migrate to work in the cities including Siem Reap, Dam Dek, and Phnom Penh. First, there are opportunities for women to work in the service sector and also in the garment industries. Second, fishing has declined and thus, fishing households earn less in fishing, and thus, working in cities would earn more incomes than fishing. At the same time, women have gained their capacity through their engagement in various social activities and play more roles than before. Apart from earning more income for their families from their work outside the fishing sector, the woman has been elected as the Commune Councilor to provide leadership to the Commune Administration. Their capacities have been built by the provincial government and development partners. However, women need more support and capacity builds for them to support other women and their families in the context of changing environments and socio-economic conditions.

Pollution

The lower water level increases the risk of water pollution. There has been increased use of agricultural inputs for rice farming and crops, affecting water quality. The increased population in Kampong Khleang has contributed to pollution as sanitation is poor in the water-land-based community, where human discharges their wastes into the lake.

4.4.3 A Land-based Community (LBC)—A Case of Rohal Soung Village

Geography

Rohal Soung is a land-based community (LBC) in the Prek Norin Commune, Ek Phnom District, Battambang Province. Prek Norin Commune has ten villages, bordered by Peam Ek commune in the West, Prey Chars Commune in the North, Krachov Factory in the South, and the Sangker River in the East. There are three Conservation Lakes, namely Ta Ek Lake, located in Rohal Soung Village; Ath Ta Hor Lake in Ansang Bork; and Toeuk Khmao Lake in Prek Trob. The Rohal Soung Village is located on the left bank of the Stung Sangker River, about 15km from Battambang Town, in the TSL floodplains. Large areas of rice fields surround it.

Table 5. The population of Prek Norin Commune

Villages	Total number of families	Total Population	Above 18 years old migration nationally	%	Above 18 years old international migration	%
1. Preaek Ta Chraeng	663	2430	225	9	81	3
2. Preaek Krouch	341	1412	113	8	97	7
3. Svay Chrum	374	3103	102	3	54	2
4. Preaek Norint	584	2139	260	12	250	12
5. Sdei	324	1180	122	10	137	12
6. Rohal Suong	339	1789	91	5	99	6
7. uong Mea	237	787	37	5	76	10
8. Reach Doun Kaev	259	1065	23	2	34	3
9. Ansang Sak	359	1303	159	12	28	2
10. Preaek Trab	420	1912	225	12	115	6
Total	3900	17120	1357	8	971	6
Source: Commune Database, 2021						

In the village, there are four main irrigated canals and one water storage dam, called Ta Arn Storage Dam, and at least each farmer's family has one water pump. Fishing has also been the main occupation of the Rohal Soung residents, and TSL is the main fishing ground for villagers from the Rohal Soung community. After the rice harvest in November or December, villagers fish in TSL. Fishing is usually done in the dry season when the water level is low in the lake.

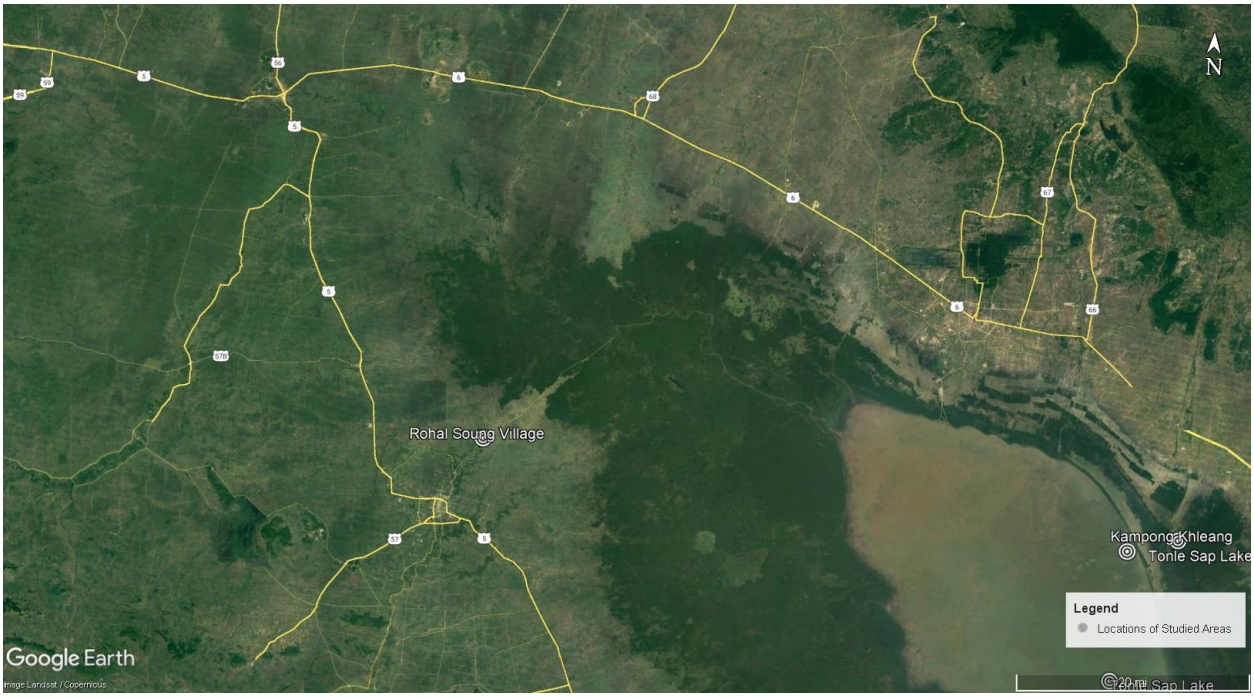

Figure 9. Map of the Rohal Soung Village

Water Level in Sangker River

Between 2010 and 2023, the water level in Stung Sangker near the Rohal Soung Community has changed drastically regarding the timing of the flooding, the water level, and the volume of water that floods the rice fields and the fishing grounds. In the wet season, because of the heavy rain in the catchment areas of the Stung Sangker River, the water level in Stung Sangker starts rising and flowing into TSL. At the same time, the water level in TSL starts rising in late August or early September and lasts much longer, flooding the floodplain areas along the Sangker River and around the Rohal Soung Village. The water level in the Stung Sangker River starts rising in August, increasing to about an average of 8m in October. The rice fields in Srekrom are flooded about 2-3m deep, and the Sreleu nearby village area is also flooded about less than 0.5m, allowing farmers to cultivate the wet season rice. About 51% of families in Rohal Soung are affected by flooding.

In November, water recedes the Srekrom, and the dry season starts in November and ends around April at a water level of around 5.22m in the Stung Sangker River. Figure 4 shows that the trends of water levels in the Stung Sangker River in Rahal Sound are declining in both the wet and dry seasons. In the last five years, water levels in Stung Sangker have declined, and water bodies have dried up, affecting fishery, farming, and water for humans and agriculture. About 27% of families in Rohal Soung are affected by droughts.

The critical water condition in the Rohal Soung community occurred between August 2019 and 2022, affecting aquatic life, particularly fishery and farming, making fishing and farming uneasy. The deep pool water bodies, including community fish conservation areas, were dry and had no water. Fish catch has dropped drastically to less than 2kg/day during the fishing season, and fishing

is no longer reliable for their income-generating activities. The surrounding areas of Rohal Soung were vulnerable to forest fire and poacher encroachments.

In 2023, the water level rises very late, and the duration of inundation is concise. It is the first time in history that the water level of the Sangker River drops to about 30-40 cm, which is walkable from one side to another of the Stung Sangker River. In the last two decades, there were two times big floods, damaging all rice and other supplemental crops, particularly in 2000 and 2011. Since then, there have been no floods in the Rohal Soung.

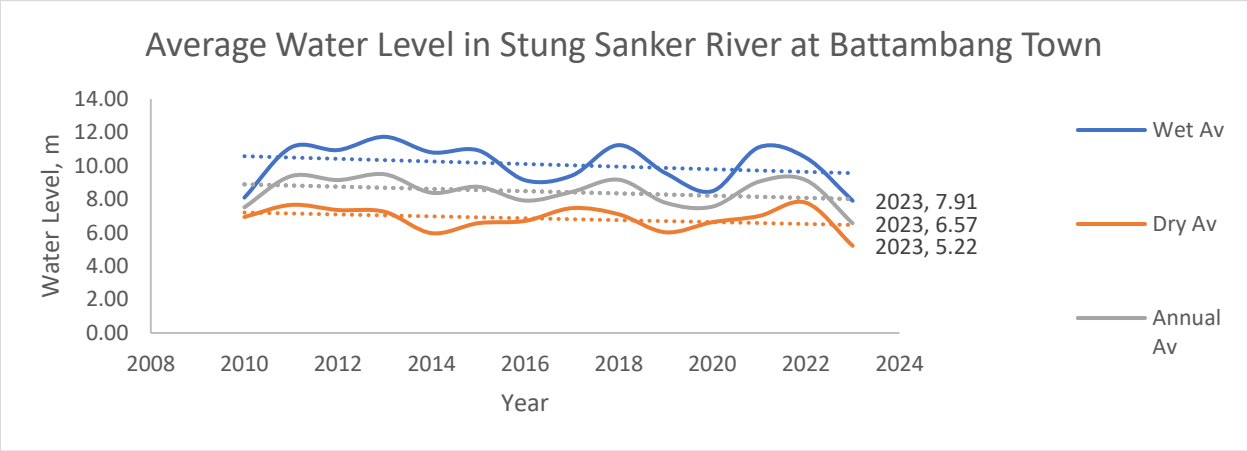

Figure 10. Water level in the wet and dry season in Stung Sanger River at Battambang Town

People

Rohal Soung is home to about 339 households with a total population of 1,789 people. About 90% of its population is engaged in farming. About 20% of households are fishing and supplemented by rice farming. Each household's rice production area ranges between 4 – 10 ha, but some families also have no rice fields for cultivation. On average, it is 1.5 ha/household.

Table 6. Percentage of households owning land and engaged in farming activities

Households/Family	Number	%
# family who have some irrigated rice land	41	11
# of families who have rice land less than one hectare	100	27
# of families who do not own any rice land	190	51
# family who have some irrigated rice land	61	16
# family using chemical fertilizer in the past year	80	22
# family using pesticide in the past year	43	12
# Families with row boats used for fishing	30	8
# of row boats used for fishing	30	n/a
# Families with motor boats used for fishing	35	9
# of motor boats used for fishing	35	n/a
# of families affected by heavy floods	190	51
# of persons affected by heavy floods	319	23

# of families affected by heavy droughts	100	27
# of persons affected by heavy droughts	577	41
Source: Commune Database 2021		

Most of the population in Rohal Soung is Khmer, and about 95% are Buddhist. Farming is their principal occupation. Some are engaged in construction works as laborers in the cities and other provinces. About 20-30% of children can finish Secondary School, and 5% can finish their Bachelor's degree in the cities. Also, around 120 households are classified as ID Poor.

Rice farming

The rice fields cover about 590ha, organized into three categories—*Sreleu* (upper field), *Srekandal* (mid-field), and *Srekrom* (lower field). This classification is based on the influence of the water level in TSL. The *Srekrom* and the *Srekandal* are usually flooded by the flooded water from TSL during the wet season, while the *Sreleu* is not affected by floods from TSL but by rainfalls and water from the upstream watershed areas. Thus, the *Sreleu* has been cultivated with the wet season rice, starting from May and ending in August, depending on rainfalls, while the *Srekadal* and the *Srekrom* with the floating rice, from May to October. The wet season rice yields 3 tons/ha. Each household owns roughly 1.5 ha of farmlands. Only a few households own farming land between 5-10ha. About 27% of households have rice land of less than one hectare, and about 51% have no rice land. About 16% of farming households could access to irrigation.

On the other hand, the lowest water levels between 2010 and 2022 in TSL and the Stung Sangker River have affected rice farming and other crops in Prek Norin Commune in general and Rohal Soung Village in Particular. It has affected the time for rice cultivation and the availability of water resources to irrigate rice farming, resulting in low productivity and low yields between 2019 and 2020. Instead, water resources from deep pools and natural ponds inside the CFi areas were pumped out by farmers to irrigate rice farming and vegetable growing.

Many farmers have complained about the high costs of farming activities and the low returns, given the increased uses of agricultural inputs such as pesticides and fertilizers. Pesticides and fertilizers were increasingly used to increase farming productivity over small land areas. The pesticide and fertilizer residues have washed away into the water bodies and fishery domains, which affect water quality and fisheries. About 22% of households use fertilizer to cultivate their rice land. Also, about 12% of households use pesticides in rice farming. Also, there are water conflicts among farmers in Rohal Soung Village and between Rohal Soung Village and other neighboring villages.

Due to changing water levels in the TSL's floodplains and the Stung Sangker River, farmers have changed farming practices to two rice crops a year. First, farmers cultivate the wet season rice farming from May and harvest in September/October, and they rely on rainfalls to cultivate the rice farming during this period. Second, after the wet season rice, farmers cultivate the dry season rice farming, starting in October/November and harvesting in January/February in the coming year. The second rice production season uses solely irrigated water between October/ November and January/ February of the coming year. The typical rice variety includes Srov Kra Ob, Srov Sra

Nger, and IR5154, which yield 5MT/ha. For rice cultivation, farmers could spend per hectare rice field as follows:

- Soil preparation (Vai dey) ranges from 180,000.00 to 210,000.00 Riels. This particular practice uses modernized machinery, and they started using it in 2000;
- Soils leveling (Rarsdey) is ranging from 180,000.00 – 200,000.00 Riels;
- Pumping for Irrigated Water is ranging from (90,000.00 Reals x 3times) = 270,000.00 Riels to (90,000.00 Riels x 4 times) = 360,000.00 Riels;
- Water fee is charged based on the cost of fuel used to pump the water to irrigate one hectare of rice, which is 4,000.00 Riels x 40 liter = 160,000.00 Riels;
- Fertilizer use ranges between 4-5 bags per ha (the price is 120,000.00 to 160,000.00 Riels/50kg/bag). The total cost for pesticides, weedicides, and other products ranges between 1.2 – 1.5 million Riels.
- For individual agricultural household who does the farming by themselves, they would spend around 3 million Riels per hectare of rice production.
- In the village, there are also the water user community and fish conservation community with a conservation lake, but currently, the lake is blocked by the adjacent land owner.

Given the lower water level in TSL, flooded forest areas were not fully flooded; thus, more flooded areas were cleared and transformed into rice fields. Also, the rice field is no longer classified into Sreleu and Srekrom; all are the same, and they cultivate two rice crops a year. From May to October, farmers cultivate the short-term wet season rice using Vietnamese rice varieties such as IR504 and OM5451, which could be harvested in 3 months, yielding 4-5 tons/ha, using heavy chemical inputs. From November to January or February, the farmer cultivates the dry season rice with the same rice variety, which could be harvested in 3 months.

Fisheries

About 10% of the households in the village are fishing as their primary income-generating activity. About 9% of households still own row and motor boats. These are households engaged in fishing. At present, in Rohal Soung, villagers who do fishing report that fishing in TSL is no longer feasible, as fishing operators in TSL practice fishing using long distancing nets placed across fishing areas in TSL, blocking fish migrating up to Stung Sangker River and floodplain. Also, fishermen in the Great Lake use modernized fishing gear, and there are no more fishing grounds for fishermen from Rohal Soung to fish. Fishermen from Rohal Soung would no longer fish in TSL, as fish and OAAs are scarce. Therefore, not many fish could escape these fishing nets and migrate upstream to the Stung Sangker River, reducing the fish population in the Stung Sangker River. For these reasons, fishermen from Rohal Soung do not go down to fish in TSL, but they go up along the Sangker River to fish in the water bodies of the Sangker Tributaries. Each time, they have to leave their homes for almost two weeks to fish and earn an average of 20,000 Riels a day, which is not enough for their families to make a living. Due to the decline in fisheries and OAAs, many fishermen have stopped fishing and started collecting aquatic plants and Water lilies for their living. They could collect water lilies for 50 – 100 bundles per bundle per day for about 300 Riels (0.070$). Generally, people in Rohal Soung Village consume imported fish from outside. Also,

some households are raised in the village, but not much, and the fish species they raise are Snakehead fishes and Catfish.

Given the reduced water bodies in the Tonle Sap floodplains, the land encroachment has intensified in the flooded forest areas close to the lake. About 3,074.60 ha of flooded forest areas in TSL in Battambang were encroached on by 757 households from Battambang Province; some were cleared for rice farming. The government made efforts to confiscate these areas from the offenders. However, the zoning of flooded forest areas in TSL has been revised, leasing to some flooded forest areas in Zone 1 and 2 removed for community owners, resulting in shrinking the flooded forest areas.

Since 2002, villagers in the Rohal Soung community have officially organized their fishing grounds into the Community Fisheries (CFi) and received formal approval from the Ministry of Agriculture, Forestry, and Fisheries (MAFF) in 2017. The total CFi area for Rohal Soung covers 1,814ha, of which about 7ha have been managed as a fishery conservation area in Rohal Suong.

Indebtedness and Migration

Despite the above, farming and fishing still cannot assure their returns. Many farmers borrow the finance from the MFIs. The rate of indebtedness is increasing, constituting 65-70% of the total population. An increasing number of populations are migrating to urban areas and overseas, accounting for 5% and 6%, respectively, to seek employment, given the decline in farming and fishing in Rohal Soung (Table 5). Nonetheless, young people have migrated to cities and overseas, including Thailand, Korea, and Malaysia.

There is a water conflict between the Rohal Soung community and the communities located upstream of the Sangker River. The Stung Sangker River was constructed to divert water to irrigate 12,000 ha in three upstream communes of Rohal Soung. Thus, there is no water they could pump from the Stung Sangker River in Rohal Soung; thus, they have to wait for water to be released from the Ta On diverting scheme. Often, water came to their rice field late; thus, villagers protested to demand the release of water early enough to save their rice farming during the dry season.

Gender

Farming and fishing are essential livelihood activities in Rohal Soung Village. About 48% of the population of Rohal Soung are women, and they have engaged in both farming and fishing activities as their main livelihood activities. Concerning fishery, NGOs, UNDP, WorldFish and other development partners have supported Rohal Soung villagers to establish the Community Fishery (CFi), fishery conservation, and agricultural development. Men and women have been active in these activities. Through the development in Rohal Soung, women's roles have been promoted in the village through NGO Programs such as Akphiwat Strey (AS). Women have been engaged in the CFis and other development works in the village and their capacities have been built to support their community works.

In the process, farming has been intensified in the last 10-15 years with competing uses of water resources and chemical agricultural inputs to increase rice yields. Fishing has declined in Rohal

Soung due to the impacts of hydrological changes in TSL and its floodplains, climate change, and overfishing. Women have been at the center of increasing agricultural activities and the declining fishing industry. Through these changing dynamics of farming and fishing, women have been affected and transformed from reproductive roles and socially productive roles, where some of them have become the Village Chiefs, the Committee members of Community fisheries and water use groups, and the Commune Councilors.

At the same time, women have been affected by the changing water regimes in the floodplain of the Tonle Sap, the declined fishery, the low rice yield, and the high cost of rice production. In rice farming, the increased dry-season rice farming has increased the demand for water to irrigate their rice fields and the use of chemical agricultural inputs such as pesticides and fertilizers. Women have spent more time getting water to irrigate their dry season rice farming at a high cost. Water conflicts between Rohal Soung farmers and neighboring villagers have resulted from the increased rice farming, putting more pressure on women. The increased cost of rice production has urged women to take more loans from the micro-finance. The low price of paddy rice has also urged women to shoulder their family's indebtedness as incomes from rice farming cannot offset the loans borrowed for rice farming. Instead, aged women force themselves to stay on in fishing, while young females may migrate to find alternative livelihoods in cities or overseas.

Also, as fishing has dropped, the landless households continue fishing, while fishing areas in TSL are no longer productive fishing grounds for villagers in Royal Soung. While young people migrate to cities or overseas for employment, aged women remain trapped in fishing, and fishing income is no longer reliable for livelihoods. Instead, women have collected the water lilies and aquatic plants to sell to generate income for their households.

Migration to cities and overseas has increased in Rohal Soung, resulting in a shortage of labor forces. Fishing and farming remain the works of aged people, who stay home and look after their grant children, whose mothers and partners migrate to work in the cities or overseas. Farming has been intensified through hiring mechanizations and increased uses of chemical agricultural inputs. This would lead to an increase in the cost of rice production, in which the high rice yields still cannot offset the production cost. To continue rice farming, farmers, especially women continue to take loans from micro-finance institutions (MFIs). From year to year, the debts are increased and farmers are heavily indebted. Women have been responsible for these indebtedness.

4.5 Institutions, Policy and Governance

The TSA was established in 2007, and the Minister of MOWRAM chairs it. The Minister of MOWRAM has also chaired the CNMC. It brings MOWRAM, TSA, and CNMC under one umbrella at the national level. These bring improved coordination concerning water governance in the MR and TSL regions. At the provincial level, the Provincial Department of Water Resources and Meteorology acts as the secretariat of the TSA. The commands and activities of the TSA are channeled and implemented through MOWRAM to the Provincial Department of Water Resources and Meteorology (PDWRAM). The PDWRAM coordinates the TSA works at the provincial level and below. However, the PDWRAM has no work in TSL. In Battambang, for rice farming, PDWRAM has built the Ta Arn Water Storage Dam to provide water to many communes such as Prek Norin, Prek Loung, Khporb, and Spean Ta Ek, could irrigate a total land area of 12,000 ha.

It also provides irrigated water to the Daun Teav via Prek Snour. It is observed that the water level of the TSL has dropped, according to the measurement board in Bakprea.

In Pursat Province, there are three tributaries of the TSL: Stung Pursat, Stung Svay Daun Keo, and Stung Maam. PDWRAM has built several storage dams upstream of the TSL tributaries in Pursat Province. There are three main irrigation structures and two storage dams (No. 3 and 5). Structure No. 5 is called Damnak Ampil, located in Phnom Kravanh, which is used for irrigation purposes and as a dike with the capacity to supply 50 million m^3 of water to irrigate the rice fields below the dams. The PDWRAM Pursat has no direct work in TSL. However, the irrigation systems built in the tributaries of TSL have reduced the water flows from the catchments to TSL. The flash flood has occurred sometime, but drought happens every year. Many factors contribute to the change and reduction of the water regime, such as forest degradation and loss, upstream development in China and LMB, Climate Change, etc.

The state agency responsible for fishery management in TSL is the Fisheries Administration (FiA). The Tonle Sap is the main fishing area where FiA manages fisheries through a commercial fishing lot system to generate revenue for the national budget and the country's economy. In 2012, RGC reformed the fishery sectors, abolishing the fishing lot system, returning large fishing lot areas into the community fisheries (CFis), and the remaining areas into fishery conservation areas. About 222 community fisheries have been established in six provinces around the Tonle Sap, with 94,033 households as members. It covers about 538,739ha around the TSL. In Kampong Khleang and Rohal Soung communities, two CFis have been established, covering 20,370ha and 1,814ha to manage fishery resources. These CFis used to receive support from FiA/FiACs and NGOs, but the support ended in recent years, making the CFis weaker.

Also, after abolishing the fishing lot system in 2012, RGC has transformed 93,246ha, or 35 percent of abolished fishing lot areas, into fishery conservation areas. The fishery conservation areas were further organized into 23 areas similar to fish sanctuaries. FiA is the sole agent responsible for the fish sanctuary and fishery conservation area management. Large canceled fishing lot areas in Battambang and Pursat Provinces were converted into fishery conservation areas (FCAs), accounting for 51 percent and 44 percent, respectively. These include the former fishing lot no.2 (50,134ha) in Prek Toal in Battambang and the former fishing lot no.2 (7476ha) in Pursat provinces. In Prek Toal, the FCA covers 50,134ha, the BTC's FCA covers 8,325ha, and Stung Seng's FCA covers 921ha. The FCA areas were former fishing lot areas, rich in fisheries, abolished in 2012. However, between 2010-2023, there was also a considerable shortage of rain during the spawning period of fish and OAAs, leading to the absence of spawning ground for natural regeneration of Fish and OAAs. In 2021-2023, despite the lower water level in TSL, FiAC of Battambang reports an increased fishery compared to the previous years due to comprehensive law enforcement by the competent agencies.

MoE was established in 1993 and designated as the authority responsible for managing the Biosphere Reserve's Core Areas and being the Cambodia focal point for the Ramsar Convention. In Battambang Province, the PDOE manages the Prek Toal Core Area of 21,341ha. In Prek Toal, WCS and MoE/PDoE have supported the establishment of the Community Based Ecotourism (CBE). So far, the CBE's Prek Toal has received many tourists who have visited Prek Toal annually, around 2 million tourists.

The Biosphere Reserve Area is located in Koh Chiveang Commune, comprising of five villages, namely (1) Khbal Tor Village, (2) Prek Toul Village, (3) Anlong Prahok Village, (4) Thang Village, and (5) Tha Our Village. In the dry season, PDOE pumped water from the lake into the inundated forested areas to protect the conservation areas in the Core Areas of Prek Toal, which could be spawning grounds for fish and OAAs. KfW and CSLAD supported nine Pumps and three small patrolling tractors to operate in the areas. The livelihoods of Koh Chiveang villagers are improving daily since there is more vigorous law enforcement on illegal fishing and illegal encroachment. In 2022, PDoE and the MoE supported the communities by installing a clean water filter for water supply with the capacity to supply 20,000 liters a day to villagers. In addition, another three clean water filters are under ongoing support to Khbal Tor, Bakprea, and Prey Chas Villages. So far, more and more international tourists are visiting the sites, creating jobs and additional income for the local communities, such as tour guides and other related services. NGOs support communities such as KfW and CSLAD, raise awareness, reduce illegal activities, lift people's living; help communities produce chili farming and marketing for the produce, etc.

In Pursat, PDoE manages 48,473ha of flooded forest in Zone 1, 2, and 3, of which about 5,835ha of the total area is managed as a community-protected area (CPA). There are two CPAs—(1) Boeung Phsart and (2) Krakor. There are interventions by PDoE on Aquaculture Extension, Extension on Conservation and protection of natural resources, and prevention of flooded forest fires caused by burning forests for wildlife hunting, rice cultivation, Chamkar, etc. PDoE has worked with NGOs such as WCS to support communities to protect the CPAs and flooded forests.

Also, in Kampong Loung, in 2021, the Provincial Government has a program to provide a social land concession to 987 households, of which one household receives 1.5ha of farmlands. The provided land concession program sites are located in Svaysor and Thnoat Chum Communes in Pursat Province, about 40km from Kampong Loung. However, some villagers who received the social land concessions have sold them out at 3,000 as they cannot make their living out of rice farming than fishing.

In Siem Reap, Zone 1, 2, and 3 covers about 70,000 ha under the responsibility of PDoE. Due to conflicts with local communities, some 10,000ha in Zone 1 and 2 have been removed and transformed into rice fields or homesteads. These have moved Zones 1, 2, and 3 more profoundly into the floodplains and water bodies. Kampong Khleang used to be located in Zone 3, but recently, it is likely that their position might have been moved to Zone 2. Also, 668 households are treated as ID Poor 1 & 2, and they received monthly support from the Samdech Techo Former Prime Minister Program, ranging from 112,000 Riels/HH/Month to 430,000 Riels/HH/Month since June 2019. This program is reviewed every three years.

5. CONCLUSION

Tonle Sap Lake is under critical condition. The water level in the lake in the dry season has dropped to about 1.37m, while the wet season water level remains at an average of 7.60m between 2010 and 2023. The reverse flow from the MR to TSL has also changed and becomes irregular. The water volume entering TSL has been reduced significantly, contributing to the decline in the inundation of TSL by nearly 50%. The reduction in volume and inundation have affected fishery

productivity and livelihoods of different communities around the lake. It has raised concerns about the future of the lake, fisheries productivity, and the livelihoods of people dependent on the lake's resources.

The future of TSL is uncertain but under threat. The current trend of developments within the Mekong and TSL regions further affects the reverse flow, as does the Tonle Sap functionality. Not only do hydropower dams built in the upper Mekong affect the flow and the RF of the Mekong, but also filling the lake and rivers linking the Mekong River and TSL contribute to changing the flow and reverse flow to TSL as well. The reverse flow would be completely altered or non-existent in the long run.

Different communities around the lake have responded differently to the changing hydrological regimes of TSL. The land-based community has responded to the changing hydrological regime and the decline in fisheries by expanding the agricultural lands into the flooded forest areas and increasing the dry season rice farming from one to 2 or 3 rice crops a year. These have led to encroaching the flooded forest areas and increased water use for dry season rice farming. There is increased use of pesticides and fertilizers for rice, which could impact aquatic resources. On the other hand, the water-land-based community has tended to capture the flooded forestlands and practice farming, given the increased land speculation, conflicting with other land uses such as conservation areas. The water-based community has few alternatives but to increase fishing efforts in the context of decreased fish catches. There is an increase in migration to cities and overseas between 5-10% among these communities around the lake. Also, there is an increase in indebtedness in the fishing communities in the lake.

The government has responded to support fishing communities in the lake by providing social land concessions to the water-based communities and social funds to support the ID Poor 1&2. Also, NGOs with funding support from donors, such as the EU, ADB, World Bank, etc., have worked to address the issues faced by different communities in TSL. Community Fisheries and Community Protected Areas have been established to protect fisheries and biodiversity in TSL, but they suffer from a lack of resources, capacity, and participation of local communities. The effects of these interventions remain to be seen, and it takes time. However, some of these interventions, such as social land concession programs, do not sufficiently address the root causes of the problems, wasting government resources. Also, some of the issues facing communities around the lake are caused by regional development, which cannot be resolved nationally.

Based on the results of the study, it is recommended into two key areas, first on the coordination and management, and second, on water policy, as the following:

Coordination and Management:

- There is a strong need for coordination and cooperation between upstream and downstream riparian states in the Mekong to protect the Mekong River and the RF to TSL. It needs to coordinate support at national and regional levels, utilizing different mechanisms to support these efforts. At the national level, TSA should play a key role in coordinating national government agencies through regular dialogue and meetings to coordinate and plan the activities to address the decline in hydrological flow into TSL. Cambodia has to

act at all levels to protect the reverse flow of the Mekong to Tonle Sap. At the regional level, the Cambodia National Mekong Committee shall actively coordinate with MRC and other agencies in the MRB to plan the development of MRB with the integration of Cambodia's interests and concerns in the plan.

- The development partners and the riparian states should work with local communities to ensure their planning and development projects address local needs, protect people and the environment, and ensure the sustainability of the Mekong River and TSL. RGC should continue to allocate more funds to CFis, CPAs, and local communities in order for them to continue to engage in the protection and management of resources in TSL.
- Further study is needed to explore the possibility of reversing this trend and keeping the Mekong's reverse flow to TSL viable and the lake beating. There is a need to engage research organizations and universities in deep research and supporting policy development to protect TSL.
- Raising more awareness about the critical conditions and the future of TSL to students public, private, and government agencies to seek their support and engage them in the protection and conservation of TSL.

Policies:

Current Policies

Currently, many laws and policies are still functional to manage the natural resources and livelihood assets of TSL. Cambodia has water law, the law of fisheries that possesses the provisions for fisheries management and practices, the policy of flooded forest management, inland fisheries exploitation, fisheries processing and export, enforcement and judgment, fisheries policies and administration, and natural conservation reserve of TSL. All the laws and policies address the current problems of TSL. Environmental laws and sub-decrees are also enacted to manage biodiversity and natural resources. However, additional policies are anticipated to address the need for sustainable conservation of natural resources and development.

A New Policy

The current policies must be reinforced and strengthened more effectively to cope with the low flow of TSL affecting the Tonle Sap Ecosystem Services. More importantly, the RGC should delegate more roles and responsibilities to the Sub-National Administrations to enforce these policies, monitor the changes in water, fishery, and natural resources in communities, and manage natural resources, addressing the local needs and ensuring their sustainability. In addition, two other alternative policies, one on water security policy and another one on natural resources protection policy, should be enacted to address water security in Tonle Sap Lake and protect against the rapid changing of lake resources:

- ***Water Security Policy*** - The water security policy for TSL is the essential instrument that may help maintain the hydrological regime, the functions of TSL's ecosystem, and all five assets of the livelihoods, creating more productivity and enhancing people's livelihoods

sustainably using the resources of TSL. The water security instrument should be formulated, by which it must distinguish the reality and different applications in the current three communities and address water issues in these communities differently. For the land-based community, water security must address the capacity of efficient water availability for triple crop cultivation and the rural water supply for human consumption. For the water-land-based community, the water security policy should address portable water for humans in dry and wet seasons. In contrast, currently, the community uses contaminated water for consumption. As for the water-based community, the policy should ensure that portable water is sufficient for dry periods and fisheries.

- ***Policy on Natural Resources Protection*** - Flood forest management policy is a vital instrument among the others. Nevertheless, it has gapped some provisions, especially on imposing a fine and guilty of illegal encroachment. The application of enforcement should be strengthened in both community and provincial administration. Enforcement should be applied for the illegal fishing gear and large-scale fishing activities in the closing fishing season. At the same time, strengthening CFis and CPAs in managing fisheries and natural resources should play essential roles in TSL.

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