

## Appendix 1: The Mekong and Lower Mekong Basin (LMB<sup>1</sup>)

### A1.1 Physical and Ecological Background

#### (a) General features

1. *Topography.* The Mekong River<sup>2</sup>, an internal river, is one of the world's largest rivers, draining from the Tibetan plateau (the highest and largest plateau on earth, with an average elevation of about 5,000 meters) to the South China Sea. The river flows through China's Yunnan Province, passes Myanmar, and runs through the Lao PDR, Thailand, Cambodia, and Vietnam. The Mekong basin as a whole spans a wide range of altitude, latitude, climate and vegetation zones along the 4,200 kilometers (km) length of the river. The upper part in China has a long and relatively narrow corridor and suitable for hydropower development and China is building a number of them. Of the total catchment of the Mekong (795,000 km<sup>2</sup>) the Lower Mekong Basin (LMB) covers 77 percent of the entire basin and account for more than four-fifths of the water that drains the basin each year. It covers more than 85 percent of Lao PDR and Cambodia territory, the whole northeastern part of Thailand, and part of the southern part of Vietnam. The LMB has a number of precious natural resources of significant socio-economic, environmental and cultural value, and a large share of the population relies on the resources and services the river provides. The basin is strongly influenced by erosion and deposition and other climatic and river processes. *Figure A1.1* shows the major tributary in the LMB with location of the water gauge stations.

2. *Rainfalls and water runoff.* The LMB is characterized by a tropical monsoonal climate, with highly seasonal rainfall pattern. The winter northeast monsoon brings lower temperatures and little to no rainfall, while the southwest monsoon, between May and October, brings higher temperatures and high precipitation. An average total water volume is about 475 km<sup>3</sup> and the mean annual runoff range from low (0-250 mm) to very high (1,751-2,400 mm). During the dry season, flows in the major tributary rivers are reduced to a fraction of the wet season discharge and many of the smaller streams completely dry up. In the upper parts of the basin, flows from China and Myanmar constitute around 18 percent of total Mekong flows, with a higher proportion during the dry season, when snow melt contributes significantly. Nearly two thirds of the flow (63 percent) originates in Cambodia and the Lao PDR, mostly from tributaries originating in upland areas. Management of these tributaries and their watersheds thus plays a key role in management of the overall Lower Mekong Basin. In most parts of the basin, flows in the driest three months constitute less than 10 percent of total annual flows, while flows in the wettest three months make up over 50 percent of total annual flows. This explains that during the wet season, between 1 and 4 million hectares of floodplain are submerged, including the Tonle Sap in Cambodia. Operation of the China dams upstream as well as those to be constructed and operated in the main stream will significantly change the flow pattern in the Mekong. Details are given in *Section A1.2*.

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<sup>1</sup> State of the Basin Report by Mekong River Commission, April 2010

<sup>2</sup> In China's Yunnan Province, the Mekong is known as the Lancang.

Figure A1.1 : Major Mekong Mainstream Gauging Stations



### ***(b) Flow and Floods***

3. The Mekong itself, as well as many of its tributaries, is characterized by highly seasonal discharge patterns, with considerable flows during the wet season both as a result of the snow melt in the Himalayas and monsoon rains in the LMB. The highest rainfalls of more than 2500 mm/year occur in the western montane regions of Lao PDR and the lowest, less than 1000 mm/year, in the central regions of Thailand within the Mun–Chi Basin. This geographical pattern determines that by far the greatest contributions to mainstream flows during the summer monsoon season originate within the large left bank tributaries in Lao PDR. This typically occurs during July and August and is linked to the reduced formation of tropical monsoonal low pressure systems. The second peak in September and October is partly related to the impact of tropical storms and typhoons moving across the LMB from the Gulf of Tonkin and the South China Sea. Their peak incidence occurs from September to November, although their average track tends to move from north to south as the season progresses.

4. During the dry season, flows in the major tributary rivers are reduced to a fraction of the wet season discharge and many of the smaller streams completely dry up. Annual runoff averages around 475 km<sup>3</sup>/year, with *per capita* water resources availability estimated at 8,500 m<sup>3</sup>/person/year, which is ‘plentiful’ in comparison to most other international river basins. In the upper parts of the basin, flows from China and Myanmar constitute around 18 percent of total Mekong flows, with a higher proportion during the dry season, when snow melt contributes significantly. Nearly two thirds of the flow (63 percent) originates in Cambodia and the Lao PDR, mostly from tributaries originating in upland areas. Management of these tributaries and their watersheds thus plays a key role in management of the overall Lower Mekong Basin. In most parts of the basin, flows in the driest three months constitute less than 10 percent of total annual flows, while flows in the wettest three months make up over 50 percent of total annual flows. This explains that during the wet season, between 1 and 4 million hectares of floodplain are submerged, including the Tonle Sap (the Great Lake) in Cambodia. This still largely unchanged hydrological regime of alternating periods of high and low flows has shaped the dominant rural livelihood patterns, while also creating rich wetlands and estuaries resulting in a significant biodiversity and abundant capture fisheries supporting the basic livelihood of communities.

5. There are considerable differences along the length of the Mekong in terms of hydraulic infrastructure, and large parts of the Mekong are still unregulated. While the tributaries that empty into the Mekong from Northeast Thailand have been developed close to their potential and the Mekong Delta in Vietnam has seen large-scale infrastructure development, the Lao PDR and Cambodia divert only about 1 percent of the Mekong annual water resources in their territories. Also, seasonal regulation of river flows through storage in dams has long been insignificant, amounting to only 2 percent of the average annual flow.

6. *Floods and droughts.* Floods and droughts are the key water resources management issue in the region. Flooding is a part of the natural cycle of the Mekong River. In the northern part and during wet season, large water flows often cause flash floods in the tributaries and mainstream. In downstream, large water flows create a reverse water flow in the Tonle Sap of Cambodia and expand its size four times larger than that of the dry season. Further downstream the Mekong spills over the flat plains and flood large areas for several months. Floods provide

significant benefits to communities, as the rich ecosystem of flood plains and wetlands does rely on the annual cycle of flooding and recession (see Table A1.1 for cause and characteristics). The seasonal changes in water level on the Mekong inundated plains drives a seasonal migration of large water birds between wetlands. Also, in the dry season wetlands are vital in maintaining breeding stocks for floodplain fish while in the wet season they function as breeding and nursery grounds for many fish species. Importantly, this ecosystem, and the services it provides, contributes significantly to rural income and livelihood. The MRC recently estimated that annual cost of flooding in the LMB is US\$ 60 – 70 million per year, while the average annual value of flood benefits is US\$ 8 – 10 billion a year. There is a need to address flood management in ways that preserve the benefits of flooding, while reducing the damage of assets and associate costs from flooding.

**Table A1.1: Cause and Characteristics of Floods in the LMB by Category**

Flood		Cause	Characteristics	Risk and Hazard Ranking
Category	Name			
Rainfall	Mainstream	Excessive rainfall over basin catchment	Generally slow onset and slow moving, especially in lower reaches where flooding can last for 2-4 months.	<i>Rank 1.</i> Mainstream flooding in Cambodia and the Viet Nam delta clearly has the highest risk and hazard. Risk and hazard of mainstream flooding in Lao PDR and Thailand are an order of magnitude less.
	Tributary	Excessive rainfall over tributary catchments	Rapid onset and fast moving because of small, steep catchments. Duration typically several days to 1 week.	<i>Rank 2.</i> Tributary flooding in Lao PDR, Thailand and Cambodia, especially flash floods and landslips, are hazardous, but risk and hazard are an order of magnitude less than mainstream flooding in Cambodia and the Viet Nam delta.
	Local	Excessive rainfall over small local catchments	Rapid onset, 'nuisance' flooding. Duration typically hours to 1 day	<i>Rank 4.</i> Risk and hazard of local flooding are low; at least an order of magnitude less than tributary flooding.
Man-Made	Dam Release	Excessive release of water from dams	Onset can be rapid and unexpected, especially for emergency releases	<i>Rank 3.</i> Likelihood of dam release flooding is small, but potentially hazardous and destructive.
	Dam Break	Structural failure of dams	Immediate onset with rapid increase in water levels and destructive	<i>Rank 3.</i> Likelihood of dam break flooding is very small, but potentially extremely

Flood		Cause	Characteristics	Risk and Hazard Ranking
			velocities.	hazardous and destructive.
	Dam Breach	Structural failure or overtopping of dikes	Unexpected flooding of 'protected' areas.	<i>Rank 3.</i> Likelihood of dike breach flooding is small to moderate. Water levels and hazard are significantly lower than for dam break flooding
Maritime	Storm Surge	Storm surge Tropical cyclones, depressions and storms	Slow onset, high water levels. Flood, wind and saltwater damage can occur.	<i>Rank 5.</i> Likelihood of significant storm surge flooding is low, but potentially hazardous and destructive. Limited to coastal areas of Viet Nam delta.
	Tsunami	Undersea earthquakes Immediate onset.	Extreme and immediate increase in water levels, very destructive.	<i>Rank 5.</i> Likelihood of significant tsunami flooding is small, but potentially hazardous. Limited to coastal areas of the Viet Nam delta, but orientation of coast provides some sheltering.

7. In Lao PDR, floods remain a main threat to poverty alleviation in rural areas. In both the northern provinces and the eastern parts of the country, which are mountainous, flash floods and landslides associated with the heavy storms coming from Vietnam can have serious consequences. In the lower flood plains along the Mekong in the southern provinces, on the contrary, floods are mainly caused by backwater from the Mekong River. This type of flooding is a largely natural phenomenon of the hydrological regime in these parts of the country. However, while these floods generally occur slowly, and therefore do not cause major human losses, they can cause significant damage to economic and livelihood, especially extensive where livelihoods are centered around agricultural production and the infrastructure which support it. So far, the Government has mostly been reactive to these floods, basically focusing on response and relief. However, and fuelled by recent experience of record water level rise in the Mekong in 2008 alongside floods, the Government has started to shift its focus on increasing preparedness. The agencies have been engaged in assessing flood risks at the level of river basins with the prospective to inform and improve early warning. Also, the Government has started mainstream flood management in key sectors such as transport, agriculture, and education to make these sectors more resilient to the flood risks.

### (c) Wetlands, Biodiversity, and Fisheries

8. *Wetlands and biodiversity.* Given a wide range of topography and climatic zones, the LMB is one of the richest areas of biodiversity in the world and comprising a large number of wetlands and critical landscapes of international biological importance (Figure A1.2). Wetlands

play a vital role in the livelihood of local people and the socio-economic development of the region. Their use for rice cultivation and freshwater capture fisheries provides people with both diets and income. In addition, wetlands have significant secondary benefits, as they buffer floodwaters and provide refuge and spawning grounds to the basins migratory fish species. Given rapid development in the region, especially hydropower and urban development, many of these wetlands are under pressure and require effective protection and management. The wetlands of the Lower Mekong Basin support some 15 globally-threatened bird species as well as the critically endangered Siamese Crocodile and Irrawaddy dolphin. The Siamese Crocodile, while formerly widespread throughout the LMB has been endangered due to excessive hunting and habitat destruction. The Mekong dolphin population has benefited from increased protection as an area tourist attraction. In addition, over twenty species of turtles occur in the LMB, ten of which are listed in the Red Data book including the critically endangered Chinese three-striped box turtle.

9. *Endangered Species and a List of an Important Protected Areas and Wetlands of regional significant in LMB.* The Mekong Basin, with its range of geographic and climatic zones, is one of the richest areas of biodiversity in the world. Local climate, geology, terrain and riparian conditions shape riverine ecosystems into an almost unquantifiable variety of types. As a testimony, the Mekong River Basin contains 16 WWF Global 200 eco-regions, which are critical landscapes of international biological importance<sup>3</sup>. Among the key aquatic ecosystems of basin-wide significance, are a number of large wetlands. Wetlands include a wide range of aquatic habitats lying at the border between land and water, and are among the most complex and diverse ecosystems in the world; with high biodiversity as well as high productivity. Wetlands play a vital role in the livelihood of local people and the socio-economic development of the region. Their use for rice cultivation and freshwater capture fisheries provides people with both diets and income. In addition, wetlands have significant secondary benefits, as they buffer floodwaters and provide refuge and spawning grounds to the basins migratory fish species. In the Lao PDR, for example, a total of 30 regionally / internationally important wetland sites have been identified<sup>4</sup>. Yet, as much of the economic growth in the region is concentrated in the flatland areas of the basin, it is little surprising that the floodplains and wetlands, alongside the biodiversity they support, are increasingly under pressure.

10. Floodplains of regional significance are summarized below:

- *Cambodia:* The middle stretch of the Mekong north of Stung Treng (14,600 ha), containing a Ramsar site, that provides refuge to rare fish, dolphins and birds, providing important breeding and feeding habitats. The middle stretch of the Mekong between Kratie and Stung Treng towns (33,808 ha), which is rich in biodiversity, and comprises a variety of habitats supporting wildlife, and most of the Mekong population of the Irrawaddy dolphins are found here. Other important wetlands include the Prek Toal (core zone of the Tonle Sap Biosphere Reserve), Boeng Chhma (a Ramsar site in Kampong Thom province), and the Bassac Marshes which are a potential Ramsar site (in Kandal province).

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<sup>3</sup> MRC 2010. State of the Basin Report 2010. Mekong River Commission, April 2010

<sup>4</sup> Claridge, 1996. IUCN publication on wetlands

Figure A1.2: Major Wetland Types in Lower Mekong Basin



- *Lao PDR*: a total of 30 regionally/internationally significant wetlands sites have been identified in the Lao PDR, mainly in the central and southern parts of the country, and all located in key tributaries of the Mekong River. These wetlands include the Siphandone Wetland (6,000 ha), the extension of the Cambodian middle stretch of the Mekong north of Stung Treng, with at least 205 fish species recorded, and a critical habitat for many of the migratory species of the LMB. Other important wetlands are found in major tributaries of the Mekong River, including the Xe Bang Fai and the Xe Bang Hiang.
- *Thailand*: similar to the wetlands in the central parts of the Lao PDR, the Lower Songkhram River floodplains (96,000 ha), which provides habitat for some 183 species of fish, and which has been labeled a potential Ramsar site. Other important wetlands in the Thai part of the LMB include the Nong Bong Khai non-hunting area (Chiang Rai province) and the Bung Khong Long non-hunting area (Nong Khai province), both registered Ramsar sites.
- *Vietnam*: The Mekong Delta contains about 20 important wetlands sites, including the Tram Chim National Park (7,588 ha), the U Minh Thuong National Park (8,154 ha), the U Minh Ha National Park (8,286), and the Mui Ca Mau National Part (41,862 ha) which is also listed as a UNESCO Biosphere Reserve.

#### List of Important Wetland Types in the LMB

Wetland Types	Countries			
	Cambodia	Lao PDR	Thailand	Vietnam
Flooded Forest	x	x	x	x
Rivers/streams	x	x	x	x
Marshes/swamps	x	x	x	x
Floodplain marshes/swamps	x	x	x	x
Peatlands	x	x		x
Lakes/ponds	x	x	x	
Ricefields	x		x	x
Reservoir			x	
Rivers/streams with pools/ rapids	x	x	x	
Floodplain lakes/ponds	x	x	x	
Floodplain grasslands	x	x	x	x
Saline lakes/ ponds/ marshes/swamps			x	
Fishponds and aquaculture			x	x
Mangrove Forest				x

Source: Vathana 2003; Phittayaphone 2003; Choowaew 2003; Tinh 2003.

11. *Fisheries.* Among the direct uses of wetlands, capture fisheries is of particular importance, as the seasonal flooding of the wetlands and flood plains (covering nearly 10 percent of the basin) is a critical determinant of the high productivity of the natural fisheries. An estimation made by the Mekong River Commission (MRC) suggests that the average fisheries yields about 2.6 million tons per year, with an additional 0.55 tons per year of other aquatic animals, while first sale value is estimated at US\$ 3.9 to US\$ 7 billion per year: roughly 3 percent of the world's total fisheries. Fisheries and aquatic animals provide the great majority of animal protein in the LMB. The Mekong is also the critical habitat for various important species such as Mekong Giant Catfish as well as other endangered species such as fresh water ray and fresh water dolphins. Among the richest fishing grounds in the Mekong is the border region between the Lao PDR and Cambodia, stretching from the Lao PDR province of Champasak southwards into the province of Stung Treng, around the ecologically sensitive Khone Falls area.

12. Table A1.2 provides and estimated consumption of fisheries products in LMB.

**Table A1.2: Estimated Consumption of Fisheries Products in LMB(2008)**

Country				Marine Products*	Total Aquatic
	Fish	OAs	Fish plus OAs		
<b>Lao</b>	185	45	230	3	232
<b>Cambodia</b>	555	121	676	13	689
<b>Thailand</b>	740	196	937	134	1,070
<b>Vietnam</b>	746	173	920	140	1,059
<b>Total</b>	<b>2,217</b>	<b>535</b>	<b>2,752</b>	<b>294</b>	<b>3,045</b>

\*fish and other marine species imported into the LMB and sold in markets. Values are fresh weight (000 tonnes (kt) per year) (Hortle 2007). Note that actual consumption is less due to losses in processing. OAs – other aquatic animals

13. However, fish resources are increasingly coming under pressure from: (a) trans-boundary environmental impacts (including infrastructure developments, chemical runoff from farming, hydropower generation and flood control), which is gradually becoming an issue; and (b) local pressures put on fishery resources. This is accompanied by a lack of effective fishery management that reflects the wider economic development in the area (better access to markets and growth in tourism) which triggered higher demands and prices. The result is rampant fishing in the border area, and reportedly, in Lao PDR, installation of excessive passive fishing gears in Khone Falls area, and in Cambodia, the exploitation of fish in sensitive areas (deep pools refuges, spawning grounds and migratory routes) and use of explosives are becoming critical issues. In view of these multiple pressures on fishery resources, and the potential of further water resources developments, as well as the complexities in negotiating a joint fishery management arrangements among the two neighboring countries, the provinces of Champasak (Lao PDR) and Stung Treng (Cambodia), in 2007, have signed an agreement to start cooperation to improve fishery management with the border area.

**(d) Population, ethnicity, and cultural heritages**

14. About 60 million people live in the Lower Mekong Basin, according to national population statistics of the four LMB countries. The figures indicate that the overall population has increased by about 12 per cent since the figures reported in 2003 (55 million) although the trends vary between countries. The LMB population has increased by 25 per cent in Cambodia, by about six per cent in Lao PDR, has remained the same in Thailand and increased by about 10 per cent in Viet Nam. The percentage of population and territory within the basin varies between countries. Cambodia and Lao PDR lie largely within the basin but together comprise only 30 per cent of the basin population. About 85 percent of the basin's population live in rural areas. Overall, population density is low at about 124 people per km<sup>2</sup> although this masks large differences between the countries. More than 70 ethnic groups live in the Mekong region, most of them practising subsistence agriculture in upland regions.

15. Of the 60 million Thailand and Vietnam accounted for 70 percent with the population density of 125 people per km<sup>2</sup> and 265 people per km<sup>2</sup> respectively. Lao PDR has the largest land area with a very small population (8 percent) and the population density of 25 people per km<sup>2</sup>. However, about 72 percent of the total population in LMB lives in rural areas and most of them are mainly subsistence farmers whose livelihoods depend on the Mekong and its tributaries, including agriculture, fisheries, and collection from forests. There are a number of ethnic minorities in the Mekong Basin in all LMB countries. The population of target provinces in Lao PDR and Cambodia is ethnically heterogeneous, with almost 40 percent of the total population being made up of ethnic minorities. There are considerable population of *Lao Tum* (middle Lao), mainly ethnic Macon, found in the Xe Bang Fai floodplain, whereas majority of the population are *Lao* in the fishing villages in Champasak. LMB is also rich in history and cultural values and the most famous ones include Ankor Wat in Cambodia and Luang Phrabang in Lao PDR. Table A1.3: shows the Socioeconomic and Development Indicators in the Lower Mekong Basin.

**Table A1.3: Socio-Economic and Development Indicators of the LMB Countries**

	Cambodia	Lao PDR	Thailand	Vietnam
Total Area (km <sup>2</sup> )	181,035	236,800	513,120	332,000
Total LMB area (km <sup>2</sup> )	156,435	206,620	203,060	66,773
LMB population 2007 (million)	13.0	5.2	23.1	18.7
Rural population (% of total population, 2007)	78	69	68	72
Average Annual Population growth (% , 2007)	1.9	2.1	0.8	1.2
Population Density (people per km <sup>2</sup> )	80	25	125	265
Life Expectancy at birth (years, 2007)	59	64	71	74
Infant Mortality (rate per 1000 live births, 2007)	65	59	7	15
Population under age of 15 (% of total)	39	37	21	29
Adult Literacy rate (%)	76	73	94	90
Access to clean drinking water (% of	65	60	98	92

population, 2006)				
Improved Sanitation (% of population with access, 2006)	28	56	96	65

Source: MRC 2010, State of the Basin Report 2010. Mekong River Commission, April 2010

## A1.2 Water Use and Development Potential

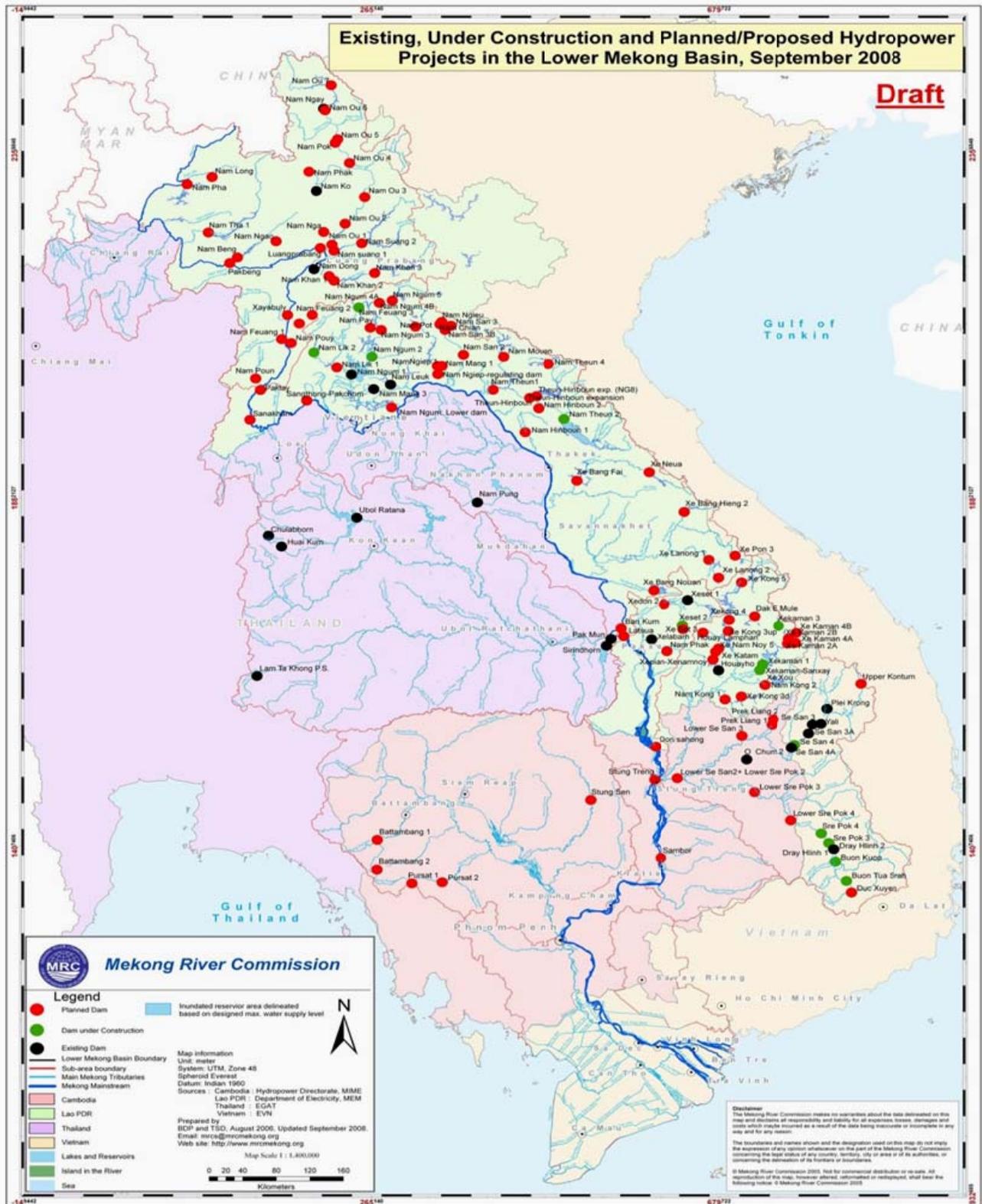
16. *Agriculture.* Agriculture is the predominant water user in the Lower Mekong basin, relying mostly on seasonal rains and the natural flooding of low-land croplands associated with them. In the upland areas, forests and less intensive farming systems constitute the main land use, though there is some expansion of industrial tree-crops. In the low-lands rice production systems are the predominant land use, with wet season lowland rice comprising 84 percent of rice production systems in Cambodia and North-east Thailand, 67 percent in Lao PDR (where upland rice is more dominant) and 40 percent in Vietnam (where irrigated rice systems are more important). Dry season irrigated rice has remained relatively limited in scale because of the seasonal pattern of the river flows, but its potential may increase as upstream river storage increases dry season flows.

17. *Hydropower.* The LMB is going through a critical stage of development. The steady and strong economic development in the region (8 percent growth on average during the last five years), has triggered renewed interest in putting water resources to productive use. In particular, hydropower development, mostly led by the private sector, is driven by a mix of energy demands and prices, as well as quests for national energy security. In the four LMB countries - Cambodia, Lao PDR, Thailand and Vietnam – about 10 large (> 10 MW) hydropower projects are under construction and almost 150 projects are at different stages of planning/proposal, including 11 projects on the Mekong mainstream. In Lao PDR, seven hydropower stations are under construction. In addition, large-scale irrigation development, particularly in northeastern Thailand and Cambodia, is also planned to increase agricultural production, both for markets and for increased food security. Navigation in the mainstream Mekong is also increasing, particularly downstream of Phnom Penh, and between Thailand and China, as economic activities intensify in the region.

18. In the upper part of the Mekong, China is completing its hydropower cascade on the Upper Mekong River, the Lancang, including the Xiaowan and the Nuozhadu hydropower projects, with 9,900 and 12,300 million m<sup>3</sup> of active storage, respectively. These, combined with other constructed and planned developments both on the Mekong mainstream and on its tributaries, are likely to cause significant seasonal redistribution of flows; models predict that dry season flows are likely to increase from water releases for hydro-electric power generation, while wet season flows on which the bulk of agriculture currently depend may be reduced, especially at the start of the rainy season as the dams are re-filled. China is gradually increasing its engagement in the dialogue with the four LMB countries through the MRC, and sharing hydrological information obtained in two hydro-meteorological stations with the MRC, while also expressing interest in collaborating with the MRC to develop transboundary hydrological models.

19. Climate change also poses a new challenge to the LMB countries. While the models predict overall temperature increases, predictions regarding precipitation are less certain. However extreme weather events, both floods and droughts, are likely to become more frequent and there is likely to be less predictability in weather patterns. Flood and drought events pose particular risks to poor rural communities; in the parts of the Mekong Delta close to the seashore, for example, a major impact could occur on agriculture production due to sea water rise and resulting salinity intrusion. Longer term climate forecasting must also be an essential building block in decision making regarding development of new hydrological infrastructure including hydro-electric facilities. The MRC has started a regional analysis on climate change impacts on the hydrology of the Mekong using a modeling approach. However existing data and information collection systems are still largely inadequate to capture the complexities of the basin. At the same time, the LMB countries have recognized the need to upgrade their own hydro-meteorological (hydromet) networks to address the risks posed by both present and future weather events, share information among riparian countries, and develop regional and improved national systems for flood and drought forecasting and warning.

20. *Potential Impacts of Hydropower Operations in Yunnan Province, China.* Particular attention has been paid to the potential hydrological impacts of the cascade of hydropower dams being developed on the mainstream in China, which, when fully developed in 2020, will have a total active storage of 23 km<sup>3</sup>, equivalent to 30 per cent of the mean annual flow volume that enters the LMB from Yunnan. This means that the degree of regulation (the proportion of flood season flows transferred to the low-flow season) could be as high as 20 per cent. The downstream consequences for the mainstream low-flow regime are amplified because a disproportionate volume of regional dry-season flows are generated in Yunnan. As far downstream as Kratie it constitutes as much as 40 per cent of the flow in April. Conversely, in the wet season the proportion falls to 15 per cent. The clear implication is that large-scale river regulation in Yunnan will have a significant impact on the low-flow regime throughout the lower system. Hydrological modelling of impacts of hydropower dams in Yunnan Province (15,800MW) has confirmed a significant increase in average discharge during the low-flow season, of about 40 per cent in the upper reaches and about 20 per cent as far downstream as Kratie. The decrease in flood season flows is proportionally far smaller (about 15 per cent in the upper reaches and less than five per cent at Kratie (MRC 2009a). These hydrological changes shift the timing of the four flow seasons, including timing of the reverse flow to Tonle Sap Great Lake, and affect the flooded area as well as the dry season area, which are key parameters for the Great Lake's productivity, including fishery production.



### A1.3 Integrated Water Resources Management in LMB

21. There is broad recognition within the region that the accelerated pace of water resources development in the Mekong Basin needs to be complemented by effective management arrangements for water and related resources to ensure that: (a) development of the water resources is sensitive to the maintenance of vital ecosystems and the productivity of capture fisheries, on which many of the poor depend for their livelihoods; and that (b) water resources development becomes a negotiated process, which synthesizes the differing interests both within the different countries and between them.

22. From a Mekong Basin perspective, the following definition of IWRM is emerging as highly relevant and relates closely to the 1995 Mekong Agreement.

“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 vital ecosystems. IWRM emphasizes integration of the management of land and water resources, of surface water and groundwater, of upstream and downstream uses, of sectoral approaches, of economic production and environmental sustainability, and of the state and non-state stakeholders.”<sup>5</sup>

23. The governments of the LMB countries have recognized that developing water resources in the Mekong is key to achieve further economic development while working to alleviate poverty. In the meantime, the governments have also become increasingly aware of the importance of social and environmental aspects of water resources development and management, given the rich biodiversity of the Mekong and the large number of poor riparian communities dependent on the Mekong River and its tributaries. Lao PDR has committed to forest conservation and watershed protection with support from various donors including the Bank, while Cambodia has taken initiatives to protect the fisheries. Vietnam is increasingly aware of the social and environmental impacts of hydropower development and is working with the Bank for a new hydropower development. The governments are also working to address water resources management in a regionally coordinated manner through the Mekong River Commission (MRC), an inter-governmental river basin organization for the Mekong River, and collaboration on water resources management among the four LMB countries has intensified during the last few years.

24. The four riparian countries of the Lower Mekong Basin (Thailand, Lao PDR, Cambodia, and Vietnam) are at different stages of economic development, have varied population sizes and related livelihood challenges, and are situated in different geographical contexts. As such, the country development agendas vary, as do water-related opportunities and risks, and technical and financial capabilities. Below follows a summary of current trends and issues in water resources management in the four countries.

- *Cambodia.* More than 80 percent of its territory within the Mekong Basin, the Mekong provides Cambodia with substantial socio-economic and cultural value. In particular, Cambodians largely depend on protein intake (estimated about 80 percent) from the captured

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<sup>5</sup> Global Water Partnership, 2000

fisheries in the Mekong (including Tonle Sap). There is a famous ‘reverse flow’ from the mainstream Mekong back to Tonle Sap during the wet season due to high water level in the mainstream Mekong. While this reverse flow causes annual floods in the Tonle Sap area, they provide significant benefits the fisheries. There is a risk that uncoordinated upstream development may alter the regional hydrology and affect the subtle ecological balance. Cambodia is also keen to support improved land and water management in its territory in the Mekong Delta, which is subject to periodical floods and droughts. Situated upstream from the Vietnam territory of the Delta, Cambodia is aware of the upstream implications of water resource developments in the Delta and is working towards coordinating developments with Vietnam in order to minimize negative downstream impacts and maximize synergies. Cambodia needs to strengthen its hydro-meteorological data collection and forecasting system to manage its water resources more effectively, to predict and plan for major weather events to minimize human losses, and to improve the basis for overall river basin planning and management.

- *Lao PDR.* The Government of Lao PDR is keen to utilize water resources in the Mekong River Basin, in both the Mekong mainstream and many of the river’s tributaries, as a means to improved livelihood conditions and socio-economic development as well as to generate foreign direct investment and public revenues from sale of electricity to neighboring countries. In particular, the Government has commissioned the private sector to conduct feasibility studies on about 40 potential hydropower projects, including four on the Mekong mainstream itself. Furthermore, development of irrigated agriculture in the lowland floodplains of major rivers of the country, are foreseen to facilitate dry-season crop production, while flood protection would reduce the risk of crop damage in the wet season. At the same time, the Government is aware that developing water resources infrastructure can have detrimental impacts on the livelihoods that rely on existing flow and nutrient flows, including rainfed agriculture and capture fisheries which rely on the integrity of floodplains and other environmental services they provide. To promote Integrated Water Resources Management (IWRM) as a best practice in the Lao PDR, the government has set-up River Basin Organizations (RBO) in the Nam Ngum and Nam Theun – Nam Kadin Basins, and plans to support IWRM approaches in other key tributaries. In 2008, the Government has also consolidated its water resources management agencies, and established the Water Resources and Environmental Agency (WREA) to mainstream IWRM in the country. Lao PDR’s hydromet systems are not well developed; after experience on the serious floods in 2008 and 2009, the Government has made a commitment to strengthen the hydromet networks and develop an effective early warning system. With the support of the GFDRR, the WREA has started an assessment of current capacities and investment needs.
- *Thailand.* The Government of Thailand has identified the provision of water resources in the country’s north-eastern region, as a top priority. The overarching concern is water shortage, particularly in light of possible climate change impacts; the Government has explored possible major projects such as water transfer from the Nam Ngum River Basin in Lao PDR or a few new reservoirs to increase storage. However, given the country’s rich history of water resources development (irrigation in particular), the Government is also aware of the safeguard issues surrounding large-scale water infrastructure development, particularly the need to have thorough consultative processes. Building on its experiences, as well as a trend

towards increasingly strong local governance, the country aims to further strengthen IWRM in water resources planning, development and management. With the support of the Bank and the ADB, the Government has initiated the formulation of a River Basin Committee (RBC) in the Ping River Basin and the Chi sub-basins (in Northeast Thailand), respectively. Thailand's hydromet systems are relatively well developed and are in a position to share experience with neighboring Lower Mekong countries.

- *Vietnam.* The Mekong Delta, lying in the southern parts of the LMB, is the major agricultural area of the country, contributing nearly 50 percent to the country's total rice production, while also being significant in terms of aquaculture. As a major inland transportation system, the Mekong Delta also serves the country for the distribution of goods. At this moment, the delta faces two major challenges: (a) growing competition between rice farmers and shrimp farmers, triggered by their competing demands on water resources (freshwater vs. brackish water), and (b) deteriorating water quality resulting from increased levels of pollutants due to rapid urban development. In the future, the Delta will face further challenges as upstream developments could change the level of nutrients that fertilize agricultural lands and changing seasonal flow patterns which could induce increased saline intrusion. Furthermore climate change could negatively impact this significant part of the country. In view of the above, the government of Vietnam is actively pursuing IWRM planning to tackle present and future water use needs. In the Central Highlands, where Vietnam is an upper riparian to the Lao PDR and Kingdom of Cambodia, water management based on the unity of the hydrological cycle is recognized as important to minimize and prevent conflicts over water utilization, while improved water resources management is also a key to reduce rural poverty. Vietnam also seeks to strengthen its hydromet systems in the Lower Mekong basin and to support data sharing with other riparian countries.