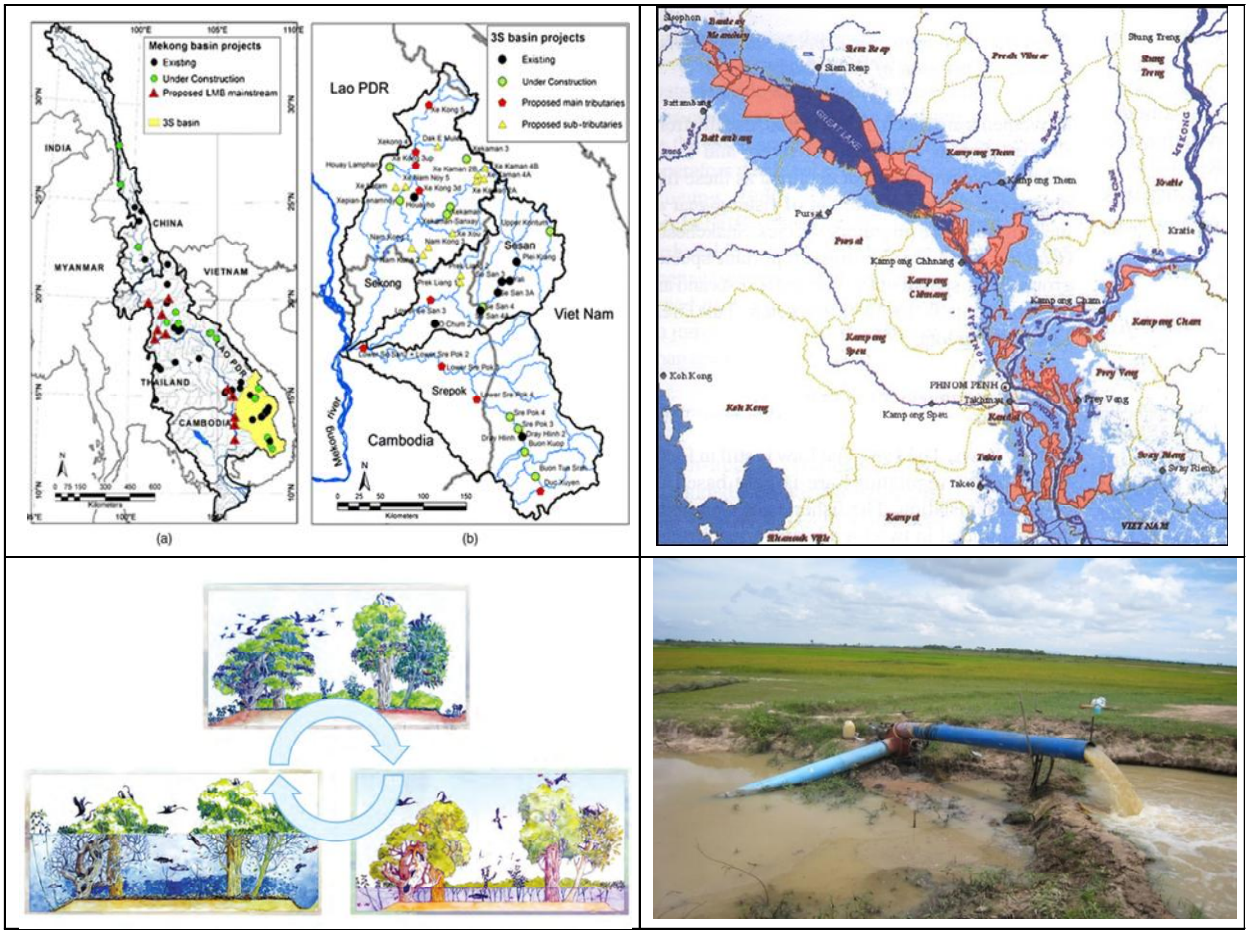
Ministry of Water Resources and Meteorology

INCEPTION REPORT

Water Resources Development and Management on the Mekong River Enhancing linkage with the Tonle Sap Great Lake



March 2017

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PREFACE

This document is the inception report prepared for the study of the diversion of the Mekong early flood water to the Tonle Sap Great Lake of Cambodia as measures to mitigate fishery ecosystem of the Lake impacted by hydropower development and their operation and water diversion for irrigation and other uses upstream and within the Tonle Sap Great Lake basin. It has been well recognized that development upstream affect flood pulse key to high fishery productivity of the Lake and Mekong Flood Plain system. The diversion of the early flood helps to reduce unprotected early rice crop risk to damages in the Mekong Delta part of Cambodia or to reduce the cost of investment for their protection in the future. The study is based on previous Integrated Water Resources Management and Integrated Flood Risk Management, guided by subsequent project concept notes submitted by the Ministry of Water Resources and Meteorology for financial support from the Mekong-ROK Cooperation Funds. The report incorporates also stakeholder comments and suggestions during the Inception Workshop of 7 April 2017.

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ABBREVIATIONS:

Abbreviation	
TLS GL	Tonle Sap Great Lake
MRC	Mekong River Commission
ASEAN	Association of Southeast Asian Nations
IFBM	Integrated Flow Basin Management
WUP	Water Utilization Programme
EIA	Environmental Impact Assessment
BDP	Basin Development Programme
ATTZ	Aquatic/Terrestrial transition zone
WUP FIN	Water Utilization Programme supported by the government of Finland
WUP JICA	Water Utilization Programme supported by JICA
TSLV	MRC Hydro-meteorological project in Tonle Sap and Mekong flood plain area
SEI	Socio Economic Impact
FMMP-C2	Flood Management and Mitigation Programme- Component 2, Structural measures
IFRM	Integrated Flood Risk Management
GWP	Global Water Partnership
RS	Rectangular Strategy
NSDP	National Strategic Development Plan
RGC	Royal Government of Cambodia
ADB	Asian Development Bank
TSA	Tonle Sap Authority
CNMC	Cambodia National Mekong Committee
MoWRAM	Ministry of Water Resources and Meteorology
NGO	Non-Governmental Organization
MoE	Ministry of Environment
MAFF	Ministry of Agriculture Forestry and fishery
MOFA-ROK	Ministry of Foreign Affairs of the Republic of Korea
MEA	Multilateral Environmental Agreement

RAMSAR	International Treaty for the conservation and sustainable use of wet land
PDIES	Procedures for Data and Information Exchange and sharing
PWUM	Procedures for Water Use Monitoring
RFMMC	Regional Flood Management and Mitigation Center
PNPCA	Procedures for Notification, Prior Consultation and Agreement
PMFM	Procedures for Maintenance of Flows on the Mainstream
PWQ	Procedures for Water Quality
DHRW	Department of Hydrology and River Works
MPWT	Ministry of Public Works and Transport
MLMUPC	Ministry of Land Management Urban Planning and Construction
DFA	Department of Fishery Administration
IFReDI	Inland Fishery Research and Development Institute
MI	Mekong Institute
TNA	Training needs assessment

Water Resources Development and Management on the Mekong River linking enhancement with the Tonle Sap Great Lake

INCEPTION REPORT

Summary

1. The Water Resources Development and Management on the Mekong River Flood Plains linking with the Tonle Sap Great Lake study is financed by the Ministry of Foreign Affairs of the Republic of South Korea managed by the Mekong Institute in Khon Kaen, Thailand.

2. The Tonle Sap Great Lake and the Mekong wetlands flood plains, one of the most productive ecosystem in the worlds is increasingly threatened by development upstream and within the basin by infrastructures development to meet increasing population demand for foods, commodities and over fishing. The TLS GL and the flood plains are unique as Mekong flood water regulator in flood management and water demand in the Mekong Delta.

3. Increasing crop intensity in the Mekong Delta, particularly in unprotected flooded areas exposes increasing risk, particularly for early season cropping to be harvested before 1st of August preceding the arrival of the Mekong peak flood in September-October.

4. The Mekong flood peak is very large beyond the capacity of any economically upstream storage and diversion structures to reduce this large flood peaks to maintain flood at the desire level around major cities and towns, economic areas in the Mekong Delta.

5. It is expected that the unique large volume of the Tonle Sap Great Lake is able to reduce early flood risk in the Mekong Delta if early flood peak could be diverted to the TLS GL within the discharge amount that could be able to maintain water flow in the Lower Mekong- Bassac rivers system below its overbank flow capacity before the harvesting time of 1st August.

6. The diversion of early flood into the TLS GL would greatly help to mitigate flow regime changes affecting particularly the Mekong flood pulse system by providing earlier and shorter route for fish larva to reach the TLS GL. Furthermore early flood area expansion in the Lake would help to speed up the interaction between aquatic and terrestrial ecosystem process, principal elements of the exceptional high productivity of the TLS GL ecosystems.

7. The TLS GL Mekong wetland ecosystems is a complex and vital assets for the people of Cambodia and the Mekong Basin, its sustainable use needs continuous, persistent and careful planning and management based on scientific tools, data and information as well as solid institutional capacity.

8. The main purpose is to identify essential structural and non-structural measures to mitigate the impact of flow regime change due to upstream and local development and subsequent environmental degradation at basinwide and local scale.

9. The MK-TLS-LINK has the following outputs:

Output 1: Assessment report on status of knowledge data and information of the Mekong – Tonle Sap Great Lake and wetland flood plains;

Output 2: Report on the Assessment of the Mekong, TLS Great Lake, Mekong Flood Plain Ecosystem, upstream and local development impacts on fisheries, agriculture and wetland ecosystem as a whole;

Output 3: Assessment of hydraulic feasibility for Early Flood Diversion from the Mekong to the Tonle Sap Great Lake;

Output 4: Proposed diversion hydraulic and appurtenant structural design

Output 5: Preliminary Socio economic analysis in the Areas covering the diversion structures and pilot areas for early flood protection studies in the Mekong delta part of Cambodia;

Output 6: Proposed strategic Direction for the flood plain development and management

The main activities to achieve the assigned output within the timeframe of one year include:

Comprehensive review and updating of available scientific knowledge data and information compilation on the Mekong water – Tonle Sap Great Lake and flood plains and related resources physical, biological, socio economic characteristics, importance on food security and national economy.

- Assessment of the Mekong, TLS Great Lake, Mekong Flood Plain Ecosystem through literature review
    - Physical ecological, biological extent and their interconnection, characteristics, their cultural, socio economic and environmental importance
    - External threats from upstream development and, flow regime changes, reservoir operation, system fragmentation, land use change
    - Internal threats from pressure on land use for agriculture, urban and agricultural land expansion, demographic increase, overexploitation of resources, impact of built structures recommended mitigation measures;
    - Governance: institutional management capacity at local, provincial national and regional level

  - Perspective for sustainable management, role and responsibility of government institutions, development partners, stakeholders, regional institutions (MRC, ASEAN)

- Assessment of flood and drought conditions
  - Flood in the Mekong Tonle Sap Flood Plain, occurrence, scientific knowledge and information, benefit of flood, negative impact of flood focusing particularly on economic and ecosystem services of flood
  - Identify existing flood management policy, strategy, strategic direction at national and regional level
  - Droughts occurrence, impact of drought on socio economic and ecosystem (the 2015-2016) droughts
  - Access to water during the dry season, government, local community strategy, climate change
- The Mekong and the Tonle Sap, The Mekong Flood plain connectivity, physical, socio economic importance of the area
  - Hydrological and biological connection
  - Hydraulic connection
  - Socio economic conditions in the project areas
  - Livelihood dependency (agriculture, fishery, river bank cultivation and others)
  - Issues being faced, flood, droughts, access to market and technology, constraint and opportunity, impacts from upstream and local development
  - Importance of the Mekong water and the Tonle Sap water
  - Agricultural assessment in the flood plain areas particularly focusing on deep flooded areas where water is accessible for early cropping and exposed to risk of early flood (up to 1st August)
  - Assess existing flood damage analysis with respect to early floods including benefit from flood
  - Assessment of potential benefit for controlled diversion on crop calendar and cropping areas in the Mekong flood plain
- Linkage the Mekong Flood water with the Tonle Sap Great Lake (delineated the area)
  - Critical review of existing literatures and studies: purposes, methodology, status, regional, local level

  - Assess existing and planned infrastructure in the area (roads, irrigation canal, reservoir for flood water storage for recession crop, aquaculture)
  - Water Balance model assessment between Mekong-Tonle Sap –Great Lake-Flood Plain for optimum early flood diversion capacity in view to reduce early flood damage and also define the minimum level of mitigation to reduce risk of damage that might be caused by early flood.
  - Assessment will be made for both cases, without control diversion and with control diversion.
  - Assessment of risk and appropriate measures to mitigate the potential increase of water level in the TLS GL during the dry season that could impact on the lake ecosystem.

- Preliminary assessment on the investment cost for diversion infrastructures both controlled and uncontrolled case.
  - Assess alignment of the proposed diversion from the Mekong River starting at Peam Chikang district around Sour Kong) to location on the Tonle Sap River or Lake to be identified
  - Assessment the location of the diversion on the left bank of the Mekong
  - Assessment of the proposed control structure on the Tonle Sap River for flow control
  - Provide preliminary assessment of diversion investment cost
  - Cost benefits analysis.
- Institutional setting
  - Existing water governance initiative
  - Policy and strategy
  - Strategic direction for water governance
- Project Management
  - Project Inception report
  - Mid- term progress report
  - Final Report
- Workshops
  - Inception workshop
  - Mid- term workshop
  - Final workshop

10. The Inception Report discusses key external and internal physical and managerial issues facing by the decline of fishery production and increasing risk of flood damages due to inadequate investment in flood protection planning and management and institutional capacity development towards sustainable use of the flood plain. The report also attempts to collect and synthesize to the extent possible existing scientific knowledges of the flood plain ecosystems including socio economic, environment, cultural and livelihood of most people at national and basinwide level.

11. The report attempts also to present the physical complexity of the river and wetland ecosystems, their interdependence, their multiple uses and services, values as compared to human perception on negative and positive impacts of floods and droughts and presents alternatives that are less damaging to environment and making use of existing natural systems to the extent possible.

12. The consultant team is aware of the risk of sustainability of the project concept that is mix structural and non-structural measures and convince that the study contribute to the reopening of previous studies with more recent data and information and also help to raise awareness and to open a plate form for inter-sectoral integrated planning.

13. Due to limited resources the study will be limited to the study of the diversion infrastructure, canal diversion, outlet infrastructure and needed water management infrastructure such as for irrigation water supply, navigation etc. Similarly, for the barrage on the Tonle Sap River, the Consultant team will only make the site selection since this is a more complex structures beyond the TOR of this assignment.

1. Overall Project Plan

1.1. Introduction

1. Rapid infrastructure development in the Mekong River Basin driving by the need for energy and natural resources for economic development is the main cause of flow regime and environmental change. The ultimate goal of the project is to identify the most appropriate structural and nonstructural measures for minimizing impacts of flow regime and environmental changes as main drivers among other ecosystems parameters such as sediment and nutrient transport defining the uniqueness of the high productivity of natural fishery and edible aquatic animals of the Tonle Sap Great Lake (TLS GL) and the agricultural productivity in the Mekong flood plain. Recognizing the physical, cultural, social, and environmental and governance dynamic and complexity the approach will be built on existing scientific knowledge at the Mekong river basin, Tonle Sap River catchment, Tonle Sap Lake and Mekong flood plain scale in Cambodia and experiences learnt in the Mekong Delta in Vietnam. Identified options will be verified against existing policy, guideline, and principles at local, national and regional level. The focus will be on a balance between structural development, inclusive management

capacity, protection/restauration of valuable wetland ecosystem and its services in supporting national food security and sustainable environment.

1.2. Organization of the report

The Inception report is organized in chapters:

Chapter 1: Introduction

It provides an overview of main activities and outputs of the MK-TLS-LINK assignment

Chapter 2: The Linkage of the Mekong with the Tonle Sap Great Lake (TLS GL)

Chapter 3: Expected outputs and Methodology

Chapter 5: Progress to date

Chapter 6: Work Plan and Deliverable and Staff Schedule

Chapter 7: Recommendation

2. The Linkage of the Mekong with the Tonle Sap Great Lake (TLS GL)

2.1. General Background

14. The Mekong is the common physical thread that defines the geographical region that is widely referred to as Indochina, drawing together Cambodia, Laos, Thailand and Vietnam into a single international water resources economy. These four countries have long recognised the need for joint cooperation and mutual consideration when planning and designing new water utilisation projects within a single transboundary river basin, this spirit of collaboration being embodied in the Mekong Agreement of 1995 (IBFRM, 2003).

15. Within this spirit of international cooperation, the Mekong region, which also includes Yunnan Province in China and Myanmar, is in a process of accelerating economic development and the associated expansion of water use. The resources of the river basin are increasingly being used for hydropower generation, irrigated agriculture and industry and the number of schemes in the planning and implementation stages, including inter-catchment diversions, grows continually in response to the projected regional demands for water and energy. Inevitably, however, there are legitimate concerns about the possibility of long-term adverse impacts in one of the world's most diverse river ecosystems. These might arise as detrimental downstream effects from new upstream abstractions, from dam construction or inter-catchment water transfers. For example, at risk from any significant modification of the mainstream flood regime would be Cambodia's inland fishery, one of the world's largest and most diverse.

Below Kratie provincial capital, the Mekong enters into its extensive flood plain where seasonal flood plain storage dominates the annual regime and there is significant

movement of water between channels over flooded areas, the seasonal refilling of the Great Lake and the reversal flow of the Tonle Sap. There is an extreme hydrodynamic complexity in both time and space and it is impossible to measure accurately the channel discharges. Water level determines the movement of water across the Landscape. The Tonle Sap Great Lake that received on average 57% of its water from the Mekong and with its unique maximum storage capacity of 83 km3 can help to mitigate 20% of the Mekong peak flood. 80% of its sediment supply comes from the Mekong water and only 20% is flushed back during the reverse flow period.

Below Kampong Cham provincial town, when the Mekong water discharge reaches the threshold of about 30,000 m^3/s, flood flow begins to spill over the riverbanks and distributed as follows:

- Q>30,000 m3/s: Overbank flow started
- 30,000<Q<42,000: 50% through the left bank and 50% through the right bank
- 42,000<Q< 52,000 60% through the left bank, 40% the right bank[1]
- Year 2000: left bank 65%, right bank 35% (WUP JICA 2004)

16. In 2002, the peak flood of 52,000m^3/s at Kampong Cham was reduced to 40,000m^3/s at Phnom Penh Chrouy Changvar, a reduction of flood peak by 20%, reducing flood risk of Phnom Penh and its major satellite towns.

The extent of this annual floodplain inundation in this part of the Basin is shown in Figure1, of the 2011 flood, satellite image taken on October 18th 2011 and figure 2 showing flood hazard maps for maximum flood frequencies 1% and 50% respectively and also a 50% and 10% maximum annual flood depth on 1st August[2]. The figures are comparable to the satellite images of the highest flood year of 2000 with flooded area 45,000 km^2 and for the driest years of 1998 26,000 km^2 in terms of flood extent indicating the importance of the flood plain wetland.

[1] Since the river banks are mainly reinforced through the years to protect the densely populated settlement and most parts serving as roads, during normal flood years flood water is channeled through natural (preks) and man-made channels (colmatage canals systems). They distribute flood water rich in suspended sediment that will in major part settled in the flood plain. Land surface is generally sloping down from the river bank to swampy areas or lakes, it defines land use from orchard (permanent fruit trees) to seasonal crops such as sesame, mung/soil bean to flood recession rice.

[2] The Mekong flow regime is for most years a bimodal system with two annual flood peaks one in July-August, the second one in September-October. It is proposed to manage to first peak by diverting early flood into the TLS GL.

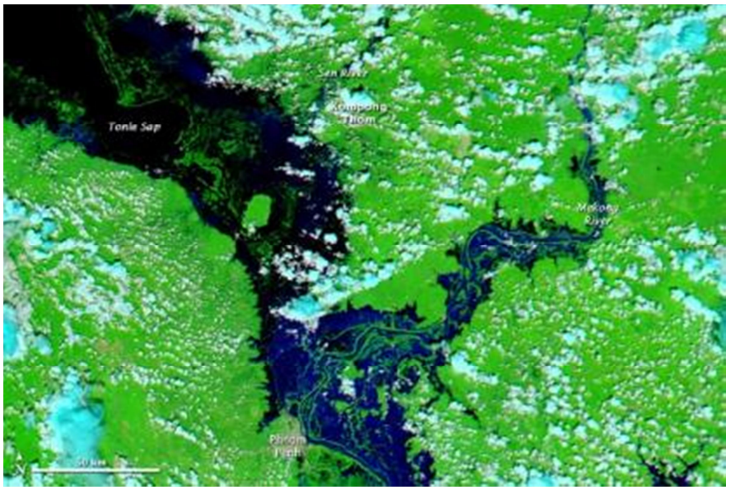
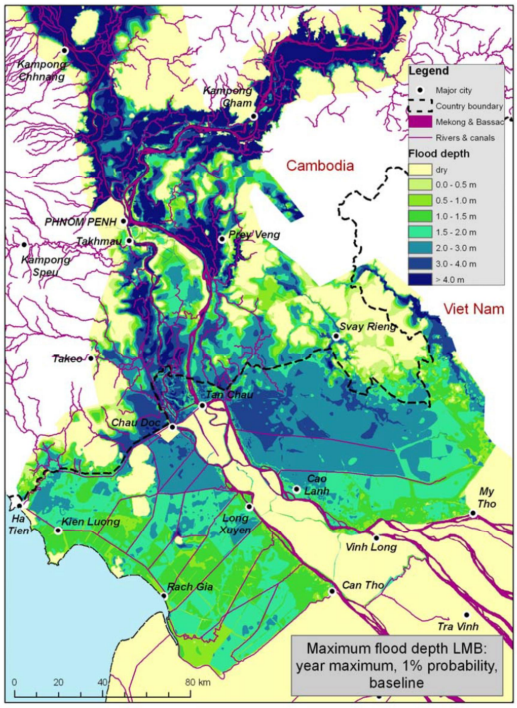
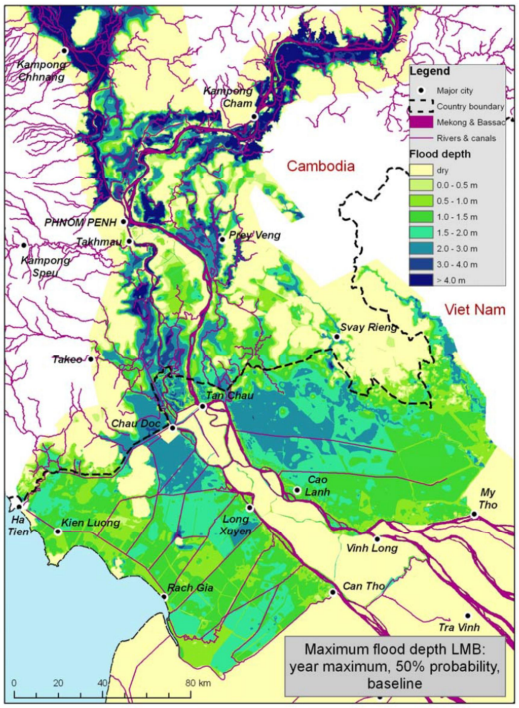


Figure 1: Flood extension of 2011 flood

The flood maps were generated from the time series of hydrological observation at Stung Treng for the period (1910-2006). A series of flood maps have been produced during the MRC-FMMP-C2 project (2006-2010).

Series of maps show flood depths for Base Case of annual maximum flood at different frequencies 1%, 4%, 10%, 20% and 50% probability (e.g. in figure 2 and 3). The base case for early flood up to 1st of August for the same probability were also produced, examples are given in figure 4 for probability 50% and 10%.





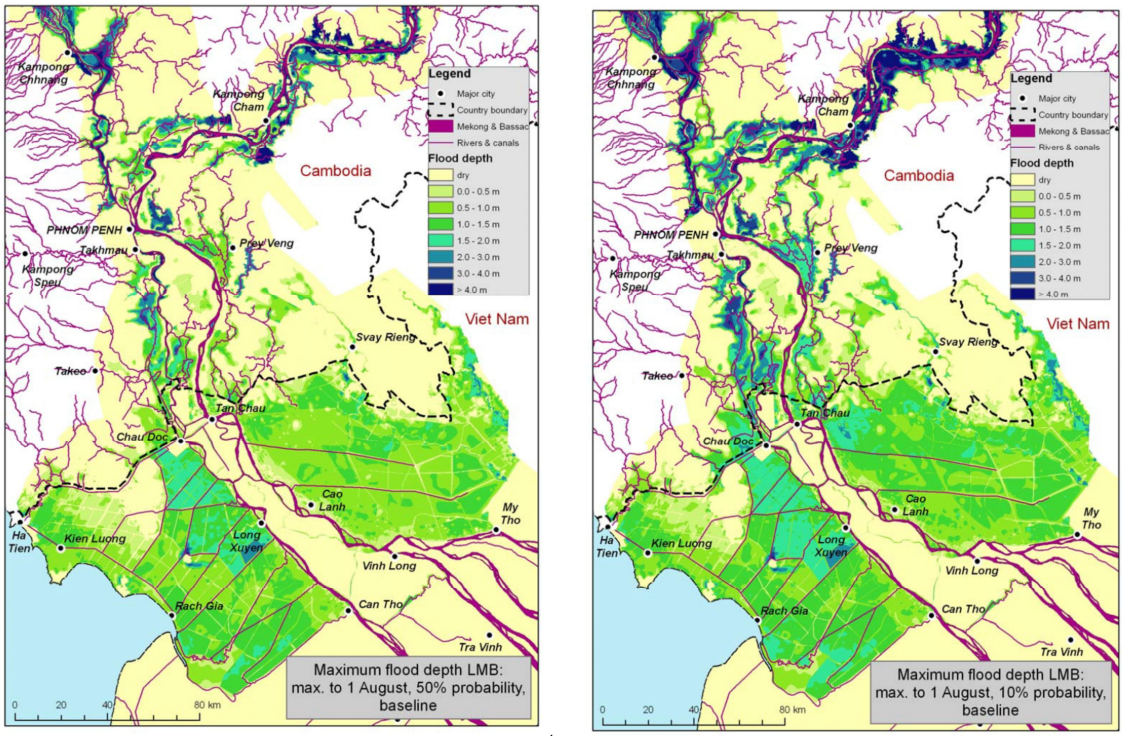


Figure 4: Maximum Flood depth base case to 1st August for probability 50% and 10%, Source: MRC FMMP-C2, 2010

17. The 2011 is one of the most severe flood in terms of discharge magnitude (peak discharge 64,250 m^3/s at Kratie on 24 September 2011, volume 460 km^3 from June to November), 37% higher than long term average 335 km^3). Other important characteristic of flood in the region are also flood volume and timing (MRC-IBFM, 2005). For example the peak discharge at Kratie for 2000 flood was 65,000 m^3/s, historically this value is not exceptionally high since it has been exceeded at least twice every decade since 1927. What makes the 2000 flood more severe in over 70 years was its volume of flow over 500 km^3, as compared to the 2011 flood 3460 Km^3. The expanding Phnom Penh capital city and its satellite towns are increasingly threatened by floods water, while the flood storage and conveyance capacity of the Mekong flood plain is reducing significantly during the last decade due to land encroachment for urban and agricultural land expansion.

18. The Mekong flood plain is being increasingly fragmented by roads, canal networks and different land uses such as land reclamation for agriculture, urbanization etc. Land use fragmentation makes the task for integrated flood risk management complex and difficult. Most roads were built across the flood plain obstructing natural flow (RN6, RN 6A, RN8, RN21, RN1, RN 11 etc. similarly great number of other provincial and rural roads). Due to complexity of flow distribution in this zone comprehensive data collection alone could not provide good understanding of flood flow distribution without applying additional tools such as hydrodynamic modeling. Only two years of such data are available (2002-2003) (MRC, TSLV Project) combining intensive data collection and modeling exercise. The study reveals that in terms of flood volume

distribution during (2002 and 2003), see figure 3 and 4 below, the flood volume of the zone 2 to 5 represents only about 15% of the volume of the zone 1 (the TLS GL). It is observed that the volume in zone 5 is as much as the double of the volume of the zone 2, figure 4. During the recession period, zone 5 recedes faster than the zone 2; it was also observed that the volume of the zone 3 is approximately the double of the zone 4. The recession pattern is similar for both zones in the area. Despite its relatively small storage volume as compared to the TLS GL. the Mekong flood plain plays important role for flood peaks management and maintenance role to the fragile ecosystem service. Integrated Flood Risk and Integrated Water Resources Management in this complex zone cannot be achieved without acquiring deep understanding flood water distribution behaviors by applying scientific data and tools.

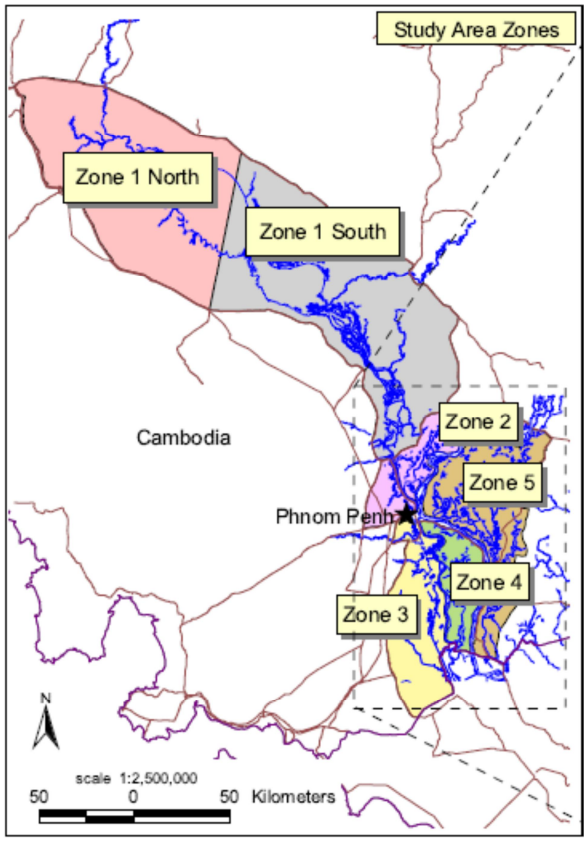
Severe flood cause suffering and economic lost to the region but of the economically active population of Cambodia, four out of five people depend on it in one way or another and therefore upon the annual flooding of the plains and wetlands around the Tonle Sap, Great Lake and Mekong system where the fish feed and breed. Any upstream activities which might detrimentally affect the quantity and quality of the water reaching this aquatic habitat, specifically during the flood season, would jeopardise the long-term sustainability of the fishery.

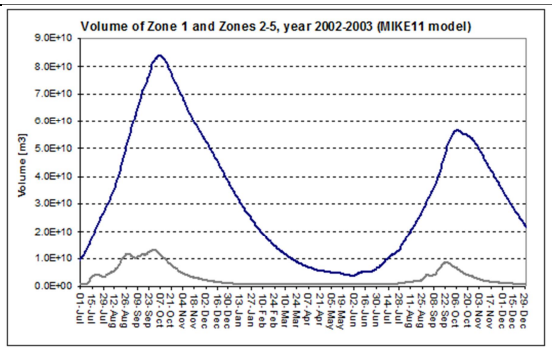
19. Lake Tonle Sap, the largest lake in the Southeast Asia, is well-known that it has been closely associated with the lives and culture of the Cambodian people since the Khmer Dynastic periods. The lake is also famous as "the elastic water world" because its water area expands drastically in rainy seasons, and as "the heart of Cambodia" referring to various and multifarious freshwater organisms, edible fish in particular. Such settings hold out a promising prospect for investigations of unique freshwater eco-system in and around the lake under the control of dynamic seasonal fluctuations in water level due to alternating wet and dry seasons.

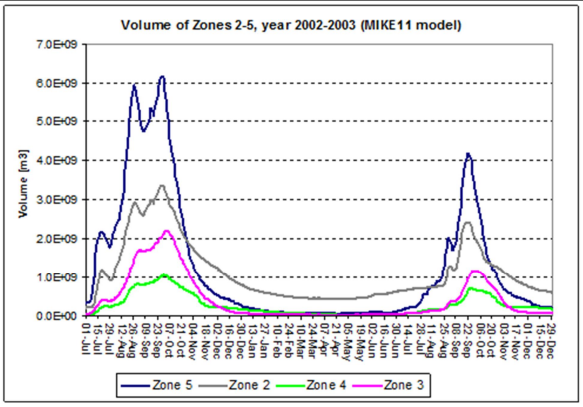
20. Despite this scientific and social importance, there are no systematic overall ecological and social researches in the past until very recent time. J.P. Carbonel et al. (Grad Lac du Cambodge) in 1962 and 1963 published their works " Le Grand Lac du Cambodge, Sedimentology and Hydrology). Afterward Tsukawaki (Tsukawaki,2005) has published the result of his works on " Formation of the Present Natural Environment on the Tonle Sap and the Lower Course of the Mekong River System in Cambodia during the Last 20,000 years" in 2005. Since then an impressive amount of data, information have been accumulated initiated by many initiatives such as MRC, ADB, World Fish Centers, Inland Fishery Research and Development Institute (IFReDI), the Tonle Sap Authority (TSA), development partners, universities, while consistent well established national institution to manage this important natural resources system is still weak with many risk of overlapping.

2.2. The Mekong -Tonle Sap-Bassac Flood Plain

21. The Mekong-Tonle Sap-Bassac Flood Plain cover a maximum area of about 45,000km^2, see figure 2 above, this area expand and shrink seasonally following the wet and dry season prevailing in the region. During the wet season the wet land area expands up to about 45,000 km^2 and shrinks to the river bed of the dry season of the major river branches and permanent lakes.







zone: (1),TLS- GL southern part ,(2) between MK and RN6; (5) between MK left bank to the left; (4) Right bank of the Bassac to the left; (4) along the Lower Mekong

- TLS GL capacity: 83 km^3
- Zone 1:= 68%
- Zone 2:= 53 %
- Zone 3:= %55
- Zone 4= 63%
- Zone 5:= 77%

The MK –Bassac flood plains are subdivided by road networks:
RN 6, RN 6A, RN 8, RN1, RN 11, RN 21 and many new rural and provincial roads.

Figure 5: Top left, different flood plain zones in the Tonle Sap Great Lake and the Mekong Delta (flood zones), Top right Comparison flood volume between TLS GL and Mekong Delta Flood Plain; Bottom left, flood volume in zone 2, zone 3, zone 4 and zone 5 (2002-2003); Bottom right: Flood volume distribution in different zones in (2002-2003)

22. Floods and droughts are recurrent phenomena in the Lower Mekong Basin, sometimes at the same times, flooding in the deep and shallow flooded areas, while the immediate surrounding are affected by meteorological droughts. A flood is a highly visible natural disaster that clamors for attention and better management. In contrast, drought is a 'quiet' and largely invisible disaster that develops and intensifies over time; an Act of God, something to be endured rather than managed. Both disasters impose large economic and social costs on the peoples of the flood plain and its surrounding. However, the economic benefits of floods far outweigh their economic costs: the average annual cost of flooding in the Lower Mekong Basin is USD 60-70 M/year; the average annual cost of flood benefits is USD 8-10 B/year, i.e. some 100 times greater. The challenge for better flood risk management is to reduce the costs and impact of flooding whilst preserving the benefits. The average annual cost of drought in the Lower Mekong Basin is at least as large as the flood cost and possibly considerably bigger (1ChuHuiLin, 2014). The figure 10 below illustrates the benefit of the ecosystem services in general.

23. Flooding endows the peoples of the LMB with environmental, social and economic benefits unparalleled in any other river basin in the world. The total average annual take of the capture fishery of the LMB is 1.5 M tonnes/year, with a further 0.5 M tonnes/year taken from reservoirs and other forms of aquaculture (MRC, 2003c). The value of the total fish take has been estimated at some USD 2.6 B/year and the estimated value of other aquatic animals (e.g. frogs, crabs and molluscs) taken from the LMB is some USD 249 M/year (MRC, 2009c). It is estimated that at least two-thirds of the LMB's population is involved in fishing, often on a part time or seasonal basis; fish is essential to the diet and livelihood of these people, especially subsistence farmers (MRC, 2003c; Johnston et al, 2003).

2.3. Flood benefits

24. As stated above, flood benefit can be very large as compared to flood damages, in the focal group discussion under the FMMP-C2 (MRC), it was revealed that after each big floods, rice yield would be 1.5-2.0 t/ha higher than after the normal flood. The application of fertilizer and pesticide is almost the same, flood benefit for agriculture would be 0.62-0.93 million riel/ha (about 150-230 US$/ha).Depending on the district in deep flooded area, 30-100% of families in deep flooded areas are fishing during flood season. The benefit of flood of capture fisheries of people fishing in deep flooded area are 0.32- 3.78 mln Riels/fishing household, about 80-945 US$ (FMMP-C2, MRC).

2.4. Economic of early rice cropping in the Mekong flood plain

25. During the last 10 years with increasing access to water mainly by diversion canals from the Mekong-Bassac mainstream, other river branches or flood water storage reservoirs, areas for rice cropping has expanded significantly including crop yields and productivity in the flood plain provinces (Takeo, Prey Veng, Kandal, Svay Rieng) at the expense of their ecosystem services. The impact to ecosystem services not only related to area loss but also on its quality including flooded forest, water quality and important species affecting livelihoods of many particularly the poorest group.

At the same time, the number of water management infrastructures has increased with newly rehabilitated canals and water control structures, pumping stations, further fragmenting the flood plain reducing its role in flood management capacity. Generally the objectives of those infrastructures were mainly focusing on supplement irrigation and flood risk management function was not included in their operation planning including flood forecasting and early warning.

Though some benefits have been reported in terms of water sharing, impact resulting from transboundary water management still remains to be properly resolved along the border between Cambodia and Vietnam.

2.5. Impacts on the TLS GL and Flood Plain from Upstream Development

26. Rapid development in the upper reaches of the Mekong River in the Lancang River part in China has gained momentum since the 1980's. To date there are nine operational schemes with combined installed capacity of 15,757.5 MW, and a further six schemes with a combined installed capacity of 5,795 MW under construction. In addition there are four schemes where site preparation has commenced with a combined installed capacity of 6,040 MW (, MRC, ISH 0306).

As an example, estimates for the change of flows for Chiang Saen (Northern Thailand), downstream of Lancang cascade, are 17-22% decrease in flow in June – November, and 60 – 90% increase in flow in December – May. The estimates for Kratie (Cambodia) are 8 – 11% decrease in flow in June – November, and 28 – 71 % increase in flow in December – May (Source: Mekong River Commission).

In the Lower Mekong River basin (LMB) existing and planned hydropower are presented in the map in F**igure 6** above. The impact of such development on ecosystem in downstream are detailed in the MRC BDP 2 Impact scenarios studies report (2010) and ICEM reports in (ICEM, Xayabury, 2011)

2.6. The Impacts on the Tonle Sap Great Lake

27. The Tonle Sap Lake is a fascinating system of great intrinsic value, and of great economic and cultural value to the people of Cambodia and the LMB. The lake and its inundation zone are already showing the impacts of over-exploitation of resources which is reducing both the biodiversity value and its potential to support livelihoods. The next decade is likely to be a critical period which will determine the future status of this

important wetland. Many of the pressures presently impacting the lake are likely to greatly increase in the short term, including population growth, especially around Siem Reap, fishing pressure and hydrological changes. Stable and effective governance systems in Cambodia are as yet not well established, and Bonheur and Lane (2002) identified governance deficiencies as a significant threat to the biodiversity of the Tonle Sap Lake. Management of the system requires cooperation from a range of government agencies. In addition the relationships between government officials and civil society, the people in the basin, will be key if the resources are to be well managed. Government legislation is of little value without public support. It is of serious concern that Tonle Sap may be impacted by developments initiated in countries outside Cambodia. In particular the development of hydropower schemes on the Mekong River in countries upstream of Cambodia present a real and present danger to the ecosystems and fisheries of the Tonle Sap Lake. It is essential that the Cambodian Government use all the influence at its disposal to ensure that environmental impacts in downstream countries are considered in the design, implementation and operation of these projects. Where these projects precede ameliorative measures, including appropriate operational rules and, where necessary, flow regulation structures should be included (Campbel Ian C, 2006).

28. The starting point of the assessments of the MRC BDP 2 stated above has been to determine the impacts of the developments set out in the scenarios on the river system in terms of flow changes and flooding. The impacts of these changes, together with the direct impact of the infrastructure are included in each scenario.

The dams in the UMB under construction in the Definite Future Scenarios altogether will introduce an additional storage of 22.9 BCM into the basin, which together with the 26 hydropower projects in the LMB with a total active storage of 13.7 BCM, will increase the total storage in the basin by 370% to an amount equivalent to 10% of the mean annual runoff (MAR). This will have substantial impact on the natural flow regime, which previously has seen no change since records began in 1915.

In addition the Foreseeable Future Scenarios include all or some of the 11 identified mainstream dams in the LMB, These are run-of river dams and potentially add up to only a further 5.2 BCM of active storage in total. Thus, in broad terms, the mainstream dams in the LMB would have only marginal effect on the overall mainstream flow volumes. But they significantly fragment the river and trap most sediment and nutrient to downstream.

Additionally, the operation of the mainstream dams can cause significant downstream fluctuations during any one day if they are operated as peaking projects. In this case, water level fluctuations locally may amount to typically 2-4m or more in extreme cases. The mainstream dams are generally sized and sited at intervals where the backwater effects of one reaches close to the next. Thus, although they may have a small effect at basin-scale on flow volumes, water levels will be significantly affected both up and downstream of their sites, the river channels will be segmented affecting sediment

transport, fish aquatic ecology (see figure 7 on water current flow and water level fluctuation on the Mekong at Stung Treng).

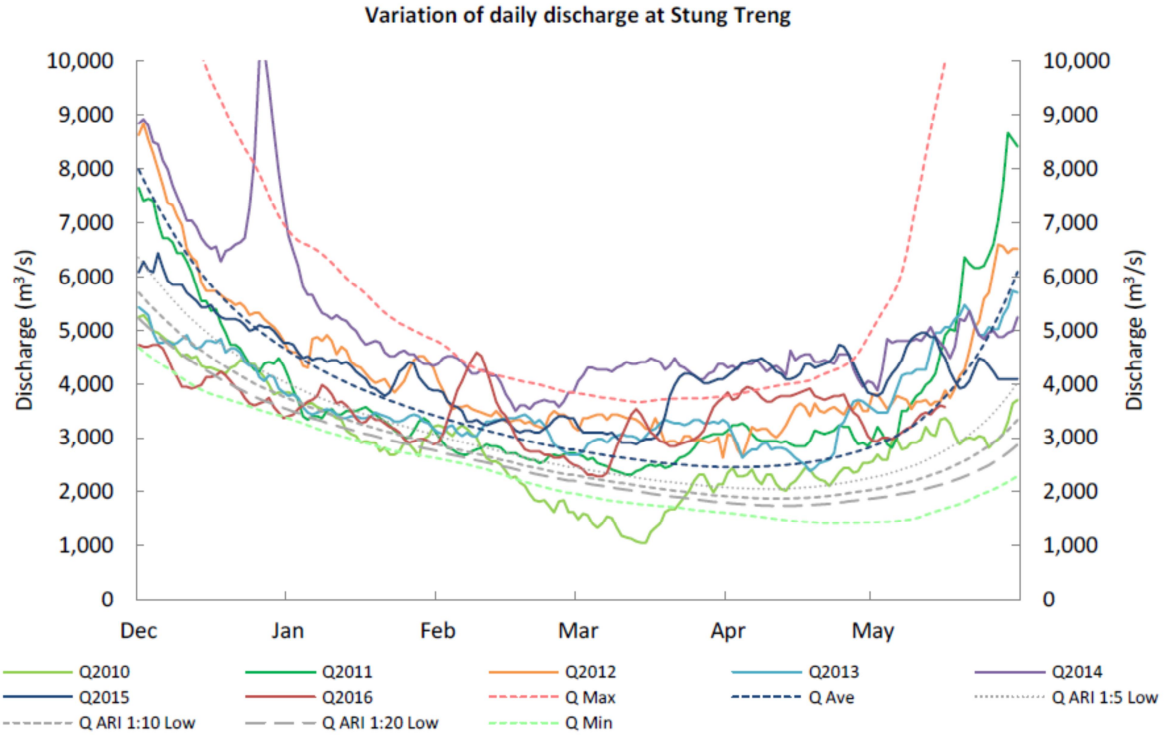


Figure 7: Variation of daily discharge at Stung Treng for individual March-May of 2010-2016, comparing to the long term average, minimum and maximum of 1962-2009. Source: MRC/China J.O 2016

The daily discharge of 2010-2011 is depicted in greenish color tone to present flow conditions before major observable changes, while discharge of 2012-2016 is illustrated in various distinct colors to reflect flow fluctuation impacted by regulation in the Lancang Basin. Daily rated discharge is represented by 'Q' with [YEAR]

29. The biggest impact of upstream development on the inflows of Mekong River water into the Tonle Sap Lake is expected to be felt in dry years when the upstream reservoirs withhold the most water in relation to the Mekong's total flow. Hydrological modeling shows that inflows into the lake would decline by between 4.5 cubic kilometers under the Intensive Development scenario and by 11 cubic kilometers under the Extreme Development scenario. Under the Intensive scenario, that represents 4 percent in a wet year and 10 percent in a dry year. Under the Extreme scenario, inflows would fall by about 10 percent in a wet year and 25 percent in a dry year. The strength of these findings is supported by hydrological modeling by the Mekong River Commission since 2001. The MRC river monitoring has clearly shown that during the dry season of 2016 the driest years in the record history, despite general expectation that dry season will increase above annual average due to flow regulation by reservoir operation for hydropower, on the contrary water levels at all stations along the Mekong from Chiang

Saen to Tan Chau-Chau Doc drop below annual average and most severely at Kratie station the water level drops below the minimum envelop curves[3] from early November until end of January, this are also valid for Kampong Cham, Bassac at Chatomuk, Prek Kdam, Tan Chauv and Chau Doc stations. The drop in water level has affected the Phnom Penh Port pontoon facilities on the Tonle Sap River at Phnom Penh never seen before.

30. The severity has triggered China to implement its emergency water supplement from its cascades dams in the Lancang River to the Mekong River by increasing the water discharge from Yunnan's Jinghong Reservoir. China decided to implement its emergency water supplement in a 'three phase plan': (1) from 9 March to 10 April 2016, with an average daily discharge of no less than 2,000 m^3/s; (2) from 11 April to 20 April 2016 with the discharge of no less than 1,200 m^3/s; and (3) from 21 April to 31 May 2016 with the discharge of no less than 1,500 m^3/s.

Upstream developments will delay the onset of the annual flood in the Tonle Sap Lake and shorten its duration. Under the Intensive scenario in a dry year, the flood would be delayed by up to 12 days depending upon the location and altitude, and its duration would be a week shorter (Eric Baran, 2007). Under the Extreme scenario, the flood would be delayed by one month and its duration would be two weeks shorter.

Upstream developments will also decrease the height and surface area of the flood. Under the Intensive Development scenario in a dry year, the maximum height would be about half a meter lower and the surface area about 10 percent smaller. The main losses would occur in very high areas that are flooded for short periods.

31. Dams upstream will sharply reduce the input of sediments into the Tonle Sap Lake, adversely affecting the recycling of nutrients and possibly threatening dry-season habitats, especially in areas with high fish productivity. The Upper Mekong Basin is the source of more than 50 percent of the suspended sediments in downstream areas of the Lower Basin. The planned cascade of eight dams in the Extreme Development scenario has the potential to trap nearly all of these sediments (Eric Baran, 2007). Loss of sediments in flood water would result in a loss of natural soil fertility (hence a loss of rice production or higher production costs due to increased use of fertilizers). It could also lead to increased erosion along the Mekong's banks and possibly to a lower survival rate for fish eggs, their buoyancy being reduced.

Delays in the onset of the flood will result in delays in the arrival of oxygen-rich waters. Dissolved oxygen levels in Tonle Sap water generally decline during dry season, until the inflow of oxygen-rich water at the beginning of flood season. While fish may swim to more oxygenated waters, eggs and larvae unable to move may be adversely affected if the arrival of the flood is delayed. Flow changes may also have an impact on the drift of

[3] Minimum envelop curves are lines delimiting the historical daily absolute minimum of water level records for the whole period of observation.

fish larvae and juveniles, which usually end up on the northern and eastern shores of the lake. Under the Intensive Development scenario, eggs and floating particles tend to drift more towards the western shore, indicating possible negative impacts on highly-productive fishing lots in the northern part of the lake. This finding is, however, based only on computer simulations and needs to be verified by observations in the field.

32. Upstream developments will expand the edge of the lake during the dry season, destroying some flooded-forest areas if they are permanently submerged. Under the Intensive Development scenario, hydrological modeling shows that the surface area of the lake will expand by between 300 and 900 square kilometers in the dry season in an average year (Eric Baran, 2007). That is equivalent to between a 15 and 45 percent increase in the lake's dry-season size. Permanent flooding of some areas is likely to kill the flooded forests that are located along the lake edge and cannot tolerate permanently flooded conditions, as they requires temporary emersion to complete their lifecycle. This forest acts as a buffer protecting the floodplain against storms and rough water conditions on the lake; this oxygen and nutrient rich habitat is also important to fish as a breeding, feeding and shelter area. The study did not include assessing the possible impacts of an expanded dry-season lake on the flooded-forest plant species or invasive species such as the water hyacinth (Eichornia crassipes) or mimosa (Mimosa pigra).

2.7. Sediment transport

33. The MRC under the assistance from Finnish Environmental Institute in association with EIA Center of Finland Ltd. (Juha Sakkula & al.) has applied modelling technique to study the origin, fate and impacts of the Mekong sediments and provide the following results as compared to annual average loads at different locations:

Table 1: Annual sediment load (million tonnes/year) at different locations along the Mekong River

Place	Annual average load in million tonnes/year	
	Estimated	Modelled
China	99	91
3S	17	18
Kratie	165	166

Using the averages the contributions are: China 60%, 3S 10% and rest of the basin 30 %. In average annual loads these translate to 99, 17 and 150 million tonnes/year respectively.

According the BDP 20 years development scenarios (Chinese dams +tributaries scenarios), the average simulated load from 1990 to 2000 show an average reduction of 46% from baseline 166 million tonnes to 88 million tonnes.

2.7.1. Sediment on the Tonle Sap Lake

34. The annual sediment flux into the Tonle Sap Lake from the Mekong and its tributaries are 5.1 million tonnes and 2.0 million tonnes respectively, and the total outflow of TSS flux from the lake back to the Mekong is 1.4 million tonnes, thus around 80% of sediment the system receives from the Mekong River and tributaries is stored in the lake and its floodplain. The annual variation of the TSS flux into the lake is significant as it varies from 3.5 million tonnes/y (dry year 1998) to over 9 million tonnes/y (wet year 2000), correlated with the flood volumes of the lake. The sedimentation rate within the proper lake area ranges between 0.1 to 0.16 mm/years since 55,000 years before present. Around 5,500 years ago the current connection was created between the Mekong and Tonle Sap. The small sedimentation rate results to accumulation of only 0.507 m of sediment in the lake since the middle Holocene epoch.

2.7.2. Sediment starvation (Mathias Kondolf, 2015)

35. Built Reservoirs upstream trap all the bedload and a percentage of the suspended load carried by a river. The most obvious effect of this is loss of reservoir capacity, as the reservoir fills with sediment (Annandale, 2013). However, the equally serious “other side of the coin” is the reduced supply of sediment to the river downstream of the dam.

Building upon prior estimates of sediment reduction from planned dams (e.g., Kummu et al., 2010) Mathias Kondolf & al. developed sediment yield estimates for each of nine geomorphic provinces in the Lower Mekong basin, calculated trap efficiencies for individual reservoirs, and compiled total storage capacity data for more accurate trap efficiency calculations (Kondolf et al., 2014b). For the Mekong River Commission ‘definite-future’ scenario of 38 dams already constructed, under construction, or certain to be built, the sediment load reaching the delta will be about half of its pre-1990 level. However, with fully build of dams in the Lower Mekong River basin, including mainstream dams, the cumulative sediment trapping by dams will be ~96% of its pre-1990 load .Sediment starvation would actually be more severe owing to the mining of about 35 Mt y per year of sand and gravel directly from the river channel mostly in Cambodia (Bravard et al., 2013).

If all dams planned for the lower Mekong River and tributaries are built as initially proposed, without designing and operating to pass sediment, nutrient loads essential for ecosystem productivity will decrease, undermining the fishery that now supports 60 million people. Morphological effects will include incision in alluvial reaches of the river, and most importantly, as 96% of the sediment supply to the Mekong delta will be trapped, it is expected that almost complete cessation of sediment deposition in the Delta.

The severity of the potential downstream impacts of sediment starvation is motivating national and international agencies to explore possibilities to relocate, redesign, and/or reconsider operations for some planned hydroelectric dams in the Mekong River basin so that they can pass sediment and fish. Further study is being made to analyse

tradeoffs between short-term power forgone vs longer-term benefits of reducing downstream dam impacts and extending reservoir life.

2.8. Flood pulse

Variation between years can be substantial, but the Tonle Sap ecosystem seems highly resilient to these naturally occurring inter-annual variations

36. Exceptional flood and drought occurrences are indeed one of the important characteristics of flood-pulsed ecosystems (Junk, 1997). The effects of droughts on fisheries production for example can be significant but do not appear to be noticeable for more than a few consecutive years at worst (Campbell et al., 2005).

The flood pulse concept as developed for river floodplain systems (Junk et al., 1989) applies with minor changes as well to ecosystems where the parent water body is a lake. It focuses on the lateral exchange of water, nutrients and organisms between a river or a lake and the connected flood plain. It considers the importance of the hydrology and hydrochemistry of the parent water body but focuses on their impact on the organisms and the specific processes in the flood plain. The flood pulse as the succession of periodic flooding and drought is the driving force in the flood plain lake system. The flood plain is considered as an integral part of the system that is periodically coupled and decoupled from the parent river or lake by the areas that are oscillating between a terrestrial and an aquatic status, the so-called Aquatic/Terrestrial Transition Zone (ATTZ) (Junk et al., 1989).

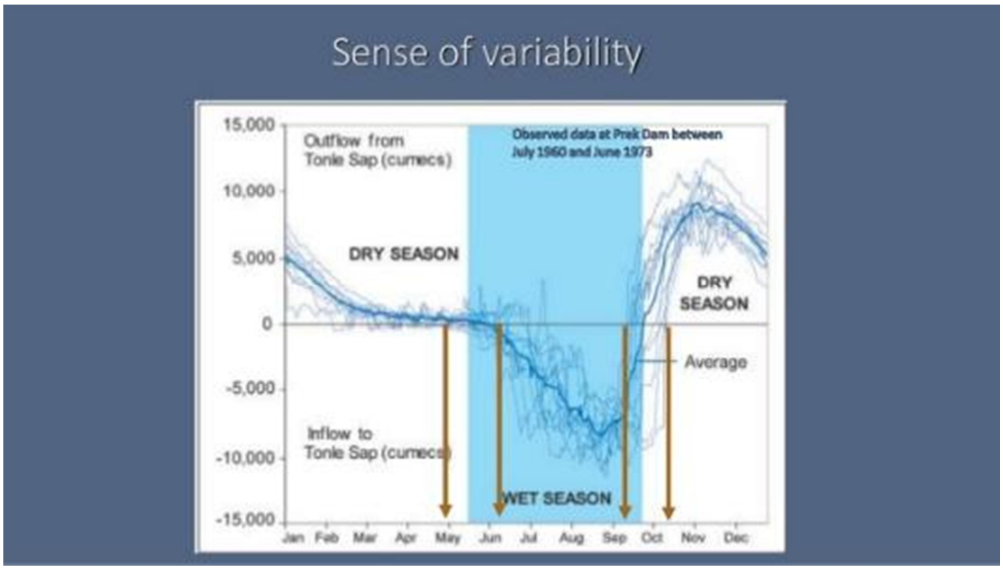


Figure 8: Patterns of inflow and outflow from Mekong to the Tonle Sap Great Lake

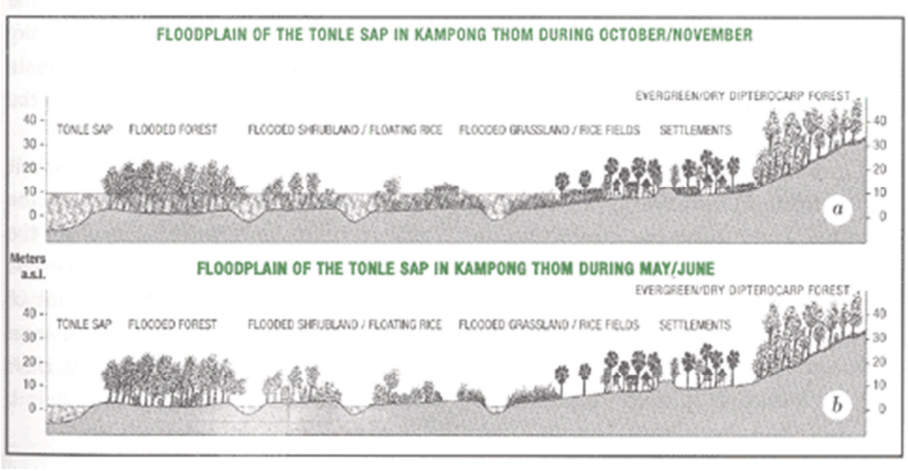


Figure 9: Transversal cross section of the TLS GL during wet and dry season (extent of interaction between aquatic and terrestrial ecosystems of the lake in Kampong Thom Province for the period: October//November (lake filled period and from May to June, the lowest period of the year.

Flood pulse includes its modality (one or more peaks), predictability, amplitude, duration, smoothness and rapidity of change. All of these characteristics have important ecological significance. Predictable pulsing favors the adaptations of organisms and increases primary production and efficiency of nutrient use.

37. The nutrient status of the floodplain depends on the amount and quality of dissolved and suspended solids of the parent lake or river. MRCS/WUPFIN (2003) provides an insight in the deposition location and quantity of suspended solids in the Tonle Sap ecosystem. While sedimentation in the lake proper is very small, substantial amounts are deposited in the floodplain vegetation on the verge of the permanent lake. The nutrient status of the deposited solids is as yet unclear. Internal processes of the floodplain, however, and nutrient transfer mechanisms between the terrestrial and aquatic phase strongly influence nutrient cycles, primary and secondary production and decomposition. At the same time, flooding is considered a disturbance factor, leading to a regular setback of community development and maintaining the system in an immature, but highly productive stage (Junk & Piedade, 1997).

Water level changes influence river and lake systems four-dimensionally in space and time. Rising water levels not only increase the wetted surface of the lake and the floodplain but at the same time influence the exchange between groundwater and surface water.

When Tonle Sap River and Lake water inundates their floodplains via overspill or via floodplain channels, various key processes occur simultaneously that drive diurnal and seasonal limnological changes. For a more detailed description of all the floodplain processes and their succession see Junk et al. (1989) and Junk & Wantzen (2004).

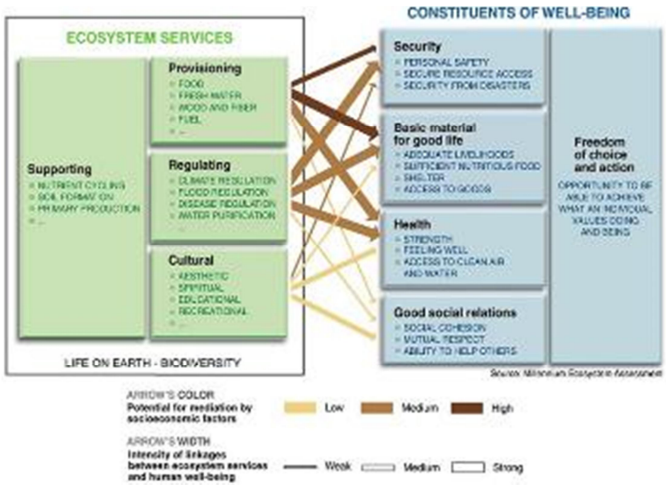


Figure 10: Diagram illustrating the benefit of the ecosystem services

38. In terms of ecological and social benefits, floodplains are among the most valuable landscapes in the world. A global review of tropical floodplains completed during the study found that fish and other natural resources are the primary benefits, followed by the replenishment of nutrients and fertile soils for farmlands and pastures. However, much is still unknown about the ecological functions of floodplains and how to value them properly. This is a reason why the impact of manmade structures on tropical floodplains is not well documented with the exception of large dams. Most of the available information is qualitative rather than quantitative. Valuations should be conducted in such a way that the results can be integrated into more conventional economic cost-benefit analyses of proposed investments in water development projects, and allow more thorough economic analyses of the predicted returns for different investment options. The figure 10 above summarises the degree of potential socio economic benefits from ecosystem services in general.

39. Dams are the main type of structure having an impact on fisheries production, through their negative impact on fish migrations. In the Mekong Basin, 87 percent of fish species for which information is available are migratory species. Sixteen percent of these species are known to be sensitive to hydrological migration triggers that will be modified by dam construction. Since the bulk of the catch actually consists of a small number of species groups that are predominantly sensitive to hydrological migration triggers, a very large proportion of the total catch is likely to be affected by river modifications (96 percent of the catch at Khone Falls, Southern Laos). The most important impact of flow modification due to upstream built structures would be experienced during the dry season and at the beginning of the rainy season.

40. The study found no examples of positive long-term impacts of dams on fisheries, nor any effective mitigation measures in the Mekong Basin. Reservoirs are sometimes presented as a way to create new fisheries upstream, but this usually does not compensate for the loss of downstream fisheries. Similarly, fish passes are often proposed to help fish migrate. However, there are no examples of fish passes that work

in the Mekong Basin. This is mainly due to ecological factors and the intensity of migrations which fish passes cannot accommodate. Out of the hundreds of species in the Mekong Basin, only nine are known to breed in reservoirs. The effectiveness of the new fish pass at Stung Chinit completed in 2006 has not yet been assessed.

41. Even a small percentage lost in fisheries will amount to tens of thousands of tonnes and millions of dollars when considering the total production of 2.6 million tonnes each year. The loss would also affect millions of people with fisheries-associated livelihoods. For instance, the fish groups that are extremely sensitive to hydrological triggers include shark catfishes (Pangasiidae), which are commercially important to both capture fisheries and aquaculture. Among the 10 fish groups that dominate the Tonle Sap catch, four are sensitive to such triggers. They account for 18 percent of the volume of the Tonle Sap catch and 14 percent of its value. On the other hand, several environmental impact assessments (EIAs) conclude that negative impacts on fisheries would be minor because of biases or flaws in their approach such as a limited scope, or because of a focus on percentages lost rather than on tonnage and livelihood values lost. In general, most dam projects in the Mekong Basin lack undisputable EIAs and detailed baseline studies that would allow the full range of cost-benefit analyses.

42. The influence of hydropower and irrigation projects within the Tonle Sap Lake's catchment basin would significantly add to the impact of developments upstream in the Mekong Basin. Even smaller dams within the Tonle Sap catchment would have an impact similar to upstream dams in reducing inflows of water in the wet season and increasing dry-season flows. (Eric Baran, 2007) shows the influence on water level of Tonle Sap developments in the case of the Tonle Sap scenario that adds hydro-electric and irrigation dams across seven tributaries that flow into the lake. Impacts of Tonle Sap projects are felt earlier than those of upstream projects. The combined impact of Tonle Sap projects and Mekong upstream projects is significantly higher than the impacts assessed separately.

43. Most Tonle Sap Great Lake tributaries has flow with great variability within wet and dry season and inter-annually, with insignificant dry season flow, some are already under heavy stress with extended period of no flow during the dry season, that leads also to disappearance of deep pools, usual refuges of fish species. With increasing reduction of natural land covers, supplies of nutrient will also decrease. Bed load sediment were increasingly mined locally before reaching the lake.

44. One of the major findings of the study is that the Tonle Sap Lake has almost 300 species, making it the third-richest lake in the world in terms of fish diversity. A review of scientific literature identified 296 species, more than twice the number recorded before. That makes the lake the richest in the world only after Lake Malawi (433 species) and Lake Tanganyika (309 species), both in Africa (Eric Baran, 2007). The dominant families in the Tonle Sap Lake are carps and minnows (Cyprinidae) with 108 species, sheatfishes (Siluridae) with 20 species, bagrid catfishes (Bagridae) and loaches

(Cobitidae) with 17 species and shark catfishes (Pangasiidae) with 14 species (Eric Baran, 2007).

45. The Tonle Sap Lake's importance in sustaining the health of Mekong fisheries is reaffirmed by the fact that it is home to a large proportion of fish species found in the Mekong River system. Although it accounts for only 11 percent of the Mekong Basin in terms of surface area, the Tonle Sap watershed has almost a third of all species recorded in the river and almost half of all the families. This qualifies the lake as an exceptional hotspot for biological diversity and calls for special attention by national and international institutions.

46. Flow reversal in the Tonle Sap River will also be affected. In the baseline the average start date for flow reversal is about 24 May with the natural year-to-year variation by +/- 19 days (5 May-12 June). In comparison with the baseline, flow reversal occurs typically on average 3 days earlier and with slightly increased variability. Also the flow reversal volume into the Tonle Sap Lake reduces on average by 7-8%. Whilst, by comparison, the natural year-to-year variation in flow volume amounts to up to about 300%, it will be appreciated that the forecast changes indicate a downward trend in flow reversal volume.

47. The influence of hydropower and irrigation projects within the Tonle Sap Lake's catchment basin would significantly add to the impact of developments upstream in the Mekong Basin. Even smaller dams within the Tonle Sap catchment would have an impact similar to upstream dams in reducing inflows of water in the wet season and increasing dry-season flows. The influence on water level of Tonle Sap developments in the case of the Tonle Sap scenario that adds hydro-electric and irrigation dams across seven tributaries that flow into the lake is significant. Impacts of Tonle Sap projects are felt earlier than those of upstream projects. The combined impact of Tonle Sap projects and Mekong upstream projects is significantly higher than the impacts assessed separately. If all existing projects are going to be built some net storage of 5.585 BCM would add up to the reduction of the volume of the lake.

48. Environmental Impact Assessments (EIAs) should be improved for Tonle Sap infrastructure projects that may have a significant impact on water and aquatic resources. Access to Environmental Impact Assessments for Tonle Sap development projects is difficult, reports being scattered across various ministries and provincial and district government offices or with project developers. Very few are available at the Ministry of Environment or other relevant ministries. Assessments are not systematically recorded or classified. The study evaluated in detail only 10 reports, mostly involving projects funded by external donors. Reports for other projects were unavailable because they were either inaccessible or did not exist.

49. Tonle Sap EIAs tend to be narrowly focused, covering a fraction of the area, the resources, the time period, and the people possibly impacted. These EIAs are often geographically limited to the project area, which provides at best a partial estimate of

the impact on fisheries. They tend to be narrowly focused on short-term biological and physical changes to water flows and fish; few assessments mention other aquatic resources like crabs, shrimps and snails - important sources of food for many people, especially the poor. They neglect longer-term impacts on the ecological system and livelihoods. Moreover, they do not systematically address socioeconomic consequences of impacts on fisheries and there are wide variations in coverage. Last, participation of stakeholders is generally very limited due to lack of a systematic mechanism for the consultation of local communities, provincial authorities, and local or international NGOs in the EIA process.

50. The quality of the Environmental Impact Assessments (EIAs) of Tonle Sap projects that might have a significant impact on water resources and fish is insufficient. The EIA process refers to the overall mechanism in place to request, submit, accept and monitor project EIAs. Increased awareness of the importance of EIA practice should be supported. There is need for improving the capacity of EIA practitioners in: i) defining the scope with a holistic approach; ii) increasing the use of available knowledge through systematic consultations of local stakeholders and of scientists; iii) making use of methods that deal with scarce data and uncertainty; iv) using methods for valuation of trade-offs between the various costs (esp. social and environmental) and benefits of built structure projects, and by v) improving stakeholder participation and the transparency of the process.

51. Overall, the Tonle Sap Lake has 23 species whose annual migrations are triggered by changes in water levels, and another 3 species triggered by changes in water flows. These fishes, accounting for about 10 percent of the species documented for the Tonle Sap Lake, are particularly sensitive to the hydrological consequences of infrastructure development such as delays in the arrival of floodwaters, increased water levels in the dry season and changes in the speed of the current. The impact of changing water levels on the remaining 90 percent of Tonle Sap species is still unknown.

52. Changes in water levels affect the annual migrations of these indicator species which account for 13 percent of the Tonle Sap Lake's catch, or between 38,000 tonnes and 56,000 tonnes a year. It is not clear how sensitive the two species of trey riel (Henicorhynchus genus) are to changes in water levels as their migrations may also be triggered by the phases of the moon. But if they are included, the proportion of the catch whose migration is triggered by changing water levels jumps to 38 percent, amounting to between 110,000 tonnes and 164,000 tonnes a year.

53. For trey sleuk russey (Paralaubuca typus), reproductive migrations and their dependence on environmental triggers are clearly documented. As for trey pra (Pangasius species), seven are very sensitive to hydrological migration triggers and three are less sensitive. These catfishes are highly valuable to both capture fisheries and aquaculture. Of the seven Cyclocheilichthys species, trey chhkok (Cyclocheilichthys enoplos), the most abundant by far, is very sensitive to hydrological triggers.

54. Fish species are currently classified under two ecological groups known as "white" and "black" fishes, but another category is needed. White fishes migrate between floodplains where they feed and the Mekong mainstream where they breed. Black fishes spend their whole lifecycle in floodplains and can resist harsh environmental conditions. However, this classification into two ecological "guilds" is too crude to reflect major responses to changes in water flow or quality. For example, several species spend the dry season in tributaries such as Stung Pursat and Stung Chinit where they may be sensitive to infrastructure development. Management plans should therefore consider "grey" fishes as a third group with intermediate patterns of behavior. The recommendation to consider "grey" fishes as a third group is based on interviews with 102 experienced Tonle Sap fishermen and is supported by studies in the western and central African floodplains as well as Bangladesh.

2.9. Floods Management concepts

2.9.1. Management of flood and drought risk

55. We do not ‘manage’ or ‘control’ floods or droughts per se, but rather the risks associated with these events. Risk is the downside of chance. We speak of the chance of success, but the risk of failure. In risk management terms, ‘risk’ refers to the (adverse) impact of an event. It incorporates the likelihood (probability) of an event occurring and the consequences of that event on affected communities, i.e. the socio-economic impact (SEI). There is a human side to risk, namely the socio-economic vulnerability of the affected community. The impact of an adverse event on a highly vulnerable community is worse than on a less vulnerable (or more resilient) community (124).

- Considering the evolution and trends, the approach to natural hazards requires a change of paradigm. One must shift from defensive action against hazards to management of the risk and living with floods
- Human uses of floodplains should be adapted to the existing hazards
- Mitigation and non-structural measures tend to be potentially more efficient and long term more sustainable solutions to water-related problems and should be enhanced

56. The interconnections between the floods and the productivity of the natural resources are complex and often not very well understood. This naturally decreases our ability to appreciate all the natural productivity-related, positive outcomes of the floods. Another reason for the development of the common belief “floods are mostly destructive” could be compressed in two word pairs: control adaptation and formal-informal. The negative impacts of floods are most obvious in arrangements in which human livelihoods and other activities are based on strong control of the natural structures or processes, such as irrigation systems and roads. Such arrangements bind financial capital and are usually funded through formal channels. Therefore the natural

variation in water level fluctuation, which one year may exceed the safety marginal of human-made control structures, are clearly seen as destructive and the economic losses are measurable. On the contrary, traditional livelihoods, such as family fisheries, small scale agriculture, hunting and gathering, have adapted to the local conditions. They utilise the rich natural resources of the flood plains without posing extensive control on them. In societies like in Cambodia, and especially among its poorest people, these livelihoods have a strong subsistence nature and the connection to formal economy is weak.

57. The analysis of flood related policies in the Mekong region showed that there is strong conception that the floods bring mostly harm as they occur. Such thinking is however slowly being replaced by more balanced and comprehensive approach, which considers also the complicated flood-related ecological processes and their benefits to the people.

Floods are an integral part of the Mekong River system. Similar to wild animal and plant species, humans have also developed adaptations to the fluctuating water level. Floods of average magnitude, or reasonably close to it, pose no significant additional risk to the human activities in the Lower Mekong Basin. The most serious damages are caused by larger and rarer floods. For the most part, floods contribute to the human well-being by enhancing the ecological diversity and productivity as well as inspiring water festivals and other fascinating cultural phenomena of the Mekong Region.

Under the MRC FMMP-C2 based on existing identified flood management project concepts and project, a strategic direction for flood risk management has been proposed for Focal Areas.

2.9.2. The development of Strategic Directions for Flood Risk Management unprotected areas

58. The flood plain of Cambodia is closely related with the envisaged land use scenarios. Current land use in these areas is merely restricted to a single rice cropping in the absence of adequate structural measures for flood management and irrigation. “Living with Flood” is the leading concept. The risk under the present land use conditions is relatively low and substantial investment in structural protection works will be difficult to justify (see FMMP_C2, volume V6C-WB_IFRM Plan, 2010). If present cropping patterns are sustained, the focus should be on vulnerability reduction by flood proofing of settlements and infrastructures and for instance the use and/or development of less vulnerable varieties.

If however, agriculture development is envisaged in these unprotected flood plains then such development would create increase risks in the absence of adequate flood protection measures. Polder would then be an obvious approach. Such development should go together with the provision of irrigation facilities. The loss of environmental benefits especially fishery related benefits, will play a crucial role in the planning and design of such a polder schemes.

59. The Focal Areas cannot be considered in isolation from the entire Tonle Sap Mekong flood plain including the remaining Mekong Delta part in Vietnam. Flood management options at delta level that aim at the reduction of the flood hazards for the entire Delta are very limited. Such an option would have to consider the reduction of flood discharges and volumes that enter the Delta or the creation of diversion and/or retention options in the Delta. Upstream retention as flood mitigation measures for the Delta is not considered a realistic option.

60. The only substantial retention option within the Delta area is related to the use of the storage capacity of the Tonle Sap Great Lake. Preliminary investigation shows that an uncontrolled of early flood water (July-August) to the Great Lake has a very limited impact on the flood hydrograph in the Delta. A controlled diversion could however delay the early flood downstream of Phnom Penh by a couple of weeks on the average. Such diversion though provides no risk reduction for infrastructures and housing in the flood plains since this type of damage is driven by the peak flood. A diversion scheme for flood risk management can be supplemented with works that regulate outflow of the Tonle Sap Great Lake and adjacent flood plains. Such a regulation would provide additional benefit since it improves the low flow conditions in the Delta. Flood management at regional level within the Delta is the approach that is being followed in the Vietnamese part of the Delta. This approach refers to the different region in the Delta with different level of flooding (deep and shallow) and distinct boundary conditions requiring different flood control solutions. This regional approach is also suggested for the Cambodia part of the Delta. The development of transboundary strategic direction is not considered appropriate, in view of the great difference between the development level and pace at the two sides of the border. Emphasis is to be given to the potential impacts that the separate regional strategic direction might have on neighboring region, rather than to try to come to common strategic directions.

2.9.3. Governance Institutional Setup

62. Internationally there is a continual increase in the pressures on the World's water resources: from population growth, consumption patterns, management issues, climate change, biodiversity loss, growing destruction and pollution of aquatic ecosystems, increasing cross-sectoral competition for water, and conflicts over access to water.

Water governance develops and sets the rules, roles and responsibilities of all stakeholders regarding the ownership, administration and management of water resources. Stakeholders include local and national governments, the private sector, civil society. Water governance is a decision-making framework, providing instruments to set rules, including laws, policies, regulations and institutional arrangements.

However, there is also a growing recognition that the resultant issues represent in many ways issues of governance, that is, a failure of government institutions to manage our resources for the well-being of humans and ecosystems. In this context, the needs for new forms of governance are also increasingly recognised around the world:

Water governance refers to the range of political, social, economic and administrative systems that are in place to develop and manage water resources, and the delivery of water services, at different levels of society (GWP 2000)

In Cambodia the concepts of good governance is well recognised. The core of the Rectangular Strategy III (RS), the key strategic policy and planning document of the Royal Government of Cambodian (RGC), is stated as "*Good Governance*":

Good governance remains at the core of achieving social justice and sustainable and equitable socio-economic development.

Rectangular Strategy III promotes:

- Good governance so that all the operations and functions of state institutions at both national and sub-national levels would be conducted in a transparent, accountable, predictable, effective and efficient manner; and
- Strengthening governance and capacity of public institutions in order to improve the efficiency of public service delivery and the investment climate

Due to pressures from population growth, urbanisation, expansion and intensification of agriculture, as well as development of transport, energy and other sectors, managing the environment and climate change for the sustainability of Cambodia's economic growth and social development has become one of the overarching environmental conditions for implementing the Strategy (RS III, para 26 p. 12).

"Many environmental issues are cross-sectoral in nature, which requires coordination across government agencies at both national and sub-national levels including cooperation with all the stakeholders" (RS III, para 26 p. 12).

RS III lists challenges that remain in ensuring the sustainability of natural resources:

- Weak governance of the natural resource management system;
- Insufficient legal and regulatory frameworks;
- Need to strengthen coordination between related institutions and stakeholders;
- Ineffectiveness of reform programs; and
- Need to strengthen the management of the impact of climate and eco-system changes

RS III also requires stepping up institutional coordination to harmonize development of irrigation infrastructure, hydropower and transportation to increase effectiveness of investment and use of water resources.

RS III reaffirms the RGC's mission and its strong commitment to sustainable development and poverty reduction, and guides the activities of all stakeholders to further pursue and strengthen long-term sustainable development aimed at promoting

economic growth, creating jobs, equitable distribution of the fruits of growth, and ensuring effectiveness of public institutions and management of *resources*.

2.9.4. The management of the Tonle Sap Great Lake

63. The management of Tonle Sap's wetlands is centered on three sectors: biodiversity, fishery and agricultural water management. However, it does not adequately consider the social and environmental importance of the wetlands. The management is segmented and the governance is weak due to poor coordination among different agencies. In response to these issues, the Tonle Sap Authority (TSA) was established to improve coordination and strengthen the lake's governance. This brings the MOWRAM, TSA and CNMC under one umbrella at a national level. Moreover, the Minister of MOWRAM is also a regional council member of MRC, improving water governance coordination in the Mekong and Tonle Sap regions. However, the MOWRAM's mandates only address water and not wetlands. Thirty-one high level representatives from government ministries and institutions are appointed as members of the TSA. This improves stakeholder representation in the TSA and contributes towards an inclusive and deliberative decision-making process. However, the decision making process is largely the domain of government agencies and civil society representation is lacking. At present, the government has involved communities and civil society organizations in the management of Tonle Sap. However, the top-down approach to decision making remains and communities and civil society are not involved in resolving conflict of determining access to fisheries groups. The government has taken strong measures to combat illegal fishing activities and the lower level government institutions have taken responsibility following the pressure from higher levels of government. The government has used the court system to combat illegal fishing and those found guilty, all small fishing operators were imprisoned [55]. Although this is a strong start by the Head of State, it is doubtful that this level of momentum will continue. The provincial Department of Water Resources and Meteorology acts as a secretariat to the TSA. TSA commands are passed to the provincial department, which then implements the action. In Tonle Sap, TSA employed nine rangers across the lake to watch all activities and they are equipping with nine boats and other facilities. However, financially, they still face limited financial supports and therefore, their works have not been satisfactory. The Department of Wetlands, within the MoE, is the state agency responsible for coordinating wetland management and ensures the integration of wetland issues into the management of fisheries, biodiversity, water and agriculture. The Department of Wetlands is working collaboratively with other government agencies and NGOs to promote the wetland institutionalization and community participation in wetland governance. All of these concerns need to be taken into account in considering the implications of multi-lateral environmental agreements (MEA) for wetland management in Tonle Sap. However, it is essential that wetlands are legally defined in the Cambodian context. At present, the lack of an overarching legal definition leaves each sector decide on their own. Wetlands are yet to be clearly defined under

Cambodian law and the lack of coherency is leading to confusion within sectors which are left to either develop their own wetland definition or none at all. Natural resource authority is segregated between territories and the legal ambiguity aggravates institutional conflicts and frustrates integrated management. The Fisheries Law leaves many resources unaccounted for, in particular, those may be considered non-fishery resources and does not provide a framework for ecosystem-based management beyond its role in fisheries production. Institutional coordination for wetland management is weak, leading to competition among different institutions having mandates, roles and responsibly in Tonle Sap and overlapped initiatives. Although MoE leads wetland management decisions, many areas overlap with fisheries management. There is no clear coordination mechanism in place to facilitate this conflict and each agency will only work within their sectoral mandate. There needs to be a legal mandate for the overall management and planning for wetlands at a national, regional and local level. Ramsar experience and guidance highlights the need take a multi-sectoral approach that involves civil society as well as the public and private sectors. A multi-institutional technical secretariat with decision-making authority, such as the one established under the sub-decree on Economic Land (industrial agriculture) Concessions 2005, is needed to effectively coordinate the management of wetlands. The Governance of Tonle Sap and fisheries management is continuously changing, from the focus on commercial fisheries exploitation to community based fishery

64. The Tonle Sap lake area is subdivided into three management zones (Mak Sthirith, 2015). Zone 1—covering 417,451 ha—extends from RN5 5 and RN 6 down to the floodplain around the lake, which is largely covered by rice fields and human settlements. Zone 2—covering 365,300 ha—has a low human settlement density, few rice fields, more vegetation and natural ponds. Socio-economic activities in this zone are closely monitored and some activities are prohibited such as land ownership, which is subject to approvals from the local administration. Zone 3—covering 642,793 ha of largely flooded forest—protected by the sub-decree. The Tonle Sap Authority (TSA) is the main state agency responsible for the management of the flooded forest and Tonle Sap as a whole. The flooded forest zoning system overlaps with the Biosphere Reserve areas. The Biosphere Reserve is managed under the authority of the Tonle Sap Biosphere Reserve Secretariat (TSBRS). The difference between them is that the Biosphere Reserve zones cover the whole lake, including the terrestrial areas, floodplains and aquatic areas. Whereas, the flooded forest zones only cover the flooded terrestrial areas and floodplains.

New forms of development around the lake are flood storage embankments to store flood water for flood recession rice cropping as well for aquaculture that has recently caused controversies in some areas.

65. At regional level water governance is the work of the MRC under the 1995 Agreement at regional level and CNMC at national level. To achieve sustainable

development and sharing water and related resources in an equitable manner, the MRC supported by the World Bank has established five rules of procedures namely:

a. Procedures for Data and Information Exchanges and Sharing (PDIES);

b. Procedures for Water Use Monitoring (PWUM)

c. Procedures for Notification, Prior Consultation and Agreement (PNPCA)

d. Procedures for the Maintenance of Flows on the Mainstream (PMFM)

e. Procedures for Water Quality (PWQ)

Successful implementation of all established procedures depends heavily on adequate scientific data, technical and institutional capacity at national level particularly of specialized technical line ministries coordinated by the CNMC.

MRC Strategic Plan (2016-2020), most relevant key result areas are key result areas No 2, and no 3,

Key result area No 2

Outcome 4: Effective and coherent implementation of MRC Procedures by member countries

Outcome 5: Effective dialogue and cooperation between Member Countries and Strategic engagement of regional partners and stakeholders on transboundary water management

Key result area No 3

Outcome 6: Basinwide monitoring, forecasting, impact assessment and dissemination of results strengthened for better decision making by member countries.

66. The updated BDS for 2016-2020 is directed at “Cooperation on water development and management to further move national sector planning towards basin-wide optimal and sustainable development in the Mekong basin”. Optimal and sustainable development and management of the resource is fundamentally a collective action challenge. Achieving the necessary cooperation depends on sufficient levels of trust, confidence and a sense of fairness existing between stakeholders. The MRC will engender stronger relationships by facilitating dialogue among its member countries and with its partners on the options to address pressing and longer-term needs and challenges, increase regional benefits, reduce regional costs, and provide water security, underpinned by established, transparent Procedures that address Member Countries’ needs.

67. The five MRC Procedures and their Technical Guidelines elaborate key principles established in the 1995 Mekong Agreement and guide Member Countries’ interactions for basin management and development. Compared to most developing

basins, they provide a solid foundation for on-going cooperation. However, effective implementation faces challenges depending on the particular Procedure, including: misconceptions regarding role among some stakeholders, perceptions of low value/high burden among some Member Countries, uncertainty about the Procedure's scope and lack of implementation capacity in some Member Countries.

68. To address these challenges, the MRC will review and update the Procedures as necessary, facilitating dialogue between Member Countries to reach a consensus where necessary. We will also promote common understanding among Member Countries about the role and scope of different Procedures, supported by targeted training at a national level where necessary. A key vehicle to achieve this will be the effective operation of the recently established Joint Platform that will act as a forum for discussion about the Procedures and will encourage a more coherent, less piecemeal, approach to their application. Stronger linkages with basin development planning will also assist in the implementation of the Procedures, making them tools to support basin development and not potential blockages.

Due to its low technical capacity Cambodia is not able to take advantage of the opportunities to protect its interests affected by for example upstream impacts based on strong and credible scientific data. There is no comprehensive integrated water resources development and management plan in the Mekong-Tonle Sap flood plain that is vital for the national economy and food security.

3. EXPECTED OUTPUTS AND METHODOLOGY

69. This chapter presents the methodology of the Consultant's Team to implement the outputs of the Assignment listed in Chapter 1. For each output we discuss the approach and the activities that will form the part of the work plan presented in Chapter 3.

Throughout the implementation of the activities and the methodology to achieve the outputs of the project, the team of consultants will coordinate closely with other related line agencies, line ministries particularly the MRC, the RFMMC, the CNMC, MOWRAM (DWRMC, DHRW), the MPWT, PLMUPC, IFReDI, MAFF etc.

3.1.1. OUTPUT1: Assessment report on status of knowledge data and information of the Mekong – Tonle Sap Great Lake and wetland flood plains

70. Most significant data and information on river flow and water level were collected at major monitoring hydrological stations along the Mekong upstream (in Thailand and Lao PDR) and the Mekong-Tonle Sap- Bassac River system including the Great Lake and secondary sediment data will be also collected. There were some gaps in historical time series data, particularly river flow at high stages and flows at stations affected by backwater. Different detail flow measurement in recent past still has some limitation in the project areas, e.g. the WUP JICA between 2000 and 2004 and the MRC TSLV

project focused mainly the stretch of the Mekong from Kampong Cham to downstream of Phnom Penh, focusing particularly on flow distribution in the flood plain.

In recent years (between 2010 to 2015) under the Flow monitoring Program of the MRC, new rating curves for Stung Treng, Kratie, Kampong Cham, Phnom Penh Chrouy Changvar, Phnom Penh Port, Chaktomuk, Koh Norea, Prek Kdam, Neak Leung and Koh Khel have been updated. New sediment data were also collected during that period.

Water resources assessment constitutes the practical basis for sustainable water management and are a perquisite for evaluation of the possibilities for water development

There is, however, growing concerns at a time when a more precise and reliable information is needed hydrological services and related bodies are less able than before to provide this information especially information on water quality, sediment transport and groundwater.

72. Data is one of the most important assets of the country for its exceptional geographical location to enable its effective participation in different water resources management of the MRC activities to implement the 1995 Agreement, particularly the elaboration of the rules and procedures in the Water Utilization Programme (WUP) and their implementation, in the establishment of baseline conditions for development scenarios assessment, flood hazard and flood risk maps. The scenario assessment was key milestone for MRC to inform member countries on impacts and quantify them from existing and planned upstream development (hydropower, irrigation and land use) on environment, ecosystem and people livelihood to enable the country to effectively implement the regional water utilization procedures. And for Cambodia to ensure that its interests are being well taking into account in any decision process.

73. All tributaries around the Tonle Sap Great Lake have not been monitored since the early 2000 despite large infrastructure investment were made in irrigation and transport sectors. Some flow data might exist at project level mainly project supported by JICA. The project team will review in detail existing studies made by CNMC and World Fish Center" Influence of Built Structures on Tonle Sap Fisheries, reports on floating rice related to flood risk, conversion of flooded forest into recession rice. Sediment flow into the TLS GL has been also severely impacted by sand dredging in tributaries

74. A great number of infrastructures such as flood diversion canal, irrigation, colmatage canals with or without pumping stations, national, provincial roads were built throughout the flood plain but most of them, particularly irrigation schemes are managed and operated by Farmers Water User Groups. Some schemes water deliveries are provided by private vendors who charge water fees in kind or money terms. Access to water is defined by the water level in major mainstream. Usually there is no organized planned cropping patterns in order to facilitate water sharing planning and farmers

receive water information only on mainstream forecasting stations through television and radio (DHRW- 3 days water level forecast) and on severe weather (storm and typhoons etc.) The consultant team will identify needs for such information to be integrated into the national strategy for IWRM and IFRM.

75. Major cities such as Phnom Penh and surrounding towns are protected from flood by dike embankments that was designed during the early 2000 of before, with new development the design frequencies of some part of the city have already changed due to rapid land use change mainly by reclamation of existing flood storage areas (lakes, depression etc.). The consultant will review all existing literatures to reassess the flood risk in water front of the major cities, particularly Phnom Penh and its satellite towns

To define data and information requirement needs to inform about the status of wetlands uses and their protection.

76. At regional level Cambodia as one of the most downstream country of MRC badly needs water information data from upstream and depends on the degree of success of the implementation of all the established MRC's rules of procedures. To abide to this obligation Cambodia has also an obligation to produce better data collection system and build its own institutional capacity particularly to protect itself from possible infraction of the rules from upstream with solid scientific facts. Agencies responsible to implement the MRC procedures have to develop a joint strategy to build technical and financial capacity to meet such requirement. The consultant team will gather all information by working with the IKMP of the CNMC and other relevant line agencies to propose a realistic strategy to overcome the shortcoming in this area.

3.1.2 Proposed activities under Output 1:

77. Update existing flow and water level data of major monitoring stations in the upper Mekong basin with particular focus on key stations in Cambodia (Stung Treng, Kratie, Kampong Cham, Chrouy Changvar, Koh Norea, Neak Leung on the Mekong), on the Tonle Sap River (Phnom Penh Port, Prek Kdam, and Kampong Luong); on the Bassac (Phnom Penh Bassac, RFMMC and Koh Khel)

1. Review of existing hydrological studies in the LMB and in Cambodia to update characteristics of the flow regimes in rivers and in the flood plain;

2. Updates water level and discharge data on the Mekong-Tonle Sap –Bassac stations and tributaries around the Tonle Sap Great Lake with new rating curves where are available;

3. Based on MRC updated scenarios assessment summarise upstream development impacts on flow regime change on the Mekong, Tonle Sap and flood plain including sediment transport (quantitative);

4. Provide summary report to be used as basic reference for strategic direction for IFRM and IWRM sustainable development and management of the Mekong-TLSGL flood plains;

3.2.1. OUTPUT 2: Report on the Assessment of the Mekong, TLS Great Lake, Mekong Flood Plain Ecosystem, upstream and local development impacts on fisheries, agriculture and wetland ecosystem as a whole

78. The Tonle Sap Lake's importance in sustaining the health of Mekong fisheries is reaffirmed by the fact that it is home to a large proportion of fish species found in the Mekong River system. Although it accounts for only 11 percent of the Mekong Basin in terms of surface area, the Tonle Sap watershed has almost a third of all species recorded in the river and almost half of all the families. This qualifies the lake as an exceptional hotspot for biological diversity and calls for special attention by national and international institutions.

79. The consultant team will review literatures describing fish biological inter-connection between the TLS GL and the Mekong River system as well as ecosystem services of the flood plain, its importance on food security of the basin population and environment.

Overall, the Tonle Sap Lake has 23 species whose annual migrations are triggered by changes in water levels, and another 3 species triggered by changes in water flows. These fishes, accounting for about 10 percent of the species documented for the Tonle Sap Lake, are particularly sensitive to the hydrological consequences of infrastructure development such as delays in the arrival of floodwaters, increased water levels in the dry season and changes in the speed of the current development. The impact of changing water levels on the remaining 90 percent of Tonle Sap species is still unknown.

80. The consultant team will make critical review on migratory species between the TLS GL and the Mekong River system, their economic importance and specific characteristics related to water flow and water level, particularly to flood pulse conditions.

Changes in water levels affect the annual migrations of these indicator species which account for 13 percent of the Tonle Sap Lake's catch, or between 38,000 tonnes and 56,000 tonnes a year. It is not clear how sensitive the two species of trey riel (Henicorhynchus genus) are to changes in water levels as their migrations may also be triggered by the phases of the moon. But if they are included, the proportion of the catch whose migration is triggered by changing water levels jumps to 38 percent, amounting to between 110,000 tonnes and 164,000 tonnes a year. The consultant team will update any new findings.

81. For trey sleuk russey (Paralaubuca typus), reproductive migrations and their dependence on environmental triggers are clearly documented. As for trey pra

(Pangasius species), seven are very sensitive to hydrological migration triggers and three are less sensitive. These catfishes are highly valuable to both capture fisheries and aquaculture. Of the seven Cyclocheilichthys species, trey chhkok (Cyclocheilichthys enoplos), the most abundant by far, is very sensitive to hydrological triggers. The consultant team will review, update and classify them.

82. Fish species are currently classified under two ecological groups known as "white" and "black" fishes, but another category is needed. White fishes migrate between floodplains where they feed and the Mekong mainstream where they breed. Black fishes spend their whole lifecycle in floodplains and can resist harsh environmental conditions. However, this classification into two ecological ''guilds'' is too crude to reflect major responses to changes in water flow or quality. For example, several species spend the dry season in tributaries such as Stung Pursat and Stung Chinit where they may be sensitive to infrastructure development. Management plans should therefore consider "grey" fishes as a third group with intermediate patterns of behavior. The recommendation to consider "grey" fishes as a third group is based on interviews with 102 experienced Tonle Sap fishermen and is supported by studies in the western and central African floodplains as well as Bangladesh. The consultant team will review and update any new knowledge and findings including the updating of newly built and planned infrastructures.

83. The influence of hydropower and irrigation projects within the Tonle Sap Lake's catchment basin would significantly add to the impact of developments upstream in the Mekong Basin. Even smaller dams within the Tonle Sap catchment would have an impact similar to upstream dams in reducing inflows of water in the wet season and increasing dry-season flows or not at all due to existing and planned water extraction for irrigation. Impacts of Tonle Sap projects are felt earlier than those of upstream projects. The combined impact of Tonle Sap projects and Mekong upstream projects is significantly higher than the impacts assessed separately. Some species are also migrating along the TLS tributaries at the end of the wet season to their spawning ground in deep pools along the rivers. Similar to the Mekong mainstream, tributaries of the TLS GL are fragmented by manmade structures, some fish passes were built but their efficiency is not known (Stung Chinit). The consultant team will make critical review of existing studies and collection information on fish migration (species) and lost after built structures.

84. The Tonle Sap-Mekong wetland ecosystem is ranked as the most productive ecosystem in the world In terms of ecological and social benefits, floodplains are among the most valuable landscapes in the world. The completed global review of tropical floodplains found that fish and other natural resources are the primary benefits, followed by the replenishment of nutrients and fertile soils for farmlands and pastures. However, much is still unknown about the ecological functions of floodplains and how to value them properly. This is a reason why the impact of manmade structures on tropical floodplains is not well documented with the exception of large dams. Most of the

available information is qualitative rather than quantitative. Valuations should be conducted in such a way that the results can be integrated into more conventional economic cost-benefit analyses of proposed investments in water development projects, and allow more thorough economic analyses of the predicted returns for different investment options. The consultant team will review all existing literature on the evaluation of the impact made structures on tropical floodplains and suggest methodology and strategy for the assessment.

85. Dams are the main type of structure having an impact on fisheries production, through their negative impact on fish migrations. In the Mekong Basin, 87 percent of fish species for which information is available are migratory species. Sixteen percent of these species are known to be sensitive to hydrological migration triggers that will be modified by dam construction. Based on existing literature review, the consultant team will list the number of known species sensitive to hydrological migration triggers and proposed strategy and methodology for further studies.

86. Existing review found no examples of positive long-term impacts of dams on fisheries, nor any effective mitigation measures. In the Mekong Basin, reservoirs are sometimes presented as a way to create new fisheries upstream, but this usually does not compensate for the loss of downstream fisheries. Similarly, fish passes are often proposed to help fish migrate. However, there are no examples of fish passes that work in the Mekong Basin. This is mainly due to ecological factors and the intensity of migrations which fish passes cannot accommodate. Out of the hundreds of species in the Mekong Basin, only nine are known to breed in reservoirs. The effectiveness of the new fish pass at Stung Chinit completed in 2006 has not yet been assessed. Based on existing literature, the consultant will compile existing reservoir fisheries in the region including known fish passes as well as initiative of sustainable hydropower as new design concept and friendlier to fishery.

87. The loss of fisheries would affect millions of people with fisheries-associated livelihoods. For instance, the fish groups that are extremely sensitive to hydrological triggers include shark catfishes (Pangasiidae), which are commercially important to both capture fisheries and aquaculture. Among the 10 fish groups that dominate the Tonle Sap catch, four are sensitive to such triggers. They account for 18 percent of the volume of the Tonle Sap catch and 14 percent of its value. On the other hand, several environmental impact assessments (EIAs) conclude that negative impacts on fisheries would be minor because of biases or flaws in their approach such as a limited scope, or because of a focus on percentages lost rather than on tonnage and livelihood values lost. In general, most dam projects in the Mekong Basin lack undisputable EIAs and detailed baseline studies that would allow the full range of cost-benefit analyses. The consultant team will conduct critical review existing procedure for estimation of fishery lost as well as available existing environmental assessment (EIAs) as well as cumulative impact assessment, including the quantification of benefit that might be lost. Provide collection of guidelines and recommendations on how to implement EIAs that

include instructions on how to consider specific environmental characteristics of flood plains (how to include economic valuation of the lost benefit of flood plains)

88. Large infrastructure projects increasingly require cumulative-impact and strategic-environmental assessments. Most structures are not isolated from the surrounding environment. The cumulative impact of many structures can be assessed, although this is complicated as it is more than simply adding up the individual impacts of each structure. In general, impact assessments rarely quantify benefits that might be lost. Existing guidelines and recommendations on how to implement EIAs typically do not include instructions on how to consider specific environmental characteristics of floodplains, how to assess the impacts of projects on floodplain ecosystems, or how to include economic valuation of the lost benefits of floodplains.

89. Environmental Impact Assessments (EIAs) should be improved for Tonle Sap infrastructure projects that may have a significant impact on water and aquatic resources. Access to Environmental Impact Assessments for Tonle Sap development projects is difficult, reports being scattered across various ministries and provincial and district government offices or with project developers. Very few are available at the Ministry of Environment or other relevant ministries. Assessments are not systematically recorded or classified. The consultant team will collect and conduct critical review of existing EIAs reports and recommend for future studies particularly to include values and benefit of wetland ecosystems in each of the tributary.

Tonle Sap EIAs tend to be narrowly focused, covering a fraction of the area, the resources, the time period, and the people possibly impacted. These EIAs are often geographically limited to the project area, which provides at best a partial estimate of the impact on fisheries. They tend to be narrowly focused on short-term biological and physical changes to water flows and fish, few assessments mention other aquatic resources like crabs, shrimps and snails - important sources of food for many people, especially the poor. They neglect longer-term impacts on the ecological system and livelihoods. Moreover, they do not systematically address socioeconomic consequences of impacts on fisheries and there are wide variations in coverage. Last, participation of stakeholders is generally very limited due to lack of a systematic mechanism for the consultation of local communities, provincial authorities, and local or international NGOs in the EIA process. The consultant will review existing process and recommend for improvement.

The quality of the Environmental Impact Assessments (EIAs) of Tonle Sap projects that might have a significant impact on water resources and fish is insufficient. The EIA process refers to the overall mechanism in place to request, submit, accept and monitor project EIAs. Increased awareness of the importance of EIA practice should be supported. There is need for improving the capacity of EIA practitioners in: i) defining the scope with a holistic approach; ii) increasing the use of available knowledge through systematic consultations of local stakeholders and of scientists; iii) making use of methods that deal with scarce data and uncertainty; iv) using methods for valuation of

trade-offs between the various costs (esp. social and environmental) and benefits of built structure projects, and by v) improving stakeholder participation and the transparency of the process.

90. One of the major findings of the previous study is that the Tonle Sap Lake has almost 300 species, making it the third-richest lake in the world in terms of fish diversity. A review of scientific literature identified 296 species, more than twice the number recorded before. That makes the lake the richest in the world only after Lake Malawi (433 species) and Lake Tanganyika (309 species), both in Africa. The dominant families in the Tonle Sap Lake are carps and minnows (Cyprinidae) with 108 species, sheatfishes (Siluridae) with 20 species, bagrid catfishes (Bagridae) and loaches (Cobitidae) with 17 species and shark catfishes (Pangasiidae) with 14 species

3.2.2. Proposed activities under Output 2:

92. Provision of a comprehensive description of the TLS GL, morphology, past and present environmental change, connection with the Mekong, trends

1. Provide comprehensive description of the TLS GL ecosystem, its importance for the country, local community, region and global environment

2. Provision of a comprehensive report on the function of the TLS GL ecosystem function, its adaptation to seasonal, inter-annual and climatic variability, expected magnitude of impacts from upstream and local development

3. Provision of a comprehensive report on flow regime change on fish migration of white and grey species with possible mitigation measures (structural and non-structural)

4. Provision of a comprehensive report on process of fish migration between the Mekong ant Tonle Sap Great Lake

5. Review existing EIA on impact assessment of infrastructures on fishery, identify the shortcoming and propose improvement to be included in the strategies.

3.3.1. OUTPUT 3: Assessment of hydraulic feasibility for Early Flood Diversion from the Mekong to the Tonle Sap Great Lake

93. The characteristics of flooding in the LMB vary from short lived peaky floods to slowly rising long lasting rounded floods. Floods could be distinguished as: (i) Tributary floods with flashy characters, (Sre Pok, Se San, Sekong etc.);(ii) Mainstream flood, along the Mekong –Bassac-Tonle Sap mainstream (slow rising and falling type); (iii) A combined flood , e.g. flood at the junction between main tributaries and the Mekong; (iv) Flood in the Mekong-Tonle Sap GL and Bassac flood plain; (v) In the Mekong Delta at the Cambodian Vietnamese border area. The consultant team will describe the

historical floods, flood characteristics (flood volume and duration), its distribution and flood hazards in the country with particular focus on fishery and flood plain agricultural production capacity;

94. The Tonle Sap Great Lake tributaries and their contribution the TLS GL. There are 12 tributaries in the TLS GL basin draining directly into the lake, all of them drain a relatively small catchment with a total areas of about 80,000 km^2, contributing about 30 % of the Great Lake storage volume. The Great Lake receives 57 to 60% of its annual volume from the Mekong River, its huge volume of about 83 km^3 is able to cut about 20% of the Mekong flood peak. Generally peak flows from the tributaries coincide with the maximum water level of the Lake. Early lake infilling contribute to early expansion of the lake flooded area and early interaction between aquatic and terrestrial ecosystem key to the lake primary production. The lake receives about 5.1 million tonnes sediment annually from the Mekong, about 2.1 million tonnes from tributaries. The consultant team will update hydrological data in the TLS GL river basin using newly collected data including newly developed structures. Historical droughts in the TLS basin will also be collected from existing literature and relevant line agencies.

95. The Mekong River between Pakse in Lao PDR and Prek Chhlong (Below Kratie) runs more or less in North South direction through a rocky river bed , falls and rapids, after Prek Chhlong turns in sharp right angle in east west direction until Stung Trong change direction again in north slightly west direction until Kampong Cham again in east west direction, passing through the ancient volcanic region around Kampong Cham and change again two more times but for a shorter distance until it meets the Tonle Sap at Phnom Penh. From Kratie downwards it runs through the alluvial plain with numerous mobile islands. Below Kampong Cham it moves from its ancient course, the Tonle Tauch westward[4]. The Tonle Sap is not the only connection between the Mekong and the TLS GL. Currently during flood period some 5% on average of the Mekong flow bypasses the Chaktomuk junction as overland flow through a number of fragmented ancient channels such as the Prek Muk Kampul, Prek Rokar Kong, Prek Peam Chikang etc.. The consultant team will review existing hydrological data modelling results from previous studies particularly, TSLV, WUP JICA and FMMP-C2 Focal areas as well as

[4] Two scientific programmes of "Tonle Sap 96 Project" in 1996 and "Tonle Sap 21 Programme" in 2000 - 2002 both lead by Shinji Tsukawaki of Kanazawa University cooperating with Department of Geology, General Department of Mineral Resources, Ministry of Industry, Mines and Energy, Kingdom of Cambodia were carried out to investigate the geological and environmental developments of the lake. As the result of both programmes, the history of the lake and related water system was concluded that the lake was born as small lakes in the central part of the Tonle Sap Basin at about 7,500 years B. P. and the present great lake was created by an environmental event which is a connetion of the lake with the Mekong River at around 5,500 years B. P by the rise and high-stand of global sea-level at the Holocene Optimum. Further, it is also pointed that the environment of the lake has been geologically and sedimentological stable since 5,500 years B.P. till the present time.

current land uses between Peam Chikang, along the Kang Chak canal to consider different diversion canal alignment options.

96. Under natural condition pre period of reservoir construction for hydropower dam and their day to day operation, the river channel modification for navigation improvement upstream and the reduction of flood storage in the Mekong-Tonle sap flood plain around the Phnom Penh areas, Mekong flood water reverse flow into the Tonle Sap Great Lake depending on the difference in water level between the Mekong at Chrouy Changvar and the Bassac at Chaktomuk triggered by the early monsoon rainfall regime. At the end of the dry season there is practically no flow out of the Tonle Sap Great Lake and the water level of the Mekong River starts to increase following the early rainfall pattern in the upstream part of the catchment building the difference in water level at Chroui Chanvar and the lake marking the date of the reverse flow each year. Above Kratie, the Mekong water is contained between its river banks, below Kratie when water level reaches 18.0 m at Kratie station, flood water starts to overspill the river banks to refill depressions in the flood plains. Below Kampong Cham, when the discharge reaches about 30,000 m^3/s, the limit of the conveyance capacity of the Mekong-Tonle Sap-Bassac rivers downstream, flood water starts flowing overbank into the flood plains behind the left and right bank of the rivers (backwater effect start to influence the Mekong flow).

97. In Cambodia, early crop rice growing areas are steadily expanding into the deep flooded areas or at the Cambodia/Vietnam border, the lowest areas of the Mekong flood plain (see map in figure 2,3 and 4) due to the relative easy access to water sources facilitated by new irrigation infrastructure investment projects. According to crop calendar for early crop in these areas, the harvest time is generally before 1st August. Early flood that occurs before this date cause damages to crop such as the case of 2011 floods (see maps in figure 4). To reduce risk[5] of crop damage it could be conceived that peaks of the early flood could be diverted to the TLS GL for early flood control. The early flood particularly during the flood transition period is of particular importance for fishery production. It is expected that Hydropower operation upstream will smooth out the hydrograph, reducing the flood pulse effect (see section 2.8). The full control diversion would help to timely adjust the reverse flow and timely expand the flooded area and stimulates the interaction between aquatic and terrestrial ecosystem, key to fishery productivity of the TLS GL. The diversion would also provide additional migration route of fish larva[6] to reach the TLS Great Lake earlier and providing better chance of their success as well during the migration back at the end of the dry season. The full control during the outflow would make the released water available for crop production within the southeastern part of the lake areas and the downstream area of

[5] Under intensive early rice cropping, unit investment is rather high up to US$ 1,000 or more for inputs such as seeds, fertilizer, pesticide, water fee, labors etc.

[6] Spawning areas of major migratory species are located in major deep pools along the Mekong and its major tributaries above Kratie (Sekong, Sesan and Sre Pok)

the flood plain as well as to combat salinity intrusion in the Mekong Delta part of Vietnam. There will be also possibility for electricity production for some period of time on the Tonle Sap River as well during the reverse and outflow to the lake. Depending on the design, the diversion and operation options.

The effectiveness of flow diversion to Tonle Sap from midway Kampong Cham-Phnom Penh (Angkor Ban area) to the Lake will be investigated for two variants:

a full controlled diversion, and

an uncontrolled diversion

98. For this purpose, a water balance model will be applied for the stretch of the Mekong between Kampong Cham and Phnom Penh will be developed (see appendix 1), including Tonle Sap River and TLS GL and a diversion canal from the Mekong to the Lake, see figure 11. In the controlled mode, the diversion is operated in such that the flow downstream

of Phnom Penh does not exceed the capacity of the Mekong and Bassac, set at 30,000 m^3/s during the early flood period, before 1st of August. Limits are further set to the diversion capacity, and Tonle Sap River capacity (10,000 $^{m3}/s$) and the Tonle Sap maximum volume (83. BCM i.e. equivalent to a Lake level of 11.0 m amsl). The model run for 100 historical flood seasons, see Annex 1

99. The simple mass balance model for the Mekong delta will be computed. The modelled area covers the Mekong River downstream of Kampong Cham, the Tonle Sap River and the Tonle Sap Great Lake. Furthermore it contains a possible diversion channel from the Mekong River (between Kampong Cham and Phnom Penh) to the Tonle Sap Lake. This shortcut is considered for the following reasons:

- to limit the flows in the Mekong River downstream of Phnom Penh in the early flood season (June - August) to prevent farmlands with unharvested crops being flooded, and
- to increase earlier the water content of the lake, which has the following benefits:
    - To earlier increase wet surface area of the lake, which helps to mitigate impacts of up stream's developments on flood pulse that affect fish ecosystem in the lake.
    - To increased water availability in the dry season for agricultural use downstream through controlled release and also relieve salinity intrusion "flushing" in Mekong Delta of in Vietnam.
- The study can also support transboundary peak flood management

100. A period of 100 years will be simulated with the model to quantify the effects this diversion channel will have on discharges, water levels and water distribution in the

system. The main boundary condition of the model consists of historical daily discharges in the Mekong at Kampong Cham over the period 1910-2016, for the same period, discharges of relevant tributaries.

The ISIS hydrodynamic model will also be used to verify the result in a broader context of early flood conditions in the TLS GL- Mekong flood plains or even to replace the WB model.

3.3.2. Proposed activities for output 3

101. Review of existing studies, concept, methodologies on flow diversion and existing major infrastructure related to water resources and land use management

1 Develop scenarios, criteria, options for flow diversion including requirement for infrastructure operation and maintenance

2 Develop simplified water balance model for flow diversion for testing for optimum diversion capacity according to set criteria for fishery and early rice crop protection (see annex 1) or apply the ISIS model runs if it could provide better results.

3. Report on early flood success versus set criteria (before 1st August)

4. Test run ISIS hydrodynamic model for comprehensive Integrated Flood Risk and Integrated Water Resources Development and Management in the Mekong Delta to include important river branches (Tonle Tauch, Kampong Trabek and Stung Slaut)

6 Comprehensive report on future institution and capacity building needs for sustainable flood management activiti 6 Comprehensive report on future institution and capacity building needs for sustainable flood management activities

3.4.1. OUTPUT 4: Proposed diversion hydraulic and structural design

102. Under natural condition the Mekong flood water starts to spill over its banks when the discharge at Kampong Cham surpasses 30,000 m^3/s almost equally distributed to the left and to the right banks, through existing natural or man-made channels (colmatage canals). From the total maximum volume of the TLS GL of 87.3 km^3, (57-60%) is supplied by the Mekong reverse flow through the Tonle Sap River and an estimated 5% bypasses the Chaktomuk junction, through a series of flood plains consisting of dead river branches interconnected during high flood flowing through 26 water crossing bridges of the RN 6A and 4 bridges on the RN6. These flows join some small left banks tributaries of the Tonle Sap discharging to the Tonle Sap River namely the Stung Snguot, and eastern tributaries of the TLS GL Stung Chinit and the Stung Sen.The Spean Tras on RN6 is the main overland flow connecting channel. Particular characteristic of the eastern tributaries of the TLS GL are the sudden change of the course, the Stung Sen and Stung Chinit, both change their course from north south direction to east west direction at a right angle at an altitude of about 30m amsl

98 The full bank capacity of the Lower Mekong-Bassac and Tonle Sap River is about 30,000 m^3/s, above this limit flood water will spill over into the flood plain and can cause damages to early crop (May-July) areas. Under the effect of southwest monsoon, local annual precipitation and flow distribution is generally bimodal. The first peak rainfall and river flow occurs generally in July/August and the second peak in September/October. The second flood peak is generally very powerful on average surpassing 40,000 m^3/s at Phnom Penh. Flood control plans in the Mekong Delta started with the establishment of the Mekong Committee (Committee for Coordination of Investigation in the Lower Mekong Basin, MC in 1957), former MRC. In the plan (1960-1997) large hydropower reservoir such as Luong Prabang, Pa Mong, Stung Treng, and Sambor will be used to mitigate flood in addition to their function to produce electricity, irrigation water supply and navigation. The TLS barrage was also included in the flood control scheme to regulate the Mekong Peak flood but the impact on fisheries was a major concern by that time. The project was abandoned after the establishment of the Mekong Agreement in 1995. During that period, China has begun implementing its cascade hydropower dam in the Lancang part of the Mekong River, and Vietnam has begun implementing its Mekong Delta Master Plan in 1992. The cascade hydropower in China has opened opportunities for mainstream runoff river hydropower types in the Lower Makong Basin. Currently there are 11 planned and under construction including the Sambor project. The conceptual design of hydropower mainstream dam has shifted from the early period design given significant focus on sustainable hydropower development emphasizing on more rigid environmental assessment particularly on fish migration.

Recently, under the MRC Flood risk management planning under FMMP-C2 following previous Flood Control Studies financed by Koica, flood diversion to the Tonle Sap Great Lake has been taken into consideration again seen that the TLS GL is the only reservoir that can help to mitigate flood. The objective of the study was:

- to limit the flows in the Mekong river downstream of Phnom Penh in the early flood season (June - August) to prevent farmlands with unharvested crops being flooded, and
- to speed up the early filling of the lake, which has the following benefits:
- to increased wet surface area, to speed up the interaction between aquatic and terrestrial which is of primary importance for the primary production of the TLS GL ecosystem.
- increased water availability in the dry season, which can be beneficial for farmland and “flushing” the delta for desalinisation purposes.

103. Integrated Flood Management (IFM) addresses issues of human security and sustainable development from a perspective of flood management, within the framework of Integrated Water Resources Management (IWRM). Some of the underlying causes that make it difficult to integrate the growing concerns regarding environmental degradation into sound flood management practices revolve around communication

gaps between the various discipline groups involved – understanding the varying perspectives of sustainable development. The IFM approach with special reference to environmental aspects is an attempt to narrow understanding gap between discipline groups. It is important for flood managers to understand the range of environmental issues involved in flood management. And at the same time to provide useful information for policy makers, environmental groups, NGOs and communities, to help them assess flood risks in relation to environmental concerns and sustainable development.

104. There are no universal criteria to determine environmentally friendly flood management practices. It is crucial to adopt practices that suit the particular circumstances in a given hydro-climatic, topographical and socio-economic setting and follow a rational and balanced approach in addressing environmental issues in flood management.

3.4.2. The activities required to address the feasibility of the diversion will include the following:

1. Conduct field survey for selection of appropriate site and type for diversion infrastructure, main diversion canal alignment, appropriate outlet options, type and location including appurtenant structures
2. Prepare conceptual design of proposed water management infrastructures based on results from modelling studies and field surveys (controlled inlet/outlet structure, diversion canal, and appurtenant structures;
3. Assist PMU in preparing detail topographical, soil, and geotechnical survey plan, Supervise data collection process, evaluate collected data
4. Conduct detail hydraulic and structural design of proposed infrastructures
5. Conduct the BoQ computation and preliminary conceptual drawing

3.5.1. OUTPUT 5: Preliminary Socio economic analysis in the Areas covering the diversion structures and pilot areas for early flood protection studies

105. Over 5 million people live in the floodplains of the Tonle Sap Lake and the Mekong delta part of Cambodia (Keskinen et al. 2011 and CNMC, BDP2, 2010). Most of Cambodia's population is heavily dependent on natural resources for their livelihood, in which Tonle Sap has an important role: it has been estimated that around half of the country's population benefits directly or indirectly from the lake's natural resources (Keskinen 2006). In Tonle Sap, the poor, landless and unemployed people are most dependent on the natural resources (Noble and Vang 2008).

Livelihoods of the rural people living around the Tonle Sap Lake are closely connected to the hydrological cycle of the lake (Keskinen 2006). The population seems to be adapted to the exceptional water regime rather than having control of it. The flood peak is actually followed by a similar peak in the level of livelihoods. This can be explained for example by the increase in fish stocks due to fish migration, and by the harvest of rice, which takes place a few months after the flooding has started. According to Keskinen

(2006), the primary livelihoods are surprisingly uniform within rural villages. This increases the vulnerability of people, because sudden changes in access to the primary livelihood can lead to an unsustainable load on the secondary livelihoods. The provincial capitals of the six provinces surrounding the lake are located by the National Roads 5 and 6. The population density there is high compared to the rural areas, the variety and level of livelihoods are higher and the dependence on the lake's natural resources is lower (Keskinen, 2006).

106. The population is growing rapidly in Tonle Sap, mostly in the agricultural zone and in some provinces like Siem Reap in the urban centers. The growth is weakest in the fishing zone, both proportionally and in absolute numbers. The biggest age group is now entering the work force, which could positively affect the economic development. The education rate of the population increased significantly between 1998 and 2008, but was still low in 2008. Especially the share of the population attending secondary, technical or higher education is very low. Education rate is clearly higher in the urban areas compared to the rural areas. The literacy rate increased substantially and was 79 % in 2008.

107. The share of working population engaged in agriculture and fishing is declining, mostly in the urban areas of Tonle Sap. However, the absolute amount of people working in the sector is growing due to population growth, meaning that more people are exploiting the common natural resources. In the fishing zone, the share of population engaged in those livelihood activities actually grew. Additionally, it seems that catching fish or shrimp is an increasing secondary livelihood activity also in the urban zone. The most rapidly growing industry sectors are construction, hotels & restaurants and real estate & renting. The fastest growing agricultural livelihood activity in both rural and urban areas was collecting or hunting food.

Fewer households owned land in 2007 than in 2004, but the average area of land was a little bit bigger. Land ownership thus seems to be concentrating in certain provinces and in hands of fewer owners. Irrigation at land plots is becoming increasingly common.

108. There are numerous private flood storage reservoirs for recession rice cropping recently built in the area between the Tonle Sap entrance and the Mekong right bank. The consultant team will assess the current socio economic in the area (Peam Chikang, Batheay, Prek Kdam district using existing socio economic data from the provincial and district data books. Group interview will be organized to discuss the preference of local communities on the development of water resources in this region. It is expected that the diversion flow will reduce risk of early flooding in the area as well. Access to water will be improved whole year round not only for agriculture but also aquaculture and livestock, including improvement of access to cheaper transportation mean through the diversion canal. With control water release from the TLS GL, water availability will be extended for some more months that could be accessible for people around the diversion canal. The controlled release of water from the Tonle Sap Barrage would also benefit water access downstream.

109. The flood plain area between Kampong Cham, RN6/RN7 and the Mekong right bank is consisting of series of ancient remnant of volcanic lakes overlay the Neogene-Quaternary basalts. Land use is this region varies from seasonal subsistence rice cropping area (subject to flooding during wet season) near to lakes area and orchard or more permanent fruit trees are in expansion. Rice cropping are also in expansion towards lower land areas covering the western site of the area, particularly flood recession rice around a flood water storage reservoir. There are number of Preks running parallel to the Mekong Rivers (Prek Muk Kampul), Prek Kang Chak and Prek Roka Kong connecting series of boeungs). During flood period part of flood water flow directly to the TLS GL across the RN6 as overland flow, partly crosses the RN 6A to join the Tonle Sap River south of Prek Kdam. During wet season, fishing is also an important activity.

Early rice cropping are expanding in the Mekong-Tonle Sap-Bassac flood plains with newly developed irrigation canals that is able to promote up to three rice crop per year, but the early crop from May to July (harvest before 1 August) is subject to early flood damages.

3.5.2. Proposed activities under the output 5:

110. Based on existing updated provincial and district data books, establish preliminary socio-economic profile of the project area (Kong Meas, Batheay (Kampong Cham), ;

1.Review recent crop damage due to early flood report, review methodology for assessing flood damage and collect existing data collected by RFMMC on flood damage to assess potential damage using the 2011 for example as reference

2.Use existing literature to assess flood damages particularly early crop damages in the Mekong flood plain

3.Design questionnaire for Working Discussion Group (WDG) on potential benefit and impact of proposed projects for different communities (fisherman, cash crop grower, rice farmers, services sectors) in the project areas (District Batheay and Kang Meas of Kampong Cham;. Chol Kiri District and Kampong Leang Districts of Kampong Chnang. And Koh Andeth and Boeri Chulsa of Takeo, selecteddistrict of Kandal and Prey Veng.

4. Preliminary potential cost benefit analysis of the early flood diversion focusing on agricultural sector.

3.6.1. OUTPUT 6: Proposed strategic Direction for the flood plain development and management

Governance framework

112. Water resources in the Mekong-Tonle Sap Lake and flood plains are very complex and of vital economic, ecological and environmental values to the country. Its

management needs to be based on solid institutional management framework founded on scientific data and information system through multi sectoral integration to avoid environmental cost for the next generation.

Water governance develops and sets the rules, roles and responsibilities of all stakeholders regarding the ownership, administration and management of water resources. Stakeholders include local and national governments, the private sector, civil society. Water governance is a decision-making framework, providing instruments to set rules, including laws, policies, regulations and institutional arrangements.

In Cambodia the concepts of good governance is well recognised. The core of the Rectangular Strategy III (RS), the key strategic policy and planning document of the Royal Government of Cambodian (RGC), is stated as "*Good Governance*":

Good governance remains at the core of achieving social justice and sustainable and equitable socio-economic development.

Rectangular Strategy III promotes:

- Good governance so that all the operations and functions of state institutions at both national and sub-national levels would be conducted in a transparent, accountable, predictable, effective and efficient manner; and
- Strengthening governance and capacity of public institutions in order to improve the efficiency of public service delivery and the investment climate

The NSDP 2014-2018

Policy Priorities for the Fifth Legislature

The Royal Government of the Fifth Legislature will reinforce and broaden the management of natural resources to strike a "balance between development and conservation", in particular, increase the contribution of natural resources to the development of agriculture sector by ensuring: (1) green cover, forest and wildlife conservation; (2) the sustainability of fisheries resources; and (3) the sustainability of the ecosystem, so that the quality of land and sustainability of water sources could be improved by focusing on the protection of biodiversity, wetlands and coastal areas.

To achieve this objective, the Royal Government will implement a comprehensive and cross cutting approach, aimed at improving the effectiveness and equity in the exploitation of natural resources, by (1) clearly determining the ownership of natural resources; (2) developing an appropriate incentive scheme for the conservation of natural resources and empowering the sub-national government, communities and individuals to participate in their conservation by focusing on training, information sharing as well as strengthening social capital, and institutional accountability and transparency; and (3) stepping up cooperation with concerned stakeholders under the framework of green growth and climate change. RGC will place priority on:

Further strengthening the management and conservation of fishery resources in a sustainable manner in line with the "Strategic Planning Framework for Fisheries Sector

2010-2019" and the "Declaration on the National Policy for Fisheries Sector", especially through the suppression of all violations of laws, rules and regulations related to fisheries including tightened control of fishing gears and fishing period, elimination of overfishing, strengthening fishing communities' capacity for the management, use and conservation of fisheries resources, protection of biodiversity and aquatic-animal habitats, control of freshwater and seawater quality through pollution minimization, protection and replanting of flooded forests and mangroves, demarcation of flooded forest and fisheries conservation zones, development of institutional and human capacity, and preparing research studies and their dissemination.

Intensifying the implementation of necessary measures to ensure the sustainability of the ecosystem, aimed at ensuring the quality of soil, and surface and underground water for serving the agriculture sector and the livelihood of Cambodian people by promoting the preparation and effective implementation of policies and regulations, as well as related action plans and programs for the management of protected natural areas such as national parks, wildlife sanctuaries, protected landscape areas, multiple use areas, wetlands, biodiversity conservation areas, natural heritage conservation areas, and maritime parks, and in particular, strengthening the implementation of "Law on the Environmental Protection and the Management of Natural Resources", "Law on Protected Natural Areas" and "Guideline on the Development of Coastal Areas in the Kingdom of Cambodia". Stepping up cooperation with relevant development stakeholders under the framework of the "National Policy on Green Development" and the "National Strategic Plan on Green Development 2013-2030" through the development of regulatory frameworks and mechanisms for carbon trading, strengthening the capability, preparation and implementation of climate change adaptation measures, assessment of the scope of the use of environmental financing mechanisms including payment for environmental services and environmental fund, strengthening the management of protected natural areas including protection of biodiversity, rain forests, and wetland areas; and environment and ecosystem monitoring and control mechanism at both national and sub-national levels.

MOWRAM's Strategic Development Plan 2014 – 2018 sets out the investments proposed across its 5 strategic areas:

I. Water Resources Management and Development and Irrigation Expansion
II. Flood and Drought Management
III. Promote the Draft Sub-decree, Provisions for Water Sustainability
IV. Water Resources and Meteorology Information Management
V. Administration Improvement and Human Resources Development

The strategy ii, iii and iv are most relevant to this study mainly implemented by three departments of MOWRAM: the Department of Water Resources Management and Conservation (DWRMC), the Department of Hydrology and River Works (DHRW) and the Department of Hydrology (DOM). According to its mandates, the DWMC shall play key roles in water governance.

113. DWRMC of MOWRAM has many functions critical to the implementation of the Water Law, the Sub-decrees on river basin planning, licensing or water quality when approved by the RGC, and IWRM. Its internal structure has 4 Offices (Administration, Water Policies and Extension, Hydropower and Flood Control, and watershed Management).

DWRMC has a listed staff of 29 people, 8 of which participated in the TNA. These had a median age of 38, of which half were in the 40 to 49 year age group. 5 of the TNA participants had an engineering degree and 2 a Masters. 2 were female, one of whom had a degree and one was a technician.

The DMRMC receives neither government funding nor specific international support Without any operational funding the Department cannot make any progress against its mandate. MOWRAM's SEDP 2014-2028 does not record any achievement related to the mandate of this Department in the previous planning period (2009-2013), other than the drafting of 4 sub-decrees under the Law. For the period 2014-2018, the only output in MOWRAM's SEDP for this Department relates to the sub-decrees, and this is not funded. There are no outputs related to other mandates of the Department such as national water planning, river basin planning, water licensing etc.

114. The Cambodia National Mekong Committee

Cambodia National Mekong Committee (CNMC) is a governmental institution operating under the direct supervision of the Royal Government of Cambodia. Its main mission is the coordination in management, protection, conservation and development of water and other related resources in the Mekong River Basin.

The goal of CNMC is to encourage, maintain and strengthen good cooperation in the Mekong Region and improve the effectiveness in the management and development of the Mekong River in Cambodia and in the region. CNMC works towards improved sustainability of Cambodia and other countries of the Lower Mekong Basin who are members of the Mekong River Commission (MRC).

CNMC works together with other National Mekong Committees in coordinating the effective implementation of the 1995 Mekong Agreement as well as the preparation and implementation of projects and programmes under the MRC's Sustainable Development Framework for water and related resources in the Mekong River Basin.

In this study the CNMC play key coordination roles integrating all sectors involved under the same planning framework.

115. The Tonle Sap Authority (TSA) shall be responsible for facilitating affairs relating to management, conservation and development of Tonlé Sap areas as follows:

- to facilitate all activities being implemented, and to be implemented by ministries, institutions, local authorities, national and international organizations, NGOs and

civil society in the Tonlé Sap areas in order to effectively ensure their smooth operation;

- to monitor, inspect and evaluate the implementation of projects in accordance with the strategy and plans of the Royal Government;
- to act as the representative of the Royal Government in activities including meetings, negotiations and settlement of problems;
- to sign agreements, protocols and contracts upon approval of the Royal Government;
- to act as counterpart with all development partners to determine which activities are to be implemented;
- to collect, analyze, and update information and data for publication and contribution to stakeholders;
- to educate, train and promote awareness to stakeholders; and to report activities to the Royal Government.

3.6.2. Proposed activities under OUTPUT 6

1. Review existing laws and sub decrees, regulations related to Water Resources Management, Land management and Environmental Management, soil conservation, wetland ecosystems related strategies and policies of relevant sectors and agencies, particularly related to flood plain/wetland management, urban planning and transports. CNMC shall play key coordination role at regional and inter sectoral integration.

2.Review of inventories of wetland ecosystem including important river branches, lakes and their attributed function to water supply, fishery, flood control, water conservation ecosystem services, environment management and proposed cross sectoral and transboundary measures for their protection and management

3. Review of MRC's established rules of procedures and related guidelines (PNCA, PWUM, PDIES, PWQ, PMFM) and their implication to national water management system and related international law and practices for transboundary management of natural resource.

4. Fishery strategic plan, Agricultural Strategic plan, Land use management plan, their status and opportunities for integration and effectiveness;

5. Identify major opportunities to develop integrated strategies through inter sectoral cooperation for sustainably use of flood plain ecosystems resources while reducing flood/droughts risk .Inter sectoral Strategic Direction for flood and drought risk management and a balance flood plain/wetland development and management.

6.Multi sectoral Consultative workshop at Mid-term and final workshop

The main output of the study will the multi sectoral consultative workshop recommendation reports.

4. Work Plan, Deliverable and Staffs Schedule

4.1. Three phases of the assignment

114. The one year assignment is subdivided into three phases:

Phase 1: Inception phase (three months), during this phases the consultant teams collect and review, update all available data and internal and external information related to the project areas as well as consulting with stakeholders at national level on the objectives and expected outcomes of the project.

Phase 2: The phase 2 (four months) will focus on the design of the water balance model and hydrodynamic model boundary conditions, data collection for model validation and results interpretation, identify and ascertain benefit and effectiveness of fishery sector, issues and constraints, solutions, indicators to support early flood diversion infrastructures design. The same will be focusing on potential improvement on early crop intensification with identification of potential geographic areas, issues and constraints to meet full potential of the diversion. Draft development and management of the Mekong-Tonle Sap flood plain. The design works will be based on existing geographical information systems supplemented by field visits and working sessions with direct affected/beneficiary communities.

Phase 3: Consolidation of the proposed management options (three months) as well as recommendation for future investment works in the areas of data and information system supporting infrastructure investment planning and institutional strengthening. Finalization of the strategic direction

4.2. Deliverables

115. The list of deliverables and the due dates are illustrated in Table 2. The dates of the workshops are indicative and they will be finalized with the guidance of the Project Management Unit (PMU).

4.3. The preparation of production of each major report (Inception, Midterm, Draft Final, and Final) will be based on the following process:

Step 1: Preparation of Draft Report Step

Step2: Submission to PMU for Comments Step

Step3: Revision of the Report based on Comments

Step 4: Comments from Stakeholders at the Dissemination Workshop

Step 5: Preparation of Final Report based on Comments

116. The length of this process depends on the time needed by various reviewers to send their comments to the Consultants' Team. It is expected that between submission of the first draft (Step 1) and final draft of each major report, there is a period of about 3 weeks. This period will be continuously monitored to assure timely completion of the report.

Table 2: Deliverables and Dates Due

No	Deliverables	Date Due	Comments
1	Inception Report	22 March 2017	3 months after mobilization
2	Inception workshop	7 April 2017	Conducted in Kampong Cham[7]
3	Mid Term Report Conceptual flood plain management and strategy	Tentative date 15 September	Exact date to be confirmed
4	Final strategic direction of flood plain ecosystem management	7 of February 2018	Exact date to be confirmed

The deliverables, the inception report will be submitted on March 22nd 2017

4.4. Work Plan

117. The work plan for the assignment is illustrated in figure12 below.

[77] The workshop report is attached in appendix…

Figure 12: Work Plan for Mekong-Tonle Sap Linkage Assignment

OUTPUTS AND ACTIVITIES	2017												
	INCEPTION PHASE			DEVELOPMENT PHASE									
	1	2	3	4	5	6	7	8	9	10	11	12	13
	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
OUTPUT 1: Assessment report on status of knowledge data and information of the Mekong – Tonle Sap Great Lake and flood plains													
1) Review of existing hydrological studies in the LMB and in Cambodia to update characteristics of the flow regimes in rivers and in the flood plain													
2) Updates water level and discharge data on the Mekong-Tonle Sap –Bassac stations and tributaries around the Tonle Sap Great Lake with new rating curves where are available;													
3) Based on MRC updated scenarios assessment summarise upstream development impacts on flow regime change on the Mekong, Tonle Sap and flood plain including sediment transport (quantitative);													
4)Provide summary report to be used as basic reference for strategic direction for IFRM and IWRM sustainable development and management of the Mekong-TLSGL flood plains;													
OUTPUT 2: Report on the Assessment of the Mekong, TLS Great Lake, Mekong Flood Plain Ecosystem, upstream and local development impacts on fisheries, agriculture and wetland ecosystem as a whole													
1) Provision of a comprehensive description of the TLS GL, morphology, past and present environmental change, connection with the Mekong, trends													
2) Provision of a comprehensive report on the function of the TLS GL ecosystem function, its adaptation to seasonal, inter-annual and climatic variability, expected magnitude of impacts from upstream and local development													
3) Provision of a comprehensive report on flow regime change on fish migration of white and grey species with possible mitigation measures (structural and non-structural)													
4) Provision of a comprehensive report on process of fish migration between the Mekong ant Tonle Sap Great Lake													
5) Review existing EIA on impact assessment of infrastructures on fishery, identify the shortcoming and propose improvement to be included in the strategies.													
OUTPUT 3: Assessment of hydraulic feasibility for Early Flood Diversion from the Mekong to the Tonle Sap Great Lake													
1) Develop scenarios, criteria, options for flow diversion including requirement for infrastructure operation and maintenance													
2) Develop simplified water balance model for flow diversion for testing for optimum diversion capacity according to set criteria for fishery and early rice crop protection (see annex 1) or apply the ISIS model runs if it could provide better results.													
3) Report on early flood success versus set criteria (before 1st August)													
4) Test run ISIS hydrodynamic model for comprehensive Integrated Flood Risk and Integrated Water Resources Development and Management in the Mekong Delta to include important river branches (Tonle Tauch, Kampong Trabek and Stung Slaut)													
5) Propose standard procedures for infrastructure operation and mainte													
6) Comprehensive report on future institution and capacity building needs for sustainable flood management activiti													
OUTPUT 4: Proposed diversion hydraulic and structural design													
1) Conduct field survey for selection of appropriate site and type for diversion infrastructure, main diversion canal alignment, appropriate outlet options, type and location including appurtenant structures													
2) Prepare conceptual design of proposed water management infrastructures based on results from modelling studies and field surveys (controlled inlet/outlet structure, diversion canal, and appurtenant structures;													
3) Assist PMU in preparing detail topographical, soil, and geotechnical survey plan, Supervise data collection process, evaluate collected data													
4) Conduct detail hydraulic and structural design of proposed infrastructures													
5. Conduct the BoQ computation and preliminary conceptual drawing													
OUTPUT 5: Preliminary Socio economic analysis in the Areas covering the diversion structures and pilot areas for early flood protection studies													
1)Review recent crop damage due to early flood report, review methodology for assessing flood damage and collect existing data collected by RFMMC on flood damage to assess potential damage using the 2011 for example as reference													
2)Use existing literature to assess flood damages particularly early crop damages in the Mekong flood plain													
3) Design questionnaire for Working Discussion Group (WDG) on potential benefit and impact of proposed projects for different communities (fisherman, cash crop grower, rice farmers, services sectors) in the project areas (District Batheay and Kang Meas of Kampong Cham, Chol Kiri District and Kampong Leang Districts of Kampong Chnang. And Koh Andeth and Boeri Chulsa of Takeo, selecteddistrict of Kandal and Prey Veng.													
4) Preliminary potential cost benefit analysis of the early flood diversion focusing on agricultural sector.													
OUTPUT 6: Proposed strategic Direction for the flood plain development and management													
1) Review existing laws and sub decrees, regulations related to Water Resources Management, Land management and Environmental Management, soil conservation, wetland ecosystems related strategies and policies of relevant sectors and agencies, particularly related to flood plain/wetland management, urban planning and transports. CNMC shall play key coordination role at regional and inter sectoral integration.													
2) Review of inventories of wetland ecosystem including important river branches, lakes and their attributed function to water supply, fishery, flood control, water conservation ecosystem services, environment management and proposed cross sectoral and transboundary measures for their protection and management													
3) Review of MRC's established rules of procedures and related guidelines (PNCA, PWUM, PDIES, PWQ, PMFM) and their implication to national water management system and related international law and practices for transboundary management of natural resource.													
4) Fishery strategic plan, Agricultural Strategic plan, Land use management plan, their status and opportunities for integration and effectiveness;													
5) Identify major opportunities to develop integrated strategies through inter sectoral cooperation for sustainably use of flood plain ecosystems resources while reducing flood/droughts risk .Inter sectoral Strategic Direction for flood and drought risk management and a balance flood plain/wetland development and management.													
6) Multi sectoral Consultative workshop at Mid-term and final workshop													
Consultative p/Mid term and Fnal Workshops	30-Mar	07-Apr					**15-Sep**					07-Feb-18	

4.5. Personnel schedule and Inputs

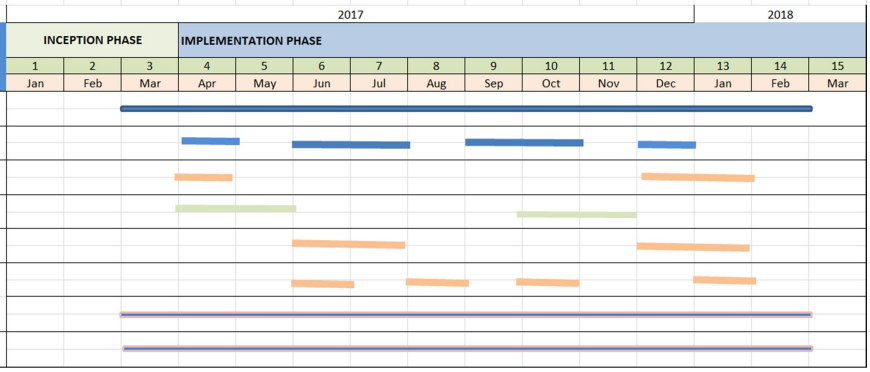
118. The personnel schedule of the MK-TLS_LINK Consultant team is illustrated Figure 13 All the five national consultants are expected to work in Phnom Penh and

their input is intermittent. They are all based (Figure 13) with frequent visits to project sites in the Mekong Delta and Tonle Sap region..

Figure 13: List of personnel and schedules

Figure 13: Staff Schedules

Names	Position	Person Month
Saing Im Sok	Team Leader	12
Tes Sopharith	Hydrologist/Hdraulic modelling specialist	6
Dr. Mak Solieng	Socio-economic Specialist	3
Dr. Chheng Phen	Fishery Ecosystem Specialist	4
El Reasei	Hydraulic Infrastructure Specilst	4
Sou Virak	GIS /CAD specialist	4
Heng Chamnan	Financial specialist	12
Chan Sopanha Hang	Project Assistant	12



4.6. Comment on the TOR and scope of the assignment

Limited input and timeframe, this assignment at best achievable outcome would be identification of issues related to national fishery, wetland of the Mekong- Tonle Sap technical, legal and institutional tools for their sustainable use and management. The achievable outputs would be the improved understanding of all required and complex interlinkage between different branches of development, management sectors and sciences as well as institutional capacity at national and regional level.

Related to physical infrastructures, only diversion options with respect to type of structures, conveyance capacity (optimum) could be explored as well as canal alignment (intake and outlet locations), preliminary bill of quantity etc. The Barrage on the Tonle Sap is a major undertaking that could include hydropower, navigation and complex fish pass installation. The consultant team can only assume that the barrage shall be built.

The social and environmental aspect will be limited only on the beneficial aspect of the project and will leave out the resettlement and environmental impact assessment for future detail project feasibility study.

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6. GLOSSARY

1995 Mekong Agreement	Agreement on the Cooperation for the Sustainable Development of the Mekong River Basin entered into by the MRC Member Countries on 5 April 1995. The Agreement sets out the goals, objectives and principles as well as the scope of this cooperation. It establishes the Mekong River Commission as the inter-governmental organization with the mandate to implement the Agreement and the projects, programmes and activities taken thereunder in cooperation and coordination with each member and the international community, and to address and solve related issues and problems.
Basin Development Plan	In accordance with the 1995 Mekong Agreement, it is the general planning tool and process that the Joint Committee would use as a blueprint to identify, categorize and prioritize the projects and programs to seek assistance for and to implement at the basin level.
Basin Development Strategy	The Mekong basin-wide IWRM-based strategy setting out shared understanding of development opportunities and risks for national implementation, medium term Strategic Priorities for basin development and management, and Strategic Actions required to be undertaken in the ensuing 5-year plan period.
Delta	A landform that forms from deposition of sediment carried by a river as the flow leaves its mouth and enters slower-moving or standing water. This occurs where a river enters an ocean, sea, estuary, lake, reservoir, or (more rarely) another river that cannot transport away the supplied sediment. River deltas are ecologically important as they provide coastline defense, are home to many species, and can impact drinking water supply.[1]
Early rice crop production	Early rice crop is short duration variety growing in lowland areas depending on early rainfall and supplement irrigation (June to end July)
Early flood	Generally the Mekong flood has two peaks (bimodal), the first peak in June July, the second peak, the annual flood peak in August-Sptember
Environment assets	Naturally occurring areas that provides environmental “functions” or services
Fisheries ecosystem	A geographically specified system of organisms (including humans), and the environment and the processes that control its dynamics
Flood	An overflow of a large amount of water beyond its normal limits, especially over what is normally dry land
Flood hazard	Is **defined** as the area that will be inundated by the **flood** event having a 1-percent chance of being equaled or exceeded in any given year.
Flood diversion	Is a flood management measure to manage flood by channeling part of the flow from the area at risk to prevent flooding
Flood plains or floodplains	An area of land adjacent to a stream or river that stretches from the banks of its channel to the base of the enclosing valley walls and experiences flooding during periods of high discharge.[1] It includes the floodway, which consists of the stream channel and adjacent areas that actively carry flood flows downstream, and the **flood fringe**, which are areas inundated by the flood, but which do not experience a strong current. In other words, a floodplain is an area near a river or a stream which floods when the water level reaches flood stage.
Flood risks	Risk is a combination of probability and consequences. The consequences may be victims and damage to homes, businesses and nature.
Integrated Water resources management (IWRM)	Integrated Water Resources Management (IWRM) is a process that promotes the coordinated development and management of water, land and related resources, in order to maximize economic and social welfare in a balanced way without compromising the sustainability of the ecosystems. IWRM is not an end in itself but a means of achieving three

	key strategic objectives of: Efficiency (attempt to maximize the economand social welfare derived not only from the water resources base but also from investments in water service provision), Equity (in the allocation of scarce water resources and services across different economic and social groups) and Sustainability (as the water resources base and associated ecosystems are finite).
Flow	Amount of water flowing through a river cross section within a unit time (second)
Modeling	**Hydrologic models** are conceptual representation of a part of the hydrological cycle. They are primarily used for hydrologic prediction and for understanding of hydrological process. A **hydraulic model** is a mathematical **model** of a water/sewer/storm system and is used to analyse the system's **hydraulic** behaviour.
MRC Procedures	The 1995 Mekong Agreement is a dynamic "framework agreement" that enables and requires the MRC to adopt and refine as needed, rules and procedures to carry out its work in close cooperation and coordination with relevant agencies and peoples of the Member Countries. It identifies key activities and mechanisms that support the sustainable equitable use, utilisation and protection of the Mekong's water and water related resources for Member CountriesThe 1995 Mekong Agreement is a dynamic "framework agreement" that enables and requires the MRC to adopt and refine as needed, rules and procedures to carry out its work in close cooperation and coordination with relevant agencies and peoples of the Member Countries. It identifies key activities and mechanisms that support the sustainable equitable use, utilisation and protection of the Mekong's water and water related resources for Member Countries (5 procedures have been established)
Strategic direction	A course of action that leads to the achievement of the goals of an organization's strategy.
Sediment	A naturally occurring material that is broken down by processes of weathering and erosion, and is subsequently transported by the action of wind, water, or ice, and/or by the force of gravity acting on the particles. For example, sand and silt can be carried in suspension in river water and on reaching the sea be deposited by sedimentation and if buried this may eventually become sandstone and siltstone,
Wetland	According to the Ramsar Convention on Wetlands: "Wetlands are areas of marsh, fen, peat-land or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres." In the BDS, loss of natural wetlands is referring to their conversion into paddy fields, farms, residential areas, etc.

7. APPENDIXES

7.1. APENDIX 1: Flow Diversion to Tonle Sap Lake

1 Model description

1.1. Model with full diversion control

Model with fully controlled diversion channel Figure 1 shows a schematic view of the modelled area. On the right it shows Kampong Cham which is the main upstream boundary of the model. For this location a discharge series over the period 1910-2006 is available. This series is derived from observed discharges in Stung Treng and discharges of the two main tributaries between Stung Treng and Kampong Cham: Prek Chhlong and Prek Te. Furthermore, the combined flow of the tributaries of the Tonle Sap lake (not including the Tonle Sap River) is taken into account.

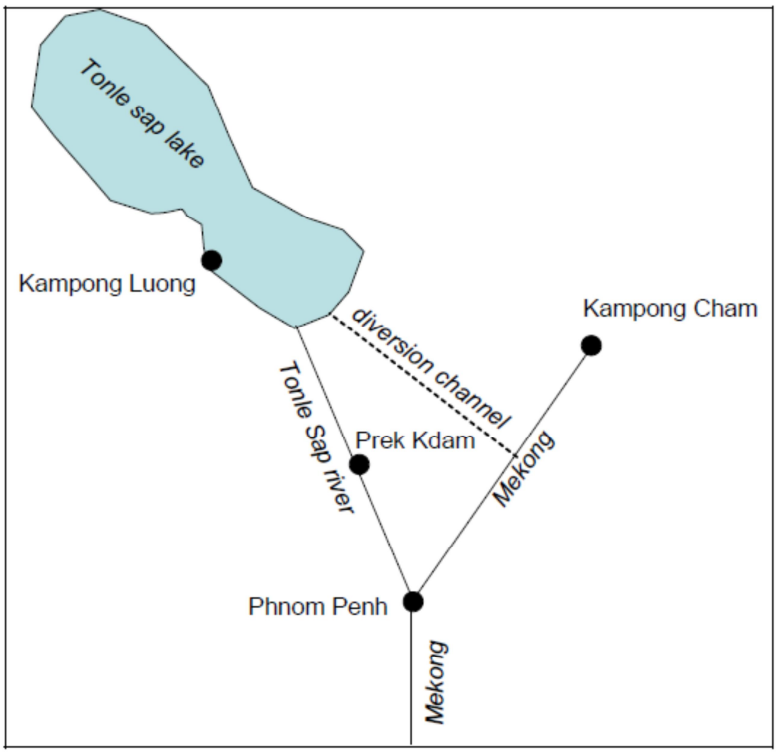

Figure 1: Schematic view of the study area

symbols:

Q_{KC} : Mekong river discharge at Kampong Cham [m^3/s]

Q_{div} : flow through the diversion channel [m^3/s]

Q_{PP} : Mekong river discharge upstream of Phnom Penh [m^3/s]

Q_{delta}: Mekong river discharge downstream of Phnom Penh [m^3/s]

Q_{TLS}: flow through the Tonle Sap river (positive direction towards the lake) [m^3/s]

Q_{trib} : combined flow of tributaries of Tonle Sap lake [m^3/s]

h_{KC}: water level in the Mekong river at Kampong Cham [m+MSL]

h_{div}: water level in the Mekong at offtake diversion channel [m+MSL]

h_{PP}: water level in the Mekong river at Phnom Penh [m+MSL]

h_{PK}: water level in the Tonle Sap river at Prek Kdam [m+MSL]

h_{KL}: water level in the lake at Kampung Luong [m+MSL]

A_{lake}: surface area of the Tonle Sap lake [km^2]

V_{lake}: volume of the Tonle Sap lake [BCM]

Note that the flow in the Tonle Sap river can be in both directions. A positive value of QTLS means that water is flowing towards the lake, a negative value means the water is flowing from the lake towards Phnom Penh. Besides flows and water levels there are some capacity limitations that play a vital role in the model:

The model will be described with the symbols as introduced above. The first equation describes the mass balance at the off-take between Kampong Cham and Phnom Penh:

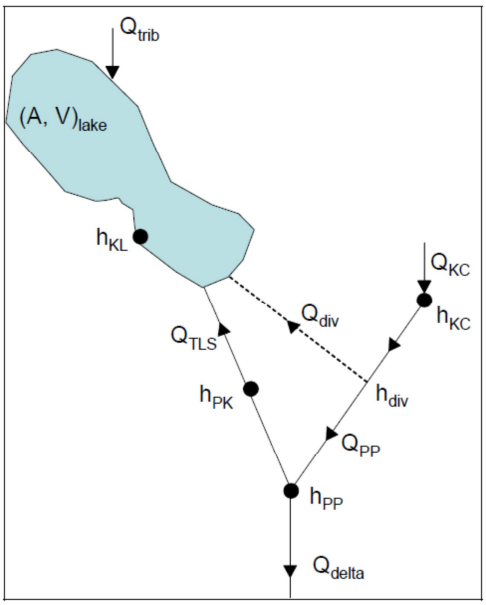

Figure 2: Schematic view of flows and water levels in the study areas

$$Q_{KC} = Q_{PP} + Q_{div} \quad (2.1)$$

The following equation describes the mass balance at Phnom Penh:

$$Q_{PP} = Q_{TLS} + Q_{delta} \quad (2.2)$$

The mass balance of the lake is as follows:

$$\Delta V = k[\, Q_{TLS} + Q_{div} + Q_{trib} \,] \quad (2.3)$$

where Δ means “increase of”. Factor k is introduced to convert discharges, expressed in m3/s, to volume, expressed in BCM. This means k equals:

$$k = \frac{86400}{10^9} \quad (2.4)$$

The value of the numerator in eq. (2.4) is the number of seconds in a day, required because the model simulations are performed on the daily time scale.

The flow in the diversion channel is assumed to be fully controlled. It will be controlled in such a way that the discharge downstream of Phnom Penh will not exceed its flood free capacity, Cdelta:

$$Q_{delta} \leq C_{delta} \quad (2.5)$$

The combination of eqs (2.1), (2.2) and (2.5) gives:

$$Q_{KC} - Q_{div} - Q_{TLS} \leq C_{delta} \qquad Q_{div} \geq Q_{KC} - Q_{TLS} - C_{delta} \quad (2.6)$$

Eq (2.6) can be considered as the operation rule for the diversion channel. In the simulations the value of Cdelta is set equal to 30,000 m^3/s. This is approximately the flow capacity of the Mekong River, downstream of Phnom Penh.

Note that eq. (2.5) and (2.6) may not hold at all times. During periods of (extremely) high flows the capacities of the diversion channel and the lake may be insufficient to divert and store the desired amount of flow, which means the flow downstream of Phnom Penh will exceed Cdelta and floods will occur. One of the main outputs of the simulations as presented in Chapter 3 is the frequency with which these undesired events occur.

According to Forsius (2007) the flow (discharge and direction) in the Tonle Sap River is determined by the water levels in Prek Kdam, Kampong Luong and Phnom Penh:

$Q_{TLS} = -8.581f^2\ (h) + 691.35f(h); hpp \geq hKL$

$Q_{TLS} = -6.608\ f^2(h) - 476.21f\ (h); hpp\ \leq hKL$

With

$$f(h) = hpk^{1.2}\ (hpp - hKL)^{0.5} \quad (2.7)$$

This means the water levels in these three locations need to be derived from the flow conditions and, in case of Kampong Luong, the volume of the lake. The relation between the lake volume and the water level at Kampong Luong is as follows:

$$hKL = \frac{0.3\ 13\ 7 + \sqrt{(0.03\ 13\ 7)^2 - 4 * 0.7\ 3\ 248 * (0.6857\ 8 - \text{Vlake})}}{2 * 0.7\ 3\ 248} \quad (2.8)$$

The water level at Phnom Penh is related to the water level at Kampong Cham, as can be seen in Figure .3:

$h_{pp} = 0.62h_{KC} - 0.34$ (2.9)

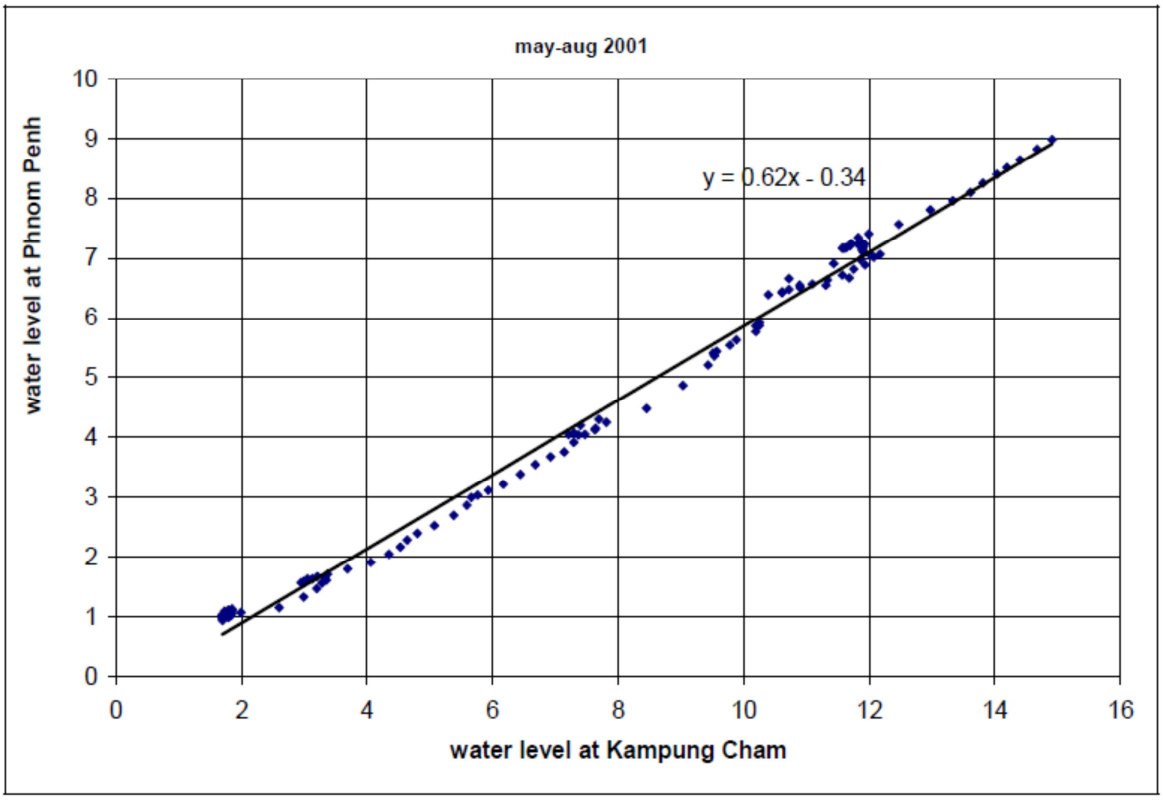

Figure 3: Water level at Phnom Penh as function of water level at Kampong Cham

With regard to eq. (2.9) it has to be emphasised that • this relation only holds for the early flood season, i.e. from May until August; • this relation is derived for the current situation, i.e. without diversion channel.

For Kampong Cham there is a stage-discharge relation available:

$$hKC\ *= \left(\frac{QKC*}{28.42}\right)^{\left(\frac{1}{2.620}\right)} - 3.91 \qquad (2.10)$$

The reason to use the asterisk (*) is because the combination of eqs (2.9) and (2.10) only holds for the current situation without flow diversion. If the flow diversion channel is realized and used, part of the flow in Kampong Cham will not reach Phnom Penh. Therefore, the water level of Kampong Cham will be related to the remainder of the flow:

$$hKC = \left(\frac{Qpp}{28.42}\right)^{\left(\frac{1}{2.620}\right)} - 3.91 \qquad (2.11)$$

Even though this does not represent the real water level at Kampong Cham, this relation suffices for the model since it is only used to derive the water level at Phnom Penh through the combination of eqs (2.9) and (2.11).

The water level at Prek Kdam is assumed to be the mean of the water level at Kampong Luong and the water level at Phnom Penh:

$$hPk = 0.5 * (hpp + hKL) \quad (2.12)$$

Furthermore, the water level at the off-take of the diversion channel, hdiv, is required to know the head of the diversion channel. This water level is derived from linear interpolation between the water levels at Kampong Cham and Phnom Penh, based on the distance to those two locations:

$$hdiv = 0.4hpp + 0.6hKC \quad (2.13)$$

Finally, there is a relation between the wet surface area of the lake and the water level at Kampong Luong:

$$Alake = 30.053hKL^2 + 109419hKL + 716.65 \quad (2.14)$$

Equation (2.14) does not influence the state of any of the other variables. The reason why it is shown here is that the wet surface area is one of the relevant outputs of the simulations, because this area influences the fish population.

2. 2. Model with uncontrolled Channel

In case of an uncontrolled diversion channel, the off-take acts as a fixed weir on the right bank of the Mekong river. The following dimensions and flow parameters have been applied:

Channel width: 2500 [m]

Discharge coefficient: 1.85 (m1/2/s]

Level of the sill: 8.0 [m+MSL] Weir formula exponent: 1.5 [-]

The flow into the diversion channel is then equal to:

Q_{div} = 0 hdiv ≤ 8.0m

$$Qdiv = 2500 * (hdiv - 8.0)^{1.5}$$ hdiv ≥ 8.0m

APPENDIX 2: Terms of Reference of Consultants

Attachment C

TERMS OF REFERENCE OF KEY PROJECT CONTRACTED PERSONNEL

TERMS OF REFERENCE

Position Title: Flood plain Development and Management Planning Specialist

Job Level: Team Leader

Duty Station: Phnom Penh, Cambodia

Report to: MOWRAM Project Director

Responsibilities: The Flood Plain Development and Management Specialist/Team Leader will be responsible for overall project management and delivery of the define task as below. He/she will be based in Phnom Penh at the Project Management Unit and might be required to travel frequently to the project area.

Specifically the candidate will be responsible for the following scope of work:

(i) Coordinate with the project owner and relevant stakeholders such as the Fishery Administration, Ministry of Agriculture, Fishery and Fishery, Ministry of Public works, Ministry of Land Management Urban Planning and Construction, the CNMC and Development Partners;
(ii) Review all documents related to the projects specifically existing documents related to the previous studies at national and regional level (MRC) level; national legal framework related to national water plan (water law), the MRC rules and procedures for water sharing;
(iii) Exploring possible options and propose the best options for early flood management, dry season water supplies and optimal fish migration conditions;
(iv) Review and supervise the impact of the development scenarios on flow regime, agriculture, fisheries and socio economic of the project area;
(v) Supervise the proposed design of water management infrastructures, site selection, capacity; required resettlement ;
(vi) Supervise and coordinate data collection survey, hydrological data, socio-economic data, topographical survey;
(vii) Establish, supervise and control of sun-contract works in data collection;
(viii) Manage the performance of the project team members according to their respective terms of reference;
(ix) Organize consultative workshops to national and relevant regional stakeholders;
(x) Present the result of the studies to all relevant stakeholders
(xi) Prepare and submit all required reporting needs: inception, quarterly, mid-term and final report

Requirements:

The Flood plain Development and Management Planning Specialist/ Team Leader will have a post graduate degree in river/water resources/hydraulic/flood plain landscape planning or hydrology and at least 15 years experiences in flood plain development and management planning, flood risk reduction planning in large river flood plain system; extensive international work experience in project implementation at regional scale involving at least two countries; management and administration and good knowledge and understanding of project implementation and implementation; experience as Team Leader of at least one project financed by development partners ADB/World Bank, and bilateral donor. Extensive experience in the Mekong Region and preferably in Cambodia will also be an asset. The candidate must

have demonstrated ability to lead teams composed of international and national consultants and to create a strong working relationship with the executing and implementing agencies. Excellent in communication (written and oral) skills and strong inter-personal skills will be considered an asset.

TERMS OF REFERENCE

Position Title: Hydrodynamic/hydrological modeling specialist

Job Level: Expert

Duty Station: Phnom Penh, Cambodia

Report to: Project Team Leader/MOWRAM Project Director

Responsibilities:

The hydrodynamic/hydrological modeling specialist will be responsible for the overall results of development scenarios in the project areas for possible options and recommend best options for further feasibility studies, but will also assist the Team Leader with respect to provision of required technical expertise. He/she will be responsible for the following scope of works:

The role require the candidate to support in the delivery of a wide range of development scenario with particular focus on integrated flood risk management which include fully integrated hydrodynamic catchment modeling for early flood risk assessment of agricultural land in the Mekong delta part of Cambodia for the design of measures for early flood protection including structural and non-structural measures, the hydraulic design of water diversion infrastructure including weirs, diversion channel, and water control structure;

Requirement:

The hydrodynamic/hydrological modeling specialist will have a post graduate degree in hydraulics/ river engineering specialized in modeling development for management and development of large flood plain with experience of at least 10 years in flood risk management. Experience in the Cambodia or in the Mekong region is an asset. The candidate should have a good communication skill and willingness to do more for less.

TERMS OF REFERENCE

Position Title: Inland Fishery Management Specialist/ecologist

Job Level: Expert

Duty Station: Phnom Penh, Cambodia

Report to: Project Team Leader/MOWRAM Project Director

Responsibilities:

The Inland Fisheries Management Specialist/ecologist will be responsible for the overall results of the possible fishery management scenarios related to flood diversion timing and magnitude including habitat change and improvement, proposed operation measures to operation of hydropower upstream to minimize impact on fishery ecosystem (minimize impact on flood pulse , nutrient and sediment transport). To supplement the decline in fish production, strategy for aquaculture development must also be reviewed and updated.

Specific task would be:

(i) Review all reference and previous studies related to fishery system and management in the Tonle Sap Great Lake-Mekong region; different development scenarios assessment and their respective impacts on fisheries and agriculture in the Mekong delta;
(ii) Assess the change in habitat at the TLS GL and along the Mekong mainstream that could impact the spawning and feeding areas of fisheries and other aquatic animals;
(iii) Identify measures to minimize impact from flow regime changes and flood pulses;
(iv) Develop a strategy for infrastructure management to optimize flood diversion to maximize fish migration during early flood period
(v) Work with other team member to develop an integrated strategy and plan for the management of fishery and early flood risk reduction in the Mekong delta.

Requirement:

The Fishery management specialist will have postgraduate in inland fishery management or inland biologist with extensive experience in inland fishery management, conservation and aquaculture development in the flood plain. Working experience in Cambodia or in the Mekong region will be an asset. He/she should have good skill communication skill, particularly in team working and in working with the communities.

TERMS OF REFERENCE

Position Title: Hydraulic structural design specialist

Job Level: Expert

Duty Station: Phnom Penh, Cambodia

Report to: Project Team Leader/MOWRAM Project Director

Responsibilities:

The hydraulic structure design specialist will work closely with the Hydrodynamic/hydrological modeling specialist, the Inland Fishery Management specialist, the socio-economist under the supervision of the Team Leader. He/she is responsible to provide detail design including bill of quantity and cost estimates for the early flood diversion infrastructure, diversion canals and, all required water control infrastructures including navigation sluice gate as might be requited. The design should follow national standard and policy for flood risk management and water conservation, including mode of operation and maintenance.

Specific task would be:

(i) Work closely with the Flood plain management specialist (Team Leader), hydrodynamic modeling/hydrologist, inland fishery management specialist and socio economist to obtain best input for the infrastructure design and construction as well as for the operation and maintenance of those structures
(ii) Undertake condition survey/assessment of integrity of existing flood defenses and hydraulic structure ;
(iii) Undertake feasibility studies and design appropriate structural intervention methods for the study areas (must include climate change condition as well);
(iv) Assessment of structural options for flood mitigation (particularly early flood) and selection of preferred options with regards to technical environmental and economic criteria;
(v) Design flood risk management infrastructures including TOR and tender document ;
(vi) Oversee the identification of long-list of all structural options;
(vii) Identify short list of flood mitigation options, and select preferred options base on environmental, and socio-economic criteria;
(viii) Detail design of preferred options;
(ix) Produce hydraulic structure design guidance ;
(x) Contribute to develop guideline for undertaking field survey for design of hydraulic structures;
(xi) Undertake conditions inspection of existing hydraulic structures and make recommendation for rehabilitation/removal/re-design options assessment;
(xii) Other tasks required by the client.

Requirement:

The hydraulic structure design specialist will have post graduate in hydraulic structural engineering design and have at least 10 years of experience in hydraulic structural design particularly related to flood risk management and mitigation. Working experience in Cambodia or in the Mekong region is an asset. He/she should have good communication skill and efficient in team work.

TERMS OF REFERENCE

Position Title: Socio-economic Development Specialist

Job Level: Expert

Duty Station: Phnom Penh, Cambodia

Responsibility:

The socio-economist will work closely with all other team member, under the overall supervision of the project Team Leader. He/she is the core of the feasibility studies of the flood diversion project.

Responsibilities

The scope of service of the socio-economist association with the technical team is to:

(i) Review or examine previous studies in the project area;
(ii) Design and manage the socio-economic baseline survey;
(iii) Assessment of the socio-economic conditions and performance of the economic sector in the project areas particularly fishery and agriculture ;
(iv) Describe the contribution the flood diversion for early crop risk reduction and improvement of fish migration;
(v) Assessment of source of income and employment, production patterns and trends;
(vi) Access to market, crops production and demand and equity;
(vii) Identification of problems and known causes and effect on agriculture and capture fisheries, on sector performance, strength, weakness, opportunities, and threats to development of the area. Causes of problems may include, among others, policy issues and governance issues, and investment issues;
(viii) Identify key performance indicators and trends such as incomes, productivity, labor market and other social indictors
(ix) Undertake necessary feasibility level studies, institutional analysis, environmental assessment, resettlement consideration, design and monitoring framework. VE/VA study, vulnerability assessment, identification and assessment of borrow quarry areas in conjunction with the structural design, and preliminary engineering designs necessary in conjunction with beneficiaries and other stakeholders to establish the economic, financial, technical etc. viability of investment. The F/S shall look at alternative options including the associated costs, benefit and risks involved in delivering the project or components of project may include new available technology which can be used to deliver the project or component of the project and selecting the best possible implementation project option/technology involved for the (i) entire fishery, early crop, dry season crop system including navigation benefit.

Requirement

The socio-economist must have at least Master Degree in Economics and social science. The socio-economist must have at least 10 years of working experience and has least completed two feasibility studies, prefeasibility studies or socio-economic survey activities. Socio-economist having experience in the flood plain development and management will be given priority.

TERMS OF REFERENCE

Position Title: GIS and Map specialist

Job Level: Expert

Duty Station: Phnom Penh, Cambodia

Responsibility:

The GIS and Map specialist will work closely with all other team member, under the overall supervision of the project Team Leader. He/she is the core of the feasibility studies of the geography and maps project.

Responsibilities

The scope of service of the GIS and Map specialist association with the technical team is to:

(i) Coordinate, support and carry out the analysis of GIS data for project activities as necessary;
(ii) Study and create GIS maps from remote sensing analysis;
(iii) Provide capacity building services to national agencies including GIS, RS, GPS, cartography and visualization of map design;
(iv) Undertakes spatial analyses and mapping for flood management a long target area (Mekong and Tonlesap) work such as Remote Sensing and GIS analysis of flood risk, and flood risk mapping for planning of zoning, land use, and cultivation of the project;
(v) Perform any other relevant tasks as required by other technical experts, team leader and PMU.
(vi)

Requirement

An advanced degree in natural/physical sciences, e.g. geography or Information Technology or in any other academic field relevant to natural resources management and/or mapping and High level training in Geographic Information Systems (GIS) either as part of an advanced degree or through separate recognized training arrangements; At least 7 years' experience in developing spatial natural resources information systems, demonstrating knowledge of natural resources classification systems and mapping, preferably in relation to the Mekong region or similar natural environments are required; Full working knowledge of ArcGIS/ArcInfo software. Knowledge in Remote Sensing related software is an advantage; Working knowledge of relational database systems; Fluency in English, both written and spoken.

TERMS OF REFERENCE

Position Title: Financial specialist

Job Level: Expert

Duty Station: Phnom Penh, Cambodia

Responsibility:

The Financial specialist will work closely with all other team member, under the overall supervision of the project Team Leader. He/she is the core of the feasibility studies of the flood diversion project.

Responsibilities

The scope of service of the financial specialist association with the technical team is to:

(i) Financial analysis and oversight for all resources managed by the project and provision of high-quality professional advice to the project management;
(ii) Work closely with Task Team Leaders on financial aspects in investment and policy operations and other project financing-related assignments, during preparation, structuring, negotiation, and closing of the transactions.;
(iii) Proper planning, expenditure tracking of the project in accordance with rules and regulations;
(iv) Work with other member of project teams to conduct financial analysis;
(v) Develop and execute financial models for project structuring and financial analysis;
(vi) Contribute and conduct analysis of financial viability of projects
(vii) Performs any other duties assigned by the Team Leader and the PMU.

Requirement

The Financial Specialist must have Master's Degree or equivalent in Finance, Business Administration, and Public Administration, Economics or related field. At least five years of relevant professional experience, with sound understanding of lending operations and project financing. Experience in project finance transactions is preferred; Experience in the usage of computers and office software packages (MS Word, Excel, etc) and advance knowledge of spreadsheet and database packages, experience in handling of web based management systems. Ability to work flexibly on a range of assignments, and prioritize a variety of complex evolving tasks;

TERMS OF REFERENCE

Position Title: Project Assistant

Job Level: Support Staff

Duty Station: Phnom Penh, Cambodia

Responsibility:

The socio-economist will work closely with all other team member, under the overall supervision of the project Team Leader. He/she is the core of the feasibility studies of the flood diversion project.

Project Assistant will work closely with all other team member, assigned administrative and project works necessary for the implementation, implemented and managed effectively in his/her period.

Responsibilities

The scope of service of the project assistant:

(i) Provides administrative assistance in the planning, preparation, implementing and monitoring of Project;
(ii) Assists the regular operations of the Project , including but not limited to maintaining relevant information and documentation; ensuring correspondence flow; supplying of stationaries, etc.;
(iii) Follows up on administrative requests, including but not limited to preparation of travel authorizations, cash advances, payments process and so on;
(iv) Responsible for the logistical organization and arrangements of the project's workshops, seminars and trainings; Coordinates and provides supports to participants;
(v) Assists in drafting correspondences, workshop proceedings, reports and related documents;
(vi) Organizes filing and recording system of the documents and oversee the reproduction of final documents;
(vii) Assist in preparing and wrapping-up the materials/documents for the meeting, training workshops, events, and related activities but not limited to photocopying.
(viii) Performs any other duties assigned by the Team Leader, financial expert, and the PMU.

Requirement

Project Assistant should have University degree in administration and/or office management or other related subjects with at least 3 years of practical experience in project assistance, administration, and office management. Very good command of English skills (reading, writing, speaking, listening and understanding) is required. Competent in using MS Office software: Microsoft Word, Excel, PowerPoint. Experience in multi-national environment is considered an advantage. Working experience in organizing the meetings and training workshops is desired. Good inter-personal and communication skills – the ability to work in team and foster team spirit is desirable.