How Do the Availability of Fish and Rice Affect Occupation and Food Security in the Lower Mekong Basin?

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Dedication

For my mother, Soua Lor,

and father, Pathong Lee

Who show unlimited, endless love and care for me.

Abstract

This study aims to contribute to our understanding of how rice and fish availability affect occupation and food security of people in the Lower Mekong Basin (LMB), including Cambodia, Lao PDR, Thailand, and Vietnam. The study focuses on subsistence and commercial fishers and farmers. The data obtained for my research are from the first basin-wide survey conducted across the four countries using a common methodology and timing in 2009. Results of the study show that the extent of dependence of people on rice and fish availability for occupation, income, and food and their resilient capacities varies greatly between strata and across study sites.

If both fish and rice decline at a common rate applicable to the whole LMB, cash income of at least one of four strata in each site will easily fall below the poverty line of $1.00 per capita per day. Seen from the perspective of food, all strata of all sites will be significantly affected if the availability of rice and fish decline. Altogether, fish and rice account for more than 81% of the total daily calorie intake. With uneven distribution of population by countries and varied social-ecological zones and livelihood activities, impacts of changes in the rice and fish availability will not distribute evenly. If changes occur throughout the Mekong, the number of people impacted will be highest in Vietnam, followed by Cambodia and Lao PDR. Thailand will be affected the least.

Please see separate PDF files for the questionnaire in five languages.

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Chapter 1. Background and Context

The biophysical and social economic conditions of the Lower Mekong Basin (LMB), including Cambodia, Lao People's Democratic Republic (PDR), Thailand, and Vietnam, are rapidly changing, driven by both development activities and climate change. This study is a snapshot of the current conditions. It aims to provide baseline data and information on certain social and economic conditions (particularly occupation, income, and food related to rice and fish availability) useful for long-term monitoring. All of these will be discussed in length throughout the dissertation.

The Mekong and its resources

The Mekong River spans some 4,800 km and six countries: China, Myanmar, Lao PDR, Thailand, Cambodia, and Vietnam (Figure 1). The Mekong traverses "several bioregions, from the Tibetan Plateau and steep gorges of the Lancang River in China, the bio-diverse region of the Nakai Plateau in Lao PDR, the drier agriculturally extensive Korat Plateau of Northeast Thailand, the natural barrier of the Khone falls of Southern Lao PDR, the fisheries-rich Tonle Sap lake in Cambodia, to the densely populated and agriculturally productive region of the Mekong Delta" (Miller 2004). The Mekong River Basin (MRB) has been seen as consisting of two main parts: the LMB and the upper part of the Mekong. The LMB, with an area of 606,000 km^2, covers 86% of the area of Cambodia, 97% of Lao PDR, 36% of Thailand, and 20% of Vietnam (BDP 2006). The upper part of the Mekong, 795,000 km^2, includes parts of Myanmar and of the Yunnan Province of China. China contributes 16% of the average flow of the Mekong, Myanmar 2%, Lao PDR 35%, Thailand 18%, Cambodia 18%, and Vietnam 11%. However, the proportion of the flow from China is higher in the dry season due to snowmelt.

Figure 1: Map of the Lower Mekong Basin (source: MRC 2009)

According to the Basin Development Plan (BDP, 2006), water resource conditions of the Mekong River can be summarized as follows. The mean annual discharge of the Mekong is about 475 km^3/year. Per capita resource use at current conditions is over 8,500 m^3 /person/year, compared to 2,200 for the Nile, 1,400 for the Rhine, 2,265 for the Yangtze, and 1,700–4,000 for the Ganges. Average annual withdrawal is around 60,000 million m^3, 12% of total annual flow. Between 1 million and 4 million hectares of floodplain are submerged during the wet season, including the Tonle Sap Lake in Cambodia. The total volume of regulated storage in the MRB for hydropower and irrigation is less than 20,000 million m^3, which is less than 5% of annual runoff. Groundwater is widely used as a source of water for domestic and industrial use. Groundwater use for irrigation is limited but expanding.

The annual flow of the Mekong is relatively predictable and not highly variable. The patterns of discharge in the mainstream Mekong are seasonal, with flood peak in August in the upper part of the LMB and in September in the lower part (MRC 2003). Severe floods have occurred regularly in the last few years, including 1996, 2000, 2001 and 2010. The consequences have been extensive, particularly human casualties, production loss, and damage to infrastructure and private property. Flood management and mitigation is an important concern with strong regional emphasis (BDP 2006).

Water quality is generally good, although localized exceptions exist (MRC 2010c). The exception is acid sulphate drainage, saline intrusion, and pollution in areas with intensive use of the Vietnamese Mekong Delta (BDP 2006). There are no direct water quality threats to the biological diversity of the river. Overall, there are no signs of eutrophication. Although information on toxic pollutants such as heavy metals and persistent organic pollutants is limited, available data suggest that there are no pollutants of concern regionally. However, certain areas with high population densities and intensive agriculture and aquaculture show signs of increased pollution. Examples include high level of nutrients in the Mekong Delta, indicating increased eutrophication. Future development activities in the MRB may increase pollution load (MRC 2010c).

The MRB is one of the richest regions of biodiversity in the world. It has been recently estimated that the Mekong region is home to 850 fish species (Hortle 2009), 20,000 plant species, 430 mammal species, 1,200 bird species, and 800 reptile and amphibian species (Thompson 2008). New species continue to be discovered, and biodiversity in the region has not yet been completely documented (Berg and Bouapao 2010). It is reported that a number of species have become locally rare or absent, although to date no fish species in the Mekong region has become extinct (MRC 2003).

The Mekong supports an inland capture fishery with an estimated commercial value of US$2 billion annually. The fishery provides a livelihood not just for fishers and their families but for thousands more who are employed full or part time making and selling food products and fishing gear, repairing boats, and providing hundreds of related services (MRC 2009). The wild fishery is especially important for the poorest and landless rural households, making significant contributions to their nutrition, food security, and income (MRC 2003).

Although the LMB is still in good biophysical condition, there are a number of threats. These include the competing demand for water by different sectors: hydropower, irrigation, industry, navigation, water abstraction, water diversion, and fisheries. These all will have unwanted impacts on the aquatic ecosystems and the livelihoods of the people living in the LMB (MRC 2003).

According to BDP (2006), hydropower potential in the LMB is big, estimated to be around 30,000 MW depending on the feasibility criteria applied. Of this, 13,000 MW are on the mainstream; 13,000 MW on Lao tributaries; 2,200 MW on Cambodian tributaries; and 2,000 MW on Vietnamese tributaries. To date, 11 schemes of the tributaries have been completed in the LMB, totaling 1,600 MW, or only 5% of the potential. Two hydropower dams have been completed on the mainstream, in Yunnan province, China: Manwan (1,500 MW) and Da-chao-shan (1,350 MW). More large mainstream hydropower dams have been started (Xiaowan) or planned (Jinghong and Nuozhadu), with 15,000 Mm^3 storage capacity.

The total irrigated areas are approximately 390,000 ha in Cambodia, 155,000 ha in Lao PDR, 540,000 ha in Thailand, 40,000 ha in the Vietnamese Highlands, and 1 million ha in the Mekong Delta. There is a high potential, around 600,000 ha in each country, for development of irrigation infrastructure within existing irrigated areas in Cambodia and Lao PDR. The tributaries are fully exploited in northeastern Thailand, and the flow is fully utilized for irrigation and to curb salinity intrusion in the delta (BDP (2006).

Some social information: LMB population

Based on Landscan data 2007, nearly 170 million people live in the four countries of the LMB. Of this, 36% (just over 61 million people) live in the LMB. Thailand has largest LMB population followed by Vietnam and Cambodia. However, as a percent of the LMB in each country, Lao PDR has the highest proportion of its population, falling within the LMB, followed by Cambodia, Thailand, and Vietnam (Table 1).

Not all people in the LMB, however, are likely to be affected by changes in the wild captured fisheries in the mainstream Mekong. Studies in the LMB suggest that distance from households to river resources, especially fish and non-fish species, plays an important role in the extent to which households depend on the resources for livelihoods. Households closer to resources tend to depend more on the resources than those that are farther away, although exceptions exist. People travel long distances for seasonal fishing in Cambodia's Tonle Sap Lake, for example. A study on social impact monitoring and vulnerability assessment (SIMVA) in the LMB undertaken in 2009 found that, on average, local people made use of ecosystems within 15 minutes distance in the dry season and 20 minutes in the wet season. Approximately 10% of the sample population used ecosystems for fishing that were more than 30 minutes away, and only 2% used ecosystems that are more than one hour away (Hall and Bouapao 2010).

Table 1: National and LMB populations

Country	Total Population	Population in LMB	Percent of LMB population in each country	Proportion of national population in the LMB
Cambodia	14,056,185	11,986,604	85%	20%
Lao PDR	6,499,725	6,117,183	94%	10%
Thailand	64,751,749	24,408,376	38%	40%
Vietnam	84,681,033	18,943,816	22%	31%
Total	169,988,692	61,457,121	36%	100%

Source: Hall and Bouapao 2010.

Moreover, population is more concentrated closer to the mainstream Mekong. Landscan data show that almost half of the LMB population lives within the 15 km corridor Table 2. By country, 10% of Thailand's LMB population lives within corridor. The rest of the countries have more than half of their LMB population living within the corridor, ranging from 56% in Lao PDR to 83% in Cambodia. Breaking the 15 km corridor into 3 sub-corridors, the largest percent of the corridor population lives within a 5 km buffer. Overall, close to 80% of the 15 km population live within 0–5 km of the Mekong mainstream. Large towns (such as Phnom Penh in Cambodia, Mekong delta in Vietnam, and Pakse, Savanakhet, Vientaine, and Luangprabang in Lao PDR) affect the distribution (Hall and Bouapao 2010).

Table 2: Corridor population

Country	Population in LMB	Corridor Population	Proportion of LMB population in the corridor
Cambodia	11,986,604	9,895,525	82.6%
Lao PDR	6,117,183	3,430,040	56.1%
Thailand	24,408,376	2,499,395	10.2%
Vietnam	18,943,816	13,851,600	73.1%
Total	61,457,121	29,676,560	48.3%

Source: Calculated based on Hall and Bouapao 2010

The 15 km buffer zones have been used by a number of the Mekong River Commission MRC programs, such as the Strategic Environment Assessment (SEA) of the Sustainable Hydropower Initiative, the Integrated Basin Flow Management (IBFM), and the Social Impact Monitoring and Vulnerability Assessment.

Population is unevenly distributed across IBFM zones (Figure 2), in contrast to the fairly well-distributed geographic zones. Division of the zones ranges from 11% to 31%, while the proportion of population ranges from 3% to 47%. Zone 6, Vietnam Mekong Delta, ranked third by area (19%), is most populated, accounting for almost half of the total corridor population (47%). Meanwhile, Zone 4, which is 11% of the total corridor area, has only 3% of the total corridor population. The second highest proportion is Zone 5 (32%), followed by Zone 3 (14%) (Hall and Bouapao 2010).

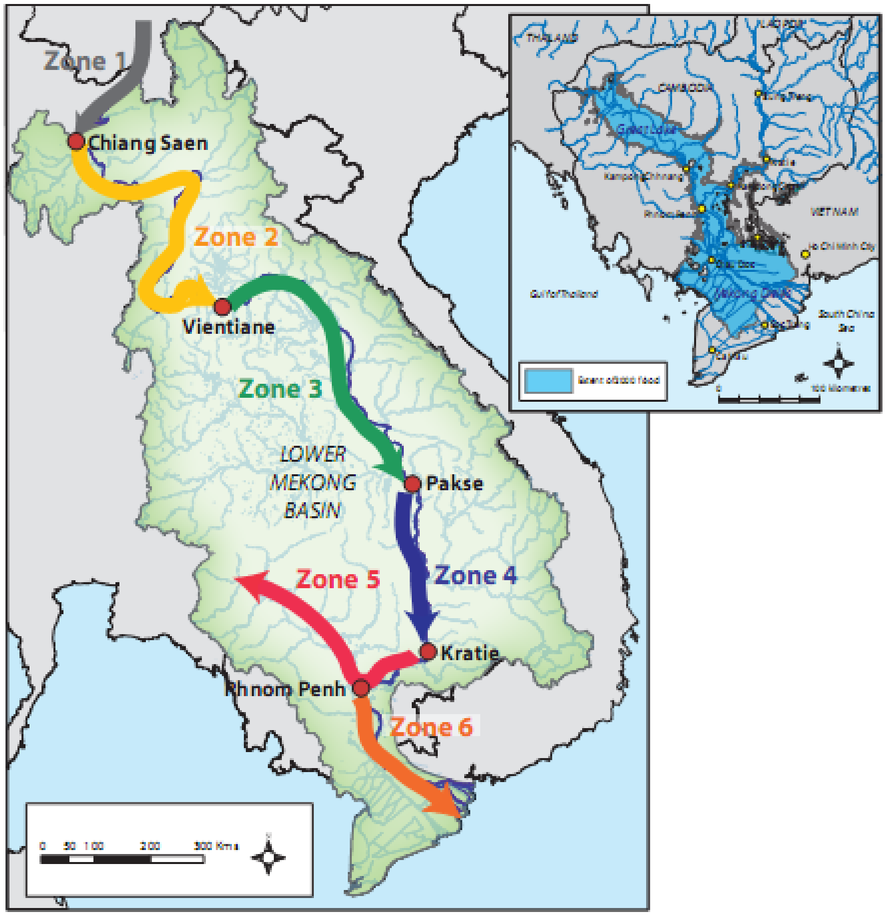

Figure 2: Zones of the MRC Integrated Basin Flow Management (IBFM)

(Source: MRC 2009c)

Although urban residents use the Mekong as a source of water, proportionately fewer depend on the river resources for subsistence than do residents of rural areas. This is because their livelihoods depend on other sectors of employment such as industries and services, while rural households tend to rely more on natural resources (MRC 2010b).

The LMB is still largely a rural area. In 2003, it was reported that more than 80% of the LMB population lived in rural areas engaged in agricultural activities, depending heavily on natural resources for livelihoods (MRC 2003, Hook et al. 2003). In 2007, Landscan data showed that 84% of the LMB population lived in rural areas, with the lowest proportion of rural population in Zones 2 and 3 (77%), and the highest in Zone 2 (88%) (Hall and Bouapao 2010). However, population growth rate in urban areas is about twice the national average because of migration toward cities. It is projected that, if this condition persists, the proportion of population in urban areas in 2025 will be in the range of 25–30% (BDP 2006).

With the uneven distribution of population by country, distance to the mainstream, rural-urban split, and geographic zone, impacts of change will not be distributed evenly. By numbers of people, if changes occur throughout the Mekong, impacts will be most significant in Vietnam, followed by Cambodia and Lao PDR. Thailand will feel the least impact.

Socioeconomic conditions

According to BDP (2006), the rapid economic growth in the past two decades in the LMB has hardly improved the quality of life of the poorest section of the population. Most rural residents continue to live in great poverty. Overall, educational levels are low. The average school attendance is less than 5 years. Population growth remains high despite the decline in fertility rates and improved health conditions and life expectancy. Projected average population growth rate for 2000–2020 is highest in Lao PDR (2.6%), followed by Cambodia (2.3%), Vietnam (1.4%), and Thailand (1%).

Some information on river basin management: the Mekong River Commission (MRC)

The MRC was formed on 5 April 1995 as part of an agreement of the governments of four member countries: Cambodia, Lao PDR, Thailand, and Vietnam. However, its history dates back to more than 50 years ago, when it was first founded as the Mekong Committee by the United Nations. MRC is an intergovernmental organization providing an institutional framework to implement the 1995 agreement. The MRC secretariat serves its member countries by supporting decisions and promoting action on sustainable development and poverty alleviation as a contribution to the UN Millennium Development Goals. The 1995 agreement sets a mandate for the MRC to cooperate in all fields of sustainable development, utilization, management, and conservation of the water and related resources of the MRB. By applying the principles of integrated basin flow management (IWRM), the MRC goal is to encourage balanced and coordinated developments and investments in many areas including the Environment Programme (EP) and Basin Development Plan of the MRC (MRC 2009).

Aims of the study

This study aims to contribute to 1) the MRC Basin Development Plan, 2) long-term social impact monitoring (SIM) for MRC, 3) our understanding of the human conditions in the LMB, and 4) recommendations to reduce poverty and vulnerability in the LMB.

The Joint Committee of the MRC is charged by the 1995 agreement to formulate a basin development plan (BDP) to promote, support, cooperate in, and coordinate the development of the full potential of sustainable benefits to all the MRC member countries and the prevention of wasteful use of waters of the MRB, with emphasis on and preference for joint and/or basinwide development projects and basins programs (BDP 2006). The BDP was initiated in early 2000.

The EP began SIM in 2004 under the MRC. SIM aims to "provide regular information on the status and trends of social conditions of the people in the Basin, linked to changes in the Basin's aquatic ecosystems" (Bouapao 2004). SIM is seen as a part of the overall environmental monitoring by the EP, which also includes water quality and ecological health monitoring (Bouapao 2004). The monitoring program is based on the 1995 Agreement of the MRC, Article 3, "to protect the environment, natural resources, aquatic life, and conditions and ecological balance of the Mekong River Basin ", and Article 7, "to make every effort, to avoid, minimize, and mitigate harmful effects that might occur to the environment, especially the water quantity and quality, the aquatic (ecosystem) conditions, and ecological balance of the river systems."

My dissertation considers a number of threats to livelihoods (e.g., incomes) and food security[1] (e.g., availability of fish and rice) that are posed by changes in water regimes

[1] According to FAO (2003), food security and insecurity are defined as follows.

Food security exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food which meets their dietary needs and food preferences for an active and healthy life. Household food security is the application of this concept to the family level, with individuals within households as the focus of concern.

Food insecurity exists when people do not have adequate physical, social or

(Box 1). My research investigates the vulnerability of people to these various threats, the most important of which is hydropower development, described at length in this chapter. I will trace the potential impacts of hydropower development on fishers and farmers in subsequent chapters.

Box 1: Threats to livelihoods and food security

Threats that cause changes in water regimes include:

- Hydropower development and consequent impacts of fisheries and rice paddies
- Pollution, with consequences on water quality
- Expansion of irrigated agriculture
- Commercialization of land and conservation from agriculture, etc.

Context of the study

According to BDP (2009), the MRC Assessment Methodology follows a logical sequence as illustrated in Figure 3. The process is designed to assess the social, economic, and environmental impacts of a number of development scenarios in accordance with criteria (Figure 4) established in consultation with national and regional stakeholders. The scenarios are a product of national and regional consultations and reflect current national plans and development proposals. Each scenario includes a number of interventions for which the main impact would be to cause a change in the mainstream conditions.

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economic access to food as defined above.

BDP draws on a vast amount of research and practical application available with MRC and its member countries for the selection of appropriate criteria for the BDP scenarios. The proposed criteria are based on a series of drafts prepared in consultation with MRC programs. They also accommodate the recommendations of the 28th meeting of the Joint Committee (JC). The final criteria for the scenarios were approved in principle by the JC in August 2008. The criteria cover the triple bottom line of economically beneficial, socially just, and environmentally sound development. They also include two criteria that measure how well each scenario achieves equitable development (BDP 2009).

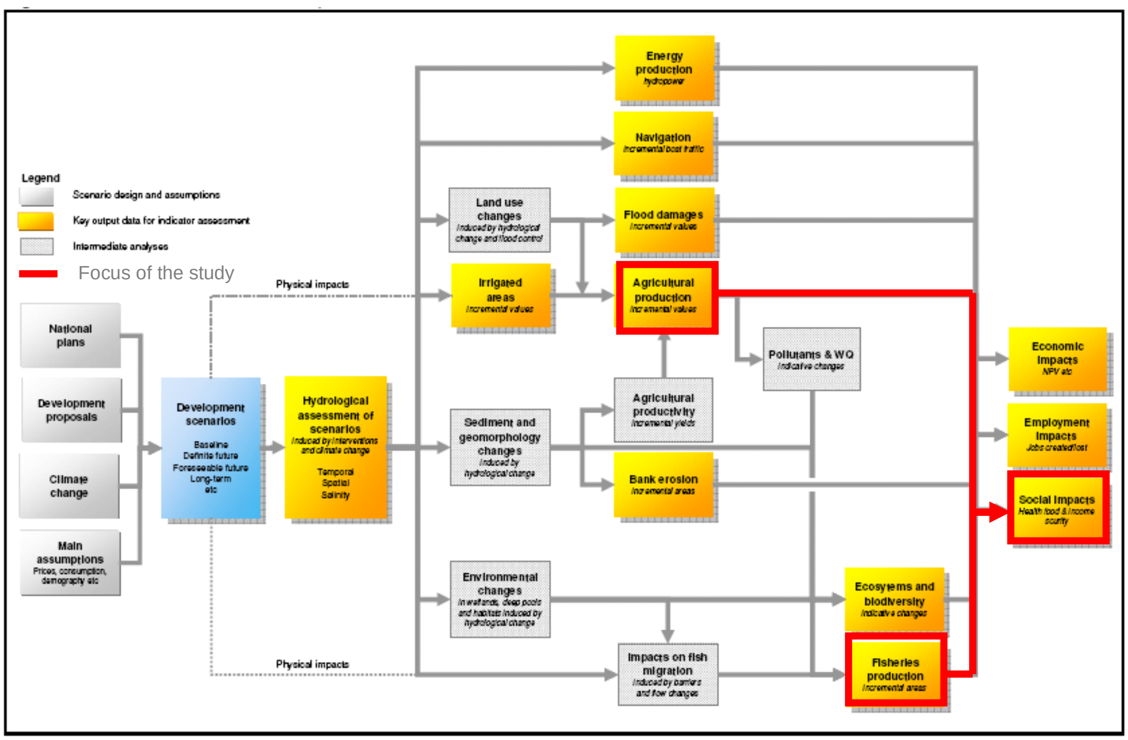

Figure 3: Overview of the MRC’s BDP assessment methodology (source: BDP 2009)

Box 2 provides a summary of the important linkages factored into the assessment approach.

Box 2: Principal linkages factored into the assessment approach

- **Hydrological indicators:** While hydrological change is in itself not included in the assessment criteria, it is clearly fundamental to assessing most other indicators. Furthermore, understanding the extent of change in the context of Articles 3, 6 and 9, which together define the acceptable limits of flow change, contributes directly to the concept of development space.
- **Irrigated areas:** Irrigated areas are determined in the Decision Support Framework (DSF) and are a product of the assumed installed irrigation facilities and the availability of water to meet the unit area water demands.
- **Energy production:** Energy production is a product of the assumed installed hydropower facilities and the flows available to generate hydropower energy.
- **Navigation:** Impacts on navigation are principally a product of the extent to which boat traffic is affected by changes to the size and duration of low flows and to any unmitigated barriers introduced to boat traffic.
- **Flood damages:** Incremental flood damages are a product of the change in flood regime, the nature and extent of flood control measures, the value of the change in land use, and the extent to which irrigated agricultural production is impacted.
- **Agricultural production:** Changes in agricultural production are brought about by changes in land use, principally through irrigation development and flood management.
- **Bank erosion:** The changes in extent and vulnerability of land to bank erosion are a product of changes in discharge and sediment transport characteristics of the

river flows.

- **Ecosystems and biodiversity:** Changes to the functioning of ecosystems and biodiversity will be brought about by changes in flow conditions in sensitive areas, changes in sediments and nutrient flows, changes in water quality induced by the interventions particularly but not exclusively from agricultural residues, changes in salinity levels, and land use changes.

- **Fisheries production:** Changes in fisheries productivity will be brought about by the same changes that affect ecosystems and biodiversity. In addition, barrier effects from dams and other control structures are expected to have a significant impact on different species, as many also be the case in the way the sector is sustainably managed in the future.

- **Economic impacts:** The economic impact of scenarios is the sum of the incremental aggregate value of the economically productive water-related sectors: hydropower, navigation, flood damage reduction, and agricultural and fisheries production.

- **Employment impacts:** The impacts on employment are a product of the changes in labor requirements within the economically productive sectors above.

- **Social impacts:** Social impacts are a product of all of the above in terms of the impacts to household health, food, and income security, with particular attention paid to the consequent impacts upon poverty levels and especially to the consequences for vulnerable groups unable to cope with the induced changes in livelihood conditions.

Source: BDP 2009

Goal	Primary Objectives		Specific development	Issue	Indicator Description	Unit	B2	B3	B4	B5	B6
					Assessment Criteria		High relevance to Work Package				
Sustainable development	Optimal development (triple bottom line)	1 Economic development	**1.1 Increase irrigated agricultural production**	Irrigable area, production tonnage and value	Incremental area Incremental crop production Net incremental economic value	'000 ha '000 ton NPV US$m	✓		✓	✓	✓
			1.2 Increase hydropower production	Hydropower capacity, power generated and value	Incremental installed capacity Incremental power generated Net incremental economic value	MW GWh/year NPV US$m	✓			✓	✓
			1.3 Improve navigation	River transport	Incremental navigable days by class Net incremental economic value	'000 boat-days NPV US$m					✓
			1.4 Decrease damages by floods	Extent and duration of annual flooding by class	Average area flooded annually to max 0.5-0.9m depth Average area flooded annually > max 0.9m depth Incremental net economic value of flood damage	'000 ha '000 ha NPV US$m		✓	✓	✓	✓
			1.5 Maintain productivity of fishery sector	Capture fisheries and aquaculture production	Incremental annual average capture fish availability Incremental annual average aquaculture production Net incremental economic value	'000 ton '000 ton NPV US$m	✓		✓	✓	✓
				Impact of flow and sediment transport changes on deep pools	Sediment loads at specified locations on mainstream Water levels at specified locations on mainstream Net incremental economic values	Trend m Trend		✓		✓	✓
		2. Environmental protection	**2.1 Maintain water quality and acceptable flow conditions**	Water quality Flow characteristics	Water quality incl. sediment in transport in mainstream Key flow charcateristics (to be defined)	Trend Trend			✓	✓	✓
				Protection of forests around Tonle Sap	Forest flooded for specified depth duration at Tonle Sap Net incremental economic values	'000 ha NPV US$m			✓	✓	✓
			2.2 Maintain wetland productivity and ecosystem services	Productivity of wetland ecosystems	Incremental wetlands with required depth-duration Net incremental economic value	'000 ha NPV US$m			✓	✓	✓
			2.3 Manage salinity intrusion in the Mekong delta	Impact of salinity intrusion on land use potential	Area within delta within thresholds of salinity levels Net incremental economic value	'000 ha NPV US$m			✓	✓	✓
			2.4 Minimize channel effects on bank erosion	River bank erosion	Incremental area at risk to erosion Vulnerability to bank erosion Net incremental economic values	'000 ha Trend Trend		✓		✓	✓
			2.5 Conservation of biodiversity	Impacts of flow management changes on endangered species	Incremental area of suitable habitats Estimated number of species affected Incremental net economic value of habitat areas	'000 ha no. NPV US$m			✓	✓	✓
		3. Social development	**3.1 Maintain livelihoods of vulnerable resource-users**	Health, food and income security	No. of people affected Severity of impact on health, food and income security	'000 h/h Trend	✓		✓	✓	✓
			3.4 Increased employment generation in water related sectors	Incremental sustainable employment from water resource interventions	Incremental number of people engaged in: Agriculture Fisheries Water-related service industries Tourism	 '000 '000 '000 '000	✓		✓	✓	✓
	4 Equitable development		**4.1 Ensure that all four LMB countries benefit from the development of water and related resources**	Aggregate benefits by country	Summation of incremental net economic benefits Summary of non-quantifiable impacts	NPV US$m Trends	✓		✓	✓	✓

Figure 4: MRC assessment criteria (source: BDP 2009)

This study hopes to contribute to understanding the social impacts of changes in agricultural and fisheries production by examining study site residents' dependence on and resilience to changes in these parameters. Specifically, the study focuses on dependence on rice and fish for occupation and food security, including income.

There are good reasons to focus on rice and fish. Both are staple foods for most people in the region. The production and the abundance of both depend on the flow regimes and availability of water.

Development activities such as hydropower dam construction can result in unintended impacts for persons upstream and downstream people. A few examples of dam impacts follow. According to Amornsakchai et al. (2000), after construction of the Pak Mun dam in Thailand on the Mun River 5.5 km upstream from its confluence with the Mekong, fish populations (particularly migratory and rapids-dependent species) declined more upstream than downstream because their migration route was blocked. The fish catch directly upstream of the dam decreased 60–80% after dam construction was completed. One or two species of fish downstream of the Pak Mun project completely disappeared from the catch after the dam construction. The report concluded that although a number of factors are involved, decline in and disappearance of the migratory and rapids-dependent species are directly attributable to impact of the location of the Pak Mun dam on migratory and rapids-dependent fish species.

The report (Amornsakchai et al. 2000) states that a large number of households were adversely affected because of the decline in fishing yield. After the dam construction, fishing communities located upstream and downstream of the dam reported 50-100% decline in fish catch as well as disappearance of many species. The number of fishing households in the upstream region decline from 95.6% to 66.7%. Fishing households found no viable means of livelihood after the dam completion, although training opportunities have been provided. As their food security and incomes destabilized they sought different ways for coping, such as emigration to urban areas in search of employment. Others had to settle in forest reserved areas or on other common property because the compensation money was not enough to buy alternative land. Households that did not use the compensation to buy productive assets were further affected by the Thai economic crisis. Income from crops declined. Number of livestock dropped as animals were sold due to a shift from farm-based occupations and a decline in grazing lands. The lost forest and grazing lands were among the other adverse impacts.

Another example of the impacts of hydropower construction is the Nam Song Diversion Project, Lao PDR, completed in 1996, funded by the Asian Development Bank (ADB) at a cost of US$31.5 million, designed to divert water to Nam Ngum reservoir to increase the generating capacity. According to KhonMuangNeua (2007), studies indicated a severe decline in fishing for more than 1,000 households, and other impacts such as shortages in clean water for washing and bathing, loss of boats and fishing nets, and loss of agricultural lands due to floods and bank erosion.

At the basinwide level, non-governmental organizations (NGOs) have long blamed China for shrinking the Mekong and causing other ecological damage by building dams on the mainstream Mekong (GRAY, 2010). “Many people suspect that China-based dams are the main reasons the Mekong's water level has been getting so low this year. …

China should think about the peoples of down-river countries too" (The Nation/Asia News Network, 2010). "The livelihood of the people living along this once mighty river may never be the same as it was only a generation ago when the river still ran free, unharnessed by any dam, and its life giving water flowed downstream. The destruction of this river and of the lives of the people who depend on it should not be allowed to happen. But it will if we all remain silent and just bear the hurt in quiet bitterness" (Prateepchaikul 2010).

In 2010, the Mekong levels become the lowest in recent decades. The unusual low level is believed by many people and organizations to be caused by the upper dams in China. It brought severe impacts on the riparian communities. In Vientiane, Lao PDR, the media reported that only irrigation systems along the mainstream Mekong were severely affected; irrigation on the tributaries did not suffer because of the low level of the Mekong **(**Syvongxay, 2010). However, some media reported that the unusually low flow in 2010 occurred also in tributaries. For example, Mekong tributaries such as the Nam Ou and Nam Khan in Lao PDR experienced low water levels, the lowest in 20 years for the Nam Ou and the lowest in 50 years for Nam Khan (McCartan, undated).

Others report that water levels have been low both in the lower and upper parts of the Mekong. "The MRC said levels at the mainstream measuring stations at Chiang Saen, Chiang Khan, LuangPrabang, Vientiane, and NongKhai are below those that occurred in the low flow season of 1993, which followed the most extreme regional drought on record in 1992. … Similarly, the river levels in Southwestern China have been at their lowest in 50 years" (Vietnam News, 2010). Drought in the upper part of the Mekong brought about impacts not only to farmers in Yunan province, but also fishers and farmers in Thailand and Lao PDR (Save the Mekong 2010).

Although the news suggests that the low flow in the mainstream Mekong in the past few decades is caused by drought, the drought might worsen the low flow due to storage of water and operation of the upstream dams. By the lack of greater transparency from China, people are left to wonder how much water is currently held behind Chinese Mekong dams after the long drought and low rainfall suffered across boundaries in the region. It is thought that China is unlikely to be willing to release additional water beyond what is necessary for electricity generation while the drought continues (McCartan, undated).

The water scarcity caused by both severe drought and water storage by upstream dams "sparked fears of food shortages, lack of access to clean water and impoverishment in some of Southeast Asia's poorest regions" (GRAY, 2010), and "will have an impact on agriculture, food security, access to clean water and river transport and will affect the economic development of people already facing serious poverty" (Vietnam News, 2010)."The present severe drought and the extreme floods of 2008 testify to the dynamic nature of the river, but also to its seasonal variation and the need for a far more cautious approach to human intervention in the river's future" (Save the Mekong 2010).

Nevertheless, dams are planned and about to be built in the lower part of the Mekong. In addition to the planned 15 dams on the upper part of the mainstream Mekong in China, 11 hydropower dams are planned in the LMB, particularly in Lao PDR. If most of the mainstream dams are built, Lao PDR will earn billions of dollars every year. It is, however, also predicted that losses to fisheries would be on the order of $US476 million per year and in the short to medium term, poverty will be made worse, particularly among the poor in rural and urban areas, by any of the mainstream hydropower projects. Having weighed the potential risk and economic benefits of the Mekong mainstream hydropower projects, the SEA of MRC recommends the projects be deferred for a decade (ICEM 2010, MRC 2010b, Wilesmith 2010). Overall, by blocking fish migration, the dams would place at risk the millions of people whose livelihoods, income, and food security depend on the river. Experience demonstrates there is no way to mitigate impacts of such large dams on fisheries (Save the Mekong 2010). While the MRC formal publication of the SEA points out that 107,000 people will be directly affected as a result of necessary relocation, and 29.6 million people in Cambodia, Lao PDR, and Thailand and 14 million in Vietnam are within the 15 km corridor of indirect impact, the media advise that these figures should be read against the total population of the LMB, being about 60% (Osborne 2010).

The dam construction on the mainstream Mekong may also cause higher tensions between countries in the LMB.

> The construction of the controversial Xayaboury dam on the Mekong River could hurt recently improving relations between Thailand and Cambodia as it would damage the latter's fisheries. …The 1,260-megawatt dam is located about 150 km downstream of Luang Prabang in Lao PDR. A majority of the power produced from the project by Thai firm CH Karnchang would be exported to Thailand. …The dam's construction would cause grave harm to the ecosystem and way of life of millions of people who live along the river. … Tonle Sap, the largest fresh water lake in Cambodia and a river system that is a major source of food and income for Cambodians, is likely to bear the brunt of the impact from the Xayaboury dam. …This environmental issue can develop into a conflict between the two countries. … Although the dam belongs to Lao PDR, Thailand is a key player in the project (Wipatayotin 2010a).

In many cases where flow is low and storage capacity is high, it may take two to three years for reservoirs to fill after new dam gates are closed. This can profoundly affect downstream populations. The low storage caused by extreme low flow such as the drought conditions in the MRB in 2010 could make it take longer than usual to fill up the reservoirs upstream. Impacts of such events will be profound. As illustrated by the case of low flow in the Mekong and its tributaries, the impacts will include shortages in water supply, lack of water for agriculture and aquaculture, and a decline in fish yields.

Extreme events such as floods also may occur because of the hydropower dams. An extreme flood occurred in October 2010 in Thailand, where 7,800 villages in 28 provinces were flooded by excessive waters from dams. Waters from dams flushed into urban centers, causing severe damage to properties and killing more than 10 people.

Some villages become islands for a number of days. Roads become waterways, cutting off transportation. Livestock were flushed away. Numerous people become homeless (Thai Television Channel 3). Two weeks of floods claimed 42 lives and continued in 27 provinces, damaging over 3.1 million *rai* of farmland and affecting approximately 2.5 million people (Anonymous 2010). The floodwaters flowed into Bangkok's Chao Phraya River at the rate of 4 million liters per second (Daniel 2010). Baht 5,000 was provided by the Thai government as financial aid for each flood-affected household, totaling Baht 5 million or US$167 million for all affected provinces (Post Reporters 2010). Damages caused by the floods are estimated to cost 106.41 million baht (about US$3.5 million) for the manufacturing sector with 259 factories in 32 provinces affected (Local News 2010).

Importantly, affected or potentially affected people may or may not be aware of such extreme events. How can all these be prevented? Such events need to be considered and taken into account when future dams are being designed, planned, implemented, and monitored.

Focus of the study

Based on the BDP Assessment Methodology and Criteria, this study hopes to contribute to determining baseline data and information on: 1) the number of people affected by changes in the availability of rice and fish in the study areas (*exposure*), 2) severity of the impacts (*sensitivity*), and 3) capacity of the population to recover from food and income shortages (*resilience*). Number of people affected will be determined by overall population of the study sites as well as their related occupations (RO).

It is assumed that people whose income and food security are directly dependent on rice and fish will be affected more than others when such resources decline. In the LMB, these are fishers and farmers. It is not known if subsistence fishers/farmers would be more affected than commercial fishers/farmers. Subsistence agriculture is self-sufficiency farming in which farmers grow only enough food to feed their families, similar to subsistence peasants who grow what they eat, build their own shelters, and live without regularly making purchases in the market (Waters 2007). For the purpose of this study, subsistence farming and fishing refers to households with sales of less than 25% of rice produced or fish caught. This delineation is subjectively drawn, and the strata will be viewed as such.

The study will thus focus on the severity of the impacts of changes in the availability of rice and fish on subsistence and commercial fishers and farmers through an examination of the proportion of related income (RI) and food (RF) they derive from rice or fish. This will be achieved through analyzing the total income earned or food consumed by the households.

I hope to understand the capacity of the population to recover from food and income shortages through an analysis of: a) location (L), b) livelihoods assets (LA), c) income diversification (ID), d) food diversification (FD), and e) supporting environment: institutions (SEI). This implies that variables to be studied are L, RO, RI, RF, LA, ID, FD, and SEI. These are important dimensions of vulnerability. In order words, vulnerability in the context of this study will be seen as a function of the variables:

V=f(L, RO, RI, RF, LA, ID, FD, SEI).

Where:

L = Location

RO= related occupations

RI = related income

RF = related food

LA = livelihoods assets

ID = income diversification

FD= food diversification

SEI= supporting environment: institutions.

Why focus on rice and fish?

"Rice plays an important role in the villagers' life and it is a symbol of well-being" (Mekong Wetland Biodiversity Programme 2005). Two-thirds of the population, or some 40 million people, in the LMB are engaged in fishing at least on a part time basis, and 65–85% of the total labor force in Cambodia, Lao PDR, and Vietnam are engaged in agricultural activities (MRC 2003). Even in Thailand, where agriculture accounts for less than 10% of gross domestic product (GDP), 70% of the workforce in the northeast region works in the agricultural sector (MRC 2003). Twenty-two percent of the area of the LMB is cultivated with rice, the major crop. Rice is typically harvested once a year, with the exception of the Mekong Delta, where 2 to 3 crops are grown (BDP 2006). In Thailand, rice occupies about 55% of the total arable land. More than 80% of Thai residents eat rice as their main meal, with an annual average of 100.8 kg per capita (Kawasaki 2010). A study of 776 villages in the Lower Songkram River Basin indicates that the most important activities for subsistence were rice farming and fishing, practiced by 92% and 92% of households, respectively. This is followed by livestock farming, accounting for 82% of the total households (MRC 2008d). In Cambodia, studies indicate that rice cultivation and fishing are the most important sources of livelihood for people living in the Tonle Sap areas (Ahmed et al. 1998).

However, it should be noted that many rural households in the LMB increasingly depend on a combination of activities, including migration. For example, 35% of workers in Cambodia hold multiple jobs. Some or all members of some farming households in rural areas work part- or full-time in nonagricultural activities.

A baseline survey on socioeconomics of households in eight fishing provinces in Cambodia undertaken during 1995–96 reported that households were found to combine farming, fishing, fish selling, fish processing and different other activities for employment, income and food (Ahmed et al. 1998). Similarly, in the Songkram River Basin, Thailand, men and women are engaged in a range of occupations (Hortle and Suntornratana 2008). In Vietnam, nonfarm income increased more than 30% between

1993 and 1998. This diversification of livelihoods helps rural people meet their basic needs, generate income, and reduce their economic vulnerability (MRC 2003, p. 60).

In the LMB, rural household animal protein for consumption is derived from fisheries and aquaculture (MRC 2003, p. 60). In the lowland areas, animal protein from inland fish and other aquatic animals ranges from 47% to 80% of animal protein, with an average intake of 18.3 g/capita/day of a total animal protein intake of 32.5 g/capital/day, which is a high intake compared to the recommended daily allowance (Hortle 2007).

In Lao PDR, over 70% of rural households depend on fishing to varying degrees for subsistence livelihood and additional cash income. In Cambodia, 40% of residents depend on the Tonle Sap Lake and its floodplains for their livelihood. Over 1.2 million people residing in fishing communes around Tonle Sap Lake rely almost entirely on fishing as their main livelihood (MRC 2003). A study conducted in eight provinces of Cambodia in 1995–96 showed that over 90% of households depended on products and benefits derived from common property resources in flooded forests, big rivers and lakes, flooded rice fields, and riverbanks (Ahmed et al. 1998). In Cambodia, fish and other aquatic animals provide over 75% of animal intake in rural areas (MRC 2003). Fish is an important part of the staple diet, supplying more than 80% of the total protein consumed in Cambodia (BDP 2006). According to World Food Programme, Vulnerability Analysis and Mapping Branch (2007), “wild meat and aquatic resources, especially wild fish, is the biggest source of animal protein in rural Lao PDR. Consumption of domesticated animals can currently not compensate for a potential loss of access to and availability of wildlife.” Some 80–90% of households fish part time (Hortle and Suntornratana 2008). In short, rice and fish are the bases for subsistence livelihoods of the millions of people in the LMB, and these will remain important in the years to come. To quote Cronin and Hamlin (2009) “subsistence livelihoods will remain important for the foreseeable near-future, and agricultural production – including fisheries – will play an important role into the future.”

Chapter 2. Literature Review

In 2005, a comprehensive literature review on vulnerability and dependence on water resources of people in the LMB was undertaken by a team contracted by the Environment Programme, MRC Secretariat. The review focused particularly on methodologies that could be adopted or adapted by the MRC in carrying out its own vulnerability assessment in the LMB. The review includes both published and unpublished documents, from the sustainable livelihoods, disaster, vulnerability, poverty, food security, gender, general development, participatory methods, assessment methods, and community-based nutrition disciplines. The review contained examples and methods from not only in Southeast Asian countries, but also other countries such as India, Uganda, and Malawi, because the review team felt that such information could be useful for the MRC's purposes, even if not in the Southeast Asian context.

The central focus of the review was on people: the human dimensions of resources use, food insecurity, and dependence on water resources related to the LMB. This implies that the abundance of literature on the biophysical and hydrological aspects of the Mekong was not included in the review unless they shed direct light on how people use the river and its water resources. For example, certain dimensions of flood pulse, floods, and dams clearly affect fish reproduction and migration; since this affects people's dependence on fisheries, such information was included. Three key areas associated with vulnerability to change in aquatic resources are included in the review: dependence, threats, and vulnerability.

This chapter will provide summaries of the literature review undertaken in 2005 (Eckman 2005, Eckman and Bouapao 2005), and updates of the issues covered by the review. Section 1 will focus on the gaps in information about vulnerability, dependence, and threats. Review of vulnerability, dependence, threats, and methods will be provided in sections 2, 3, 4, and 5 respectively. The chapter conclusion and discussion are provided in section 6.

2.1. Gaps in information about vulnerability

Eckman (2005) and Eckman and Bouapao (2005) found important gaps in information about vulnerability in the LMB. These include, but are not limited to, lack of data and information on which people are dependent and vulnerable, where are they located, why and how people become dependent and vulnerable, and when this takes place. There are also gaps in information about the scope and magnitude of various threats to livelihoods and food security, although numerous threats are identified. Information and evidence regarding people's coping mechanisms when facing stresses and threats exists, but detailed information on how these mechanisms function is sparse. Other areas with gaps include (Eckman 2005):

- access rights and property rights, especially related to aquatic resources and water tenure
- conflict as a determinant of food insecurity, poverty, and vulnerability

- labor and employment as elements of livelihoods security, as well as livelihoods data in fisheries
- nonfish aquatic resources
- gender and age (life stage) aspects
- high-quality data of Vulnerability Analysis Mapping (VAM) for Lao PDR

In fact, it is their recommendations (Eckman and Bouapao 2005) that led to a study to gain an in-depth understanding of the relationship between livelihoods and water resources (including rice and fish), known as SIMVA Phase II, which was completed in 2009. The literature review found that most of vulnerability studies tend focus on biophysical dimensions of ecosystems.

Updates on gaps

A further literature review undertaken in the late 2000s showed that although advances have been made, similar limitations exist. Most research on social vulnerability in Indochina has been based on case studies (often local in nature), current conditions (rather than future projections), a single nation (rather than across boundaries) (Luong et al. 2009), and physical/material assets (rather than social/institutional and motivational and attitudinal) (e.g., Mekong Wetland Biodiversity Programme 2005).

Although numerous guidelines and methods are readily available for vulnerability assessment, these are mostly designed for assessment at the community/village level.

Examples of approaches designed for vulnerability assessment at finer scales such as the community level include Care's Climate Vulnerability and Capacity Analysis (CVCA) (Daze' et al. 2009), and the methodology used by the Mekong Wetland Biodiversity Programme undertaken jointly by International Union for Conservation of Nature (IUCN), MRC, and United Nations Development Programme (UNDP; Mekong Wetland Biodiversity Programme 2005). It is difficult to assess the degree to which case studies' conclusions are of general relevance (Luong et al. 2009). Data for the wider scale are important for many programs such as the BDP (BDP 2009, BDP 2010), SEA (ICEM 2010), and IBFM zones (IBFM 2008).

Luong et al. (2009) pointed out that to date most research on social vulnerability has paid little attention to future projections, exploring the key processes shaping vulnerability to current hazards and trends as an analog for the future. They conclude that studies have tended to neglect the improvement of understanding that might result from comparison across boundaries. In the LMB, a number of initiatives have begun to address regional and trans-boundary issues, but these are in the early stages of development. Examples include the MRC SIMVA, initiated in 2005 (Eckman 2005, Eckman and Bouapao 2005, Fisher and Bouapao 2006), the pilot studies in the four LMB countries undertaken in 2008–09 using a standardized questionnaire (Hall and Bouapao 2010), the IBFM (MRC 2006a), and the SEA for hydropower development in the mainstream Mekong (ICEM 2010). Among these, however, SIMVA is the only activity designed to collect primary data throughout the LMB. It is also the activity that attempts to make the data comparable across national boundaries by using the same methodology and time frame. The SIMVA completed its pilot phase in 2009, and is starting the baseline survey for the whole LMB corridor from the Chinese border through the Tonle Sap Lake down to the Mekong Delta.

Another example of projects aiming to address regional and trans-boundary impacts is the “Mekong Region Future” (CSIRO AusAID 2009), undertaken by the Commonwealth Scientific and Industrial Research Organization (CSIRO), Australian Agency for International Development (AusAID). Livelihood vulnerability of people in the Greater Mekong Sub-region (GMS) will be one of the key dimensions to be addressed by the Mekong Region Futures project. Luong et al. (2009) provide an analysis of social vulnerability for Cambodia, Lao PDR, and Vietnam.

A literature review undertaken in the early 2000s found that most vulnerability studies tend focus on biophysical dimensions of ecosystems (Eckman and Bouapao 2005). A review update in the late 2000s showed similar findings, stating that previous studies associated with climate change in upland areas have focused on the biophysical dimensions, and that studies on social dimensions of climate change are limited (Espaldon et al. 2009, Mekong Wetland Biodiversity Programme 2005).

Little is known about local perceptions in LMB countries regarding vulnerability, although local people’s livelihoods are more closely linked to the immediate biophysical environment than are those of most planners, policy makers, and researchers. Local knowledge, perceptions, and understanding can be cross-referenced with other sources of knowledge to find commonalities and differences, enriching understanding of vulnerability. The advantages of local knowledge is that it is “very local specific and based on actual observed changes, as well as providing a direct link to people’s vulnerability” (WSMP 2008).

In short, vulnerability assessment has focused little on a) wide-scale studies (capable of providing conclusions of general relevance), b) future projections, exploring important processes that shape current vulnerability and trends as an analogue for the future, c) improving understanding that results from cross-border comparison, or d) social/institutional, motivational, and attitudinal dimensions.

2.2. Vulnerability

The literature review undertaken in 2005 (Eckman 2005, Eckman and Bouapao 2005) found that understanding of the terms “vulnerability” and “food insecurity” varies across organizations, reflected by various distinct definitions (e.g., Economic and Social Council, United Nations 2008, Füssel 2006, Alwang et al. 2001, Cutter et al. 2008, the World Bank 2006). Yet none of the definitions is a good fit for understanding vulnerability in the context of water resources, particularly at basin and trans-boundary scales. Certain groups of people are more vulnerable than others, but information is limited. The literature review suggests that food insecurity is widespread throughout the LMB. Food availability and insecurity show strong seasonable variation in all countries. There is a strong relationship among vulnerability, the capacity of people, and the processes that link the two. Vulnerability assessment needs to take into account people’s capacities as well as resilience and mitigation over time. The literature review identified that people's capacities are a key variable in determining their resilience to complex and interacting threats, and hence to reducing their vulnerability. Enhancing capacities will enable people to better withstand stresses and shocks and to recover from extreme events. The review identified that people adopt a variety of coping strategies to deal with stresses and threats, and that numerous coping strategies exist, depending on local conditions, assets, and cultures.

Updates on vulnerability

In the last few years, considerable attention has been paid to climate change–related vulnerabilities (Daze' et al. 2009, Cruze et al. 2007, Chinvanno et al. 2008, Downing and Patwardhan 2005, Espaldon et al. 2009, FÜssel et al. 2006, Mekong Wetland Biodiversity Programme 2005, Pulhin et al. 2008, Cutter et al. 2008), and the term *social vulnerability* has appeared more frequently in the literature (O'Brien et al. 2004, Luong et al. 2009, WFP 2010b, Eckman 2007, Davis et al. 2004, Hall and Bouapao 2010, Cutter et al. 2003), suggesting greater attention to the concept. Attention has also been extended to social vulnerabilities in the context of water resources (Downing et al. 2006, UNFCCC 2007).

In the context of LMB, a body of vulnerability assessment exists (Joy 2007, ADPC and IUCN 2003, Ministry of Planning, Royal Government of Cambodia and United Nations World Food Programme 2003, Luong et al. 2009). Vulnerability is defined as "the ability of an individual, group, or society to cope with, respond to, and adapt to a range of external stresses, including both environmental and societal change" Luong et al. (2009), and social vulnerability "is a function of specific social, economic, geographical and political characteristics" (ibid). Vulnerability includes a range of factors that expose households and make them susceptible to particular hazards (WFP 2010b).

In Asia, it is documented that vulnerabilities of people and ecosystems are not only comparable, but *actually connected to vulnerabilities somewhere else* (Adger et al. 2009). The response of a nation or community to new opportunities or economic insecurity may cause vulnerability somewhere else through migration, land use change, disease transmission, and social marginalization (ibid). Adger et al. (2009) argue that vulnerability needs to be recognized as a phenomenon that is teleconnected and interdependent. They note that the increasing interconnection of global commodity markets implies that vulnerabilities of farmers in Asia are directly linked to those in Europe or elsewhere. They suggest that while local vulnerability assessments are important, understanding interrelated vulnerabilities of local but distant spaces will be important for future studies.

In the context of water-related resources in Asia, it is projected that climate change will result in[2] a) increasing water stress for over 100 million people because of the decline in freshwater availability, b) decrease in river flows as glaciers disappear, c) decreases in crop yield, putting many million people at risk from hunger, and d) increased land

[2] In the context of climate change, the Intergovernmental Panel on Climate Change (IPCC) warned that as a result of the projected global warming, a higher frequency of intense extreme events all across Asia is possible (Cruze et al. 2007).

degradation and desertification due to reduced soil moisture and evapotranspiration (UNFCCC 2007). Communities reports of damaging floods appear to have occurred with greater regularity in recent years (Mekong Wetland Biodiversity Programme 2005). A study on the impacts of climate change on agriculture in four provinces in Cambodia indicated that rice production variability and climate variability are correlated, particularly because of floods and droughts (Thoeun 2008).

Since 2005, after the literature view of the MRC team (Eckman 2005, Eckman and Bouapao 2005), vulnerability is still viewed differently by different authors (eg. FÜssel 2006, Cutter and Finch 2008), although there have been certain agreements in certain definitions (Daze' 2009, IPCC 2001, Cruz et al. 2007, Adger 2000). For example, Care International follows the definition of IPCC, Working Group II (2001)[3] for its Climate Vulnerability and Capacity Analysis (Daze' 2009). Yet the IPCC definition has been challenged by the IPCC itself (Carter et al. 2007), noting that the IPCC definition needs to "account for an expanded remit by including social vulnerability (O'Brien et al. 2004) and to reconcile it with risk assessment (Downing and Patwardhan 2005)". Cater et al. (2007) note that states of vulnerability to climate risk include vulnerability to current climate, vulnerability to climate change in the absence of adaptation and mitigation measures, and residual vulnerability (Jones et al., 2007), and that care should be taken to describe clearly the meanings and derivation of vulnerability, as it is largely dependent

[3] "the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes" (IPCC, Working Group 2001).

on context and scale (Downing and Patwardhan 2005).

Who are most vulnerable?

In the context of floods in urban areas, Lebel et al. (2009) conclude that low-income households are more vulnerable than wealthier households, and that within the lower income group, migrants, women, children, disabled, and elderly are most vulnerable. In the context of upland areas, agriculture is seen as the most vulnerable sector to extreme events related to climate change (Espaldon et al. 2009). Data from six countries reveal that rice production is most negatively affected in both upland and lowland areas by climate change (ibid). People who most immediately and directly rely on natural resources are often the most vulnerable to impacts of environmental change (Lebel et al. 2009b). The vulnerable include children, female-headed households, the elderly, and disabled persons (Alwang et al. 2001, Davis 1996).

A comparison between communities in Savannakhet province of Lao PDR and others in Ubon Ratchathani province of Thailand regarding vulnerability to climate change shows that rain-fed rice farmers in Ubon Ratchathani are more vulnerable than farmers in Savannakhet province because they depend highly on income from rice farming and have less coping capacity. The results also indicate that rain-fed rice farmers in Savannakhet are likely to be less vulnerable because of the diversity in income sources and the natural resources that support their livelihoods (Chinvanno et al. 2008).

Poverty in rural areas caused by factors such as limited opportunities for skill development, investment, or innovation is a major source of vulnerability to both environmental and market challenges. Furthermore, social vulnerability is not fixed, but highly dynamic in the fast-growing, poorer regions (Luong et al. 2009).

The final report of the SEA of Mekong Mainstream Hydropower under the MRC (ICEM 2010) concluded that vulnerability of rural populations increased because all of the LMB countries reveal continued depletion/contamination of natural resources coupled with very high dependence of livelihoods on river and land resources, especially for ethnic minorities. People most directly and immediately dependent on natural resources are often most vulnerable to environmental change (Lebel et al. 2009b). The ICEM (2010) continues to conclude that as livelihoods are disrupted or communities that depend on natural resources are increasingly removed from traditional sources of livelihood, the incidence of stunting, wasting, and other form of disease related to poverty increases because the food chain is disrupted or cut off. Wild foods are extremely important for both food security and nutritional intake and cannot easily be replaced by meat from livestock because of the constraints of storage, transport, land availability to raise livestock, and cost associated with maintaining animals. The most vulnerable groups of people are those with low diversity in livelihood activities and income sources.

Resilience

Based on the Food Insecurity and Vulnerability Information and Mapping Systems (FIVIMS) framework, level of vulnerability is determined by the capacity to cope with stresses (FIVIMS 2009, FIVIMS 2010). Two people may be equally vulnerable to a drought, but they might differ in their ability to cope. Consequently, any discussion of vulnerability must be coupled with an examination of resilience (Haughton 2004). Income diversity and the variability of income sources over time can be an indicator of vulnerability at the household level, where it is hypothesized that the higher the diversity of income, the greater the resilience of livelihoods to disruption of specific income sources (Adger 1999).

Assets are an important means of resilience (Moser 1996, Adger et al. 2004b, DIFID 1999). Households with welfare-generating assets are considered less vulnerable to welfare losses associated with extreme events such as floods and droughts (Alwang *et al.,* 2001). Livestock is an important livelihood asset that enhances household capability to recover or withstand shock. A case study in Lao PDR reported that losing livestock is the most serious loss of long-term livelihood and household security in a flood event. Buffalo and cows are used as a mechanism for saving. The sale of livestock is an important source of funds when a disaster strikes or medical emergency arises. Livestock serve as safety net and are often the most valuable asset in a household. Cows and buffalo also play an important role in livelihood as draft animals in the paddy fields (Mekong Wetland Biodiversity Programme 2005). In rural Lao PDR, the value of one buffalo can cover the cost of rice to feed four or five people for a year (WFP 2001). After any extreme even such as a flood, the loss of livestock and/or rice and paddy fields makes households more vulnerable due to the diminishing of their safety nets.

Households that were previously quite wealthy might suddenly find themselves in a precarious situation. Their sense of security also drops because of the degradation of important household assets (Mekong Wetland Biodiversity Programme 2005).

Long wooden boats are another important asset. They are used for fishing and also for travel to neighboring villages or to towns for supplies of rice and other basic needs. During difficult times such as flooding, they are particularly important. They enable households to recover goods, search for cattle, etc., in the immediate aftermath of the event. Losing a boat severely limits the opportunities for maintaining income from fishing, especially for reaching desirable fishing grounds (Mekong Wetland Biodiversity Programme 2005).

Adaptive capacity differs between countries, depending on social structure, culture, economic capacity, geography, and the degree of environmental degradation. Capacity is increasing in some parts of Asia – witness the success of early warning systems for extreme events in Bangladesh and in the Philippines. But capacity is still limited due to poor resource bases, inequalities in income, weak institutions, and limited technology (UNFCCC 2007).

Coping and adaptation

According to UNFCC (2007), local communities hold a large body of knowledge and experience on coping with climatic variability and extreme events. Local people have always aimed to adapt to variability in their climate. To adapt they have made preparations based on their resources and knowledge accumulated through past experience in changing weather patterns. This includes experience to recover from extreme event such as floods, drought, and hurricanes. In the context of LMB, past studies indicate that communities and households have developed a variety of ways dealing with extreme events such as floods for centuries by drawing on the plentiful resources of the wetlands around the community. Although not all the coping strategies developed by the communities are effective in helping them to improve their livelihoods, the strategies do allow households to meet their most basic and immediate (Mekong Wetland Biodiversity Progamme 2005). Examples of the strategies are finding alternative sources of livelihood, turning to family and friends, selling labor and making goods for sale, selling livelihood assets, going into debt, and accepting assistance from the government and/or other organizations. At the community level, coping strategies include rice banks, village funds, livestock enclosures, and revolving animal banks (Mekong Wetland Biodiversity Programme 2005). Household vulnerability in the LMB will likely increase because livelihoods and coping strategies are both highly dependent on natural resources that are declining, significantly reducing households' capacity to cope with extreme events (Mekong Wetland Biodiversity Programme 2005).

According to UNFCCC (2007), adaptation to climate change in developing countries is important and has been highlighted by those countries as urgent or high priority. Although the extent of climate change impacts remains uncertain, there is sufficient information and knowledge on strategies and plans to implement adaptation activities in many developing countries. However, adaptation is not easy due to limited human capacity and financial resources. The most effective adaptation approaches for developing countries are those addressing a range of environmental stresses and factors. To be likely to succeed, strategies need to link with coordinated efforts aimed at reducing poverty, combating land degradation, reducing loss of biodiversity and ecosystem services, and improving adaptive capacity. Some quantitative research uses indicators associated with adaptive capacity such as environmental capacities, human resources, and national economic capacity (Moss et al. 2001, Carter et al. 2007). Other research uses indicators related to conditions, processes, and structures that promote or constrain adaptive capacity (Eriksen et al. 2005).

In short, consideration of the social dimensions of vulnerability has gained attention. Understanding of vulnerability has improved not only through comparison across space and over time, but also through linkages between distant places, useful for trans-boundary impact assessment. Vulnerability assessment has paid considerable attention to coping and adaptation at various levels, ranging from households to entire countries. Recent vulnerability literature confirms the critical vulnerable groups, including people whose livelihoods depend on natural resources or who have low diversity in sources of income. Coping and adaptation strategies are available and used by local communities to meet their basic needs (although they do not necessarily help to improve their livelihoods). Nevertheless, because the strategies currently being used are highly dependent on natural resources and the resources are in decline, the capacity of people to cope with shocks and stresses is also declining.

2.3. Dependence

The MRC literature review (Eckman 2005, Eckman and Bouapao 2005) confirmed that there is a clear and widespread dependence on water resources in the LMB. The review confirmed the critical importance of aquatic resources, particularly fish, to the livelihoods and food security of the people in the LMB. People use all sizes and types of fish, and there is very little wastage of this valuable resource. There is considerable variability in the availability of fish resources from one site to another and from season to season. Dependence on fish for income and food experiences seasonal cycles associated with fish migration. The link between dependence and vulnerability, however, is less direct, with intermediate links between the two. Eckman (2005) concluded that a number of highly useful data sets about food security/insecurity exist for all LMB countries. This includes FIVIMS, VAM, and Global Information and Early Warning System (GWIES). The databases for each LMB country identify its most food-insecure and vulnerable districts and communities.

Updates on dependence

Since 2005, studies indicate that while livelihoods and food security in the LMB continue to depend largely on natural resources, including rice and fish (BDP 2006, Kawasaki 2010, Hall et al. 2006, IBFM 2006), natural resources, including rice and fish, have declined in availability (MRC 2008a, Vannak 2010). Access to natural resources such as fishery resources is highly unequal (Serey 2008). Dependence is highly seasonal (Meusch et al. 2003, Mollot et al. 2003, Balzer et al. 2005, Halwart 2008), and distance to rivers, lakes, and wetlands plays an important role in the degree of dependence on water resources (Bouapao and Hall 2010). Subsistence livelihoods in the LMB will remain important for the near future, and agricultural production and fisheries will continue to play an important role in the years to come (Cronin and Hamlin, 2007-2009).

Adger et al. (2004) suggest a number of indicators useful in presenting dependence on agriculture: agriculture employees (percent of total population), rural population (percent of total), and agricultural export (percent of GDP). Indicators related to natural resources and ecosystems are protected land area, percent of forest cover, water resources per capita, groundwater recharge per capita, unpopulated land area (percent), and forest change (percent per year).

In short, while the dependence of livelihoods on natural resources, including water resources, remains high and income diversity remains low for millions of people in LMB countries, the resources they depend on are declining. This implies that vulnerability to extreme events related to climate changes (such as floods) and development (such as hydropower dams on the mainstreams that will inevitably bring about adverse impacts on the fish population and hence income and food) is increasing rather than decreasing.

2.4. Threats

The MRC literature review (Eckman 2005 and Eckman and Bouapao 2005) identified diverse threats to people, their livelihoods, and the resources they use, many of which interact. The threats are from a wide variety of sources, many beyond the knowledge or control of the people or organizations. Examples include population growth, changes in rights to access common property resources, climate extremes, and development activities. It would be very costly and politically challenging to address each of the threats in a comprehensive way for the purpose of reducing vulnerability and poverty.

Most of the literature relevant to development and livelihoods addresses the concept of threat rather than risk. Risk is more associated with disaster and disaster management. The two are from different domains and use different methodologies and working terminologies. The literature review identified threats to human dependence on water resources that were already known and expected. Examples include destruction of aquatic species habitat, blockage of fish migration (e.g., damming), reduced access to common property resources, demographic pressures, conversion of land to other uses (especially wetlands), unsustainable fishing and land use practices, uncontrolled forest fires (Lao PDR), pollution (including pesticides and fertilizers), water control structures, and post-harvest losses (Thailand and Vietnam).

Common threats shared by all the LMB countries are floods, drought, conversion of land, and unsustainable practices. Eckman (2005) noted other known threats that were not widely noted in the literature, including invasive species, loss of access to property rights, conflict, labor considerations such as migration and labor shortages, and the threat of HIV/AIDS to food security.

The literature review confirmed that threats in a given location are often complex and interacting, with negative implications for both people and water resources. For ecosystems, rarely is a given species imperiled as a result of a single threat, and it is often impossible to tease out the intertwined consequences of the numerous disturbances happening with a given ecosystem. In threat analysis, the categories themselves often overlap, implying the difficulty in isolating plausible causes.

Updates on threats

Threats that have been hotly debated in the past few years (and that will likely to be debated in the years to come) can be grouped into development activities (most immediate) and natural extremes, particularly climate change (longer term). The most frequently assessed threat is hydropower development in the mainstream Mekong (also others in its tributaries) (e.g., Amornsakchai et al. 2000, KhonMuangNeua 2007, GRAY 2010, Prateepchaikul 2010, Syvongxay 2010**,** Save the Mekong 2010, ICEM 2010, MRC 2010, Wilesmith 2010, Osborne 2010), which will have significant impacts on fish populations (e.g., Amornsakchai et al. 2000, KhonMuangNeua 2007), agricultural lands (KhonMuangNeua 2007), and hence livelihoods of the millions of people living nearby and beyond (ICEM 2010, MRC 2010b, Wilesmith 2010).

In relation to climate change, more frequent and intense flooding is expected (Office of Environmental Policy and Planning 2000, Kingdom of Cambodia 2002). Rice production in Cambodia will be more variable, particularly around Tonle Sap Lake and the Mekong River (Ministry of Planning, Kingdom of Cambodia 2002). In Thailand, agricultural development could be affected substantially, although the impacts would vary among crops and provinces. Crop yields and cropping patterns might be severely affected (Office of Environmental Policy and Planning 2000). In Vietnam, the growing season might increase. Crop productivity might be affected. Vegetation coverage and the forest would be seriously affected. The coastal zone would be severely affected, with millions of hectares of the Mekong Delta inundated. Human health would be negatively affected (Socialist Republic of Vietnam 2003).

2.5. Methods

Eckman (2005) and Eckman and Bouapao (2005) noted in their literature review that developed methods for assessing vulnerability, livelihoods, and threats including conceptual models that already exist. Examples of methods for assessing vulnerability include Capabilities and Vulnerability Analysis (CVA), Vulnerability and Capacity Assessment (VCA), Risk Mapping and Local Capacities (RMLC), Socioeconomic and Gender Assessment Methodology (SEAGA) of Food and Agriculture Organization FAO), Asset Vulnerability Framework (AVF), and Coping Strategies Index (CSI). Examples of methods for assessing livelihoods include Household Livelihood Security Assessment (HLSA), and Participatory Learning and Assessment (PLA). Examples of methods for assessing threats include strengths, weaknesses, opportunities, and threats (SWOT) analysis and Precautionary Monitoring, based on community-defined indicators of unsustainability (Eckman 1994). Both are tested methodologies, although SWOT is by far more widely known. Still others are more qualitative, strongly participatory and adaptable to variety of information needs. Examples of these include Participatory Rural Assessment or Appraisal (PRA), PLA, and Gender-Differentiated Task Calendar

(GDTC).

Other methods are intended for monitoring of food insecurity, such as the FIVIMS (FAO 2000) and the Vulnerability Assessment Mapping (VAM) (WFP 2010b). These methods have contributed to the identification of most food-insecure communities in the LMB. However, they have never been applied to river systems (Eckman 2007). Although none is designed expressly for assessment of social vulnerability in the context of water resources, Eckman and Bouapao (2005) suggest they could be modified to suit to the need for vulnerability assessment in the context river basin management. For example:

- CARE’s HLSA method (Cannon et al undated) may be useful to assess livelihoods.
- FAO's FIVIMS approach can be applicable for vulnerability mapping across countries and sub-areas.
- The RMLC method and CVA (Cannon undated) may be useful to assess vulnerabilities and threats to local communities.
- The CSI framework (WFP and CARE) can be useful for assessing coping strategies of dependent and food-insecure families.
- Certain socioeconomic survey approaches and PRA techniques can be useful for vulnerability assessment in the context of water resources.

Updates on methods

A number of studies on vulnerability took place in the recent years using a combination of approaches, such as multi-stakeholder processes and multi-criteria (e.g., Mekong Wetland Biodiversity Programme 2005, Phulhin et al. 2008, Chinvanno et al. 2008, BDP 2010, Luong et al. 2009, UNFCCC 2007), and new methods were developed specifically for assessing vulnerability to climate change (e.g., Daze' et al. 2009). A joint study of the MRC, IUCN, and UNDP Mekong Wetland Biodiversity Programme uses a *multi-stakeholder process* for its vulnerability assessment. Men and women grouped by main type of livelihood (e.g., fishing, farming) are involved in the discussion (Mekong Wetland Biodiversity Programme 2005). The assessment considers vulnerability to floods, with the combined assets of a household before and after determining the vulnerability of the household to flooding. Such a study focuses on the flood's impact on households and how flooding affects the capacity of the household to maintain its livelihood. Impact indicators used for the study are physical/material (losses of rice and paddy fields, livestock, and equipment; housing damage), social/institutional, and motivational/attitudinal. For local people, if only one indicator is used to assess vulnerability, villagers would use rice sufficiency (whether a family has a sufficient amount of rice for the whole year). Physical assets are key elements that reduce vulnerability for many households. Proximity to roads and urban centers also plays an important role in determining vulnerability. The study compares two villages, and results show that proximity can significantly increase livelihood opportunities such as trade. One of the studies carried out in Philippines (Phulhin et al. 2008, cited in Espaldon et al.

2009) looked at the nature and degree of human vulnerability to climate-related impacts at two levels: community and household. At the community level, four areas of concern were covered: food availability, water supply, livelihood, and health conditions. At the household level, based on the four major areas of concerns, vulnerability indicators were identified and an index was developed. The index was to determine the factors affecting the vulnerability of households to climate variability and extreme events. Results of the assessment showed that, given the same climate extremes, vulnerability is different between different socioeconomic strata, depending on livelihood, assets, and the effectiveness of coping mechanisms and/or adaptation strategies.

A vulnerability study of rain-fed farming in Lao PDR and Thailand (Chinvanno et al. 2008, cited in Espaldon et al. 2008) uses a *multi-criteria method* to identify and categorize the vulnerable groups in the study area. The criteria include dependence on on-farm production, economic conditions, and coping capacity of households.

Luong et al. (2009) provide an analysis of social vulnerability for Cambodia, Lao PDR, and Vietnam based around factors of poverty and inequality; property rights, particularly changes in land allocation and ownership; and the changing roles of formal and informal institutions as a framework for the analysis.

Care's CVCA (Daze' et al. 2009) provides a framework for analyzing vulnerability and capacity to adapt to climate change at the community level. It is a methodology for collecting and analyzing data on vulnerability and adaptive capacity of communities, households, and individuals, taking into account the role of local and national institutions. Its tools include participatory research, analysis, and learning. CVCA focuses on climate change. It examines both hazards and conditions and provides analysis of the interactions between them. It emphasizes multi-stakeholders analysis, collaborative learning, and dialogue. Although the CVCA emphasizes communities, it includes enabling environments. It recognizes that vulnerability to climate change might differ within countries, communities, and even households. With this, to suit requirements of specific groups, context-specific activities are important. Yet it considers national institutions that play an important role in shaping capacity of people to adapt to climate change (Daze' et al. 2009).

Regarding broader dimensions of vulnerability, the practice of vulnerability assessment (e.g., BDP 2010) is based mainly on the concepts of exposure, sensitivity, and resilience (Alwang et al. 2001, Bohle et al. 1994, Downing et al. 2006, Prowse 2003, Eckman 2005, Cannon et al. 2003). Increasingly it calls for inclusion of policy measures that emphasize social aspects, involving strengthening collective action, protecting common property resources, diversifying livelihoods, and reducing poverty (O'Brien et al. 2004b). This enhances the capacity to respond to stressors and secure livelihoods under present conditions in a way that can also reduce vulnerability to future climate change (Carter et al. 2007), and determinants of adaptive capacity (Turner et al. 2003, Schröter et al. 2005; O'Brien and Vogel 2006).

In assessing the different scenarios of the MRC BDP, aspects of social impacts considered are dependency, exposure, sensitivity, and resilience (Box 3).

Box 3: Assessment dimensions and key indicators

Dimensions	Definition	Key Indicators
Dependency	The proportion of the population for whom river resources are important for upholding livelihoods, health and well-being	percent part-time fishers percent full-time fishers percent households engaged in collection of other aquatic animals (OAA) Consumption of fish/fish products
Exposure	The state of being exposed to contact with something – here defined by location, viz., hydropower dams and rivers that are affected by dam construction	Location in areas directly affected by hydropower dams upstream/downstream Location on floodplains Proximity to rivers, tributaries, and wetlands connected to the main river system Impacts on fish and other aquatic animals/plants (OAA/P)s Increase in irrigation area Flooding risks
Sensitivity	The degree to which a system (e.g., human, environmental,	Dependency value/rank (% fishers) Importance of fish and OAA for

	biological) is affected by and responds to stimuli in proportion to their magnitude	food security
Resilience	The capacity of a system (e.g., human, environment, biological) to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure, identity, and feedbacks	Poverty rate Access to social services Alternative livelihoods, including aquaculture Literacy rate

Source: BDP 2010

Looking at the key indicators, dependency and sensitivity can fall under the same category, simply because the indicators can be the same. Dependency value/rank (percent fishers) within the sensitivity dimension can mean percent part-time fishers, percent full-time fishers, and percent households engaged in collection of OAA/P in the dependency category.

In Australia, social vulnerability is assessed through four levels: individual within household (relating to personal attributes), community (relating to how people interact with those around them), regional/geographical (relating to how far people are from services), and administrative/institutional (relating to disaster funding and mitigation studies) (Dwyer et al. 2004).

In short, the methods recently developed and used for vulnerability assessment have differed from one case to another, using multiple stakeholders, processes, and criteria for their assessment. No single method is universally useful. Yet the methods used and developed tend to fit into the broader aspects of vulnerability that is quite widely referred to, particularly exposure, sensitivity, and resilience.

2.6. Chapter conclusion and discussion

To reiterate, vulnerability assessment is focused mainly on 1) case studies, from which it is difficult to draw conclusions about general relevance; 2) present conditions, rather than future projections, to help planning and decision-making; 3) single space, rather than a cross-border or trans-boundary scope; and 4) biophysical dimensions of vulnerability, with little on non-biophysical vulnerabilities. Social vulnerabilities have gained substantial attention from researchers, although much remains for further work. It is also useful to reiterate that vulnerability is not just comparable across space and time, but also connected. It might be very important to increase understanding about this, especially at this time of globalization and regionalization.

Coping and adaptation capacities are important aspects of vulnerability assessment. These should be assessed at different levels, ranging from individual to national and regional. Recent vulnerability literature confirms that people whose livelihoods depend on natural resources, including water resources, are particularly vulnerable to declines in such resources. Unfortunately, these resources are declining, increasing vulnerability of people with few livelihood options. A study undertaken in the LMB in 2009 indicated that members of close to one in three households across the study sites believed it would be difficult for them to find an alternative to their present water-dependent livelihood activity (Hall and Bouapao 2010). Households in the Tonle Sap Lake area appeared to be particularly vulnerable, with close to 80% of the respondents saying they could not think of any alternative to their current livelihood activities (primarily fishing and flood recession agriculture) if there were significant decline in the productivity of current resources (ibid.).

Local communities are using coping and adaptation strategies to meet their basic needs. However, the strategies are threatened because they rely heavily on natural resources that are declining due to a variety of causes. This suggests a need for immediate attention of government and international organizations to help to reduce vulnerabilities. Otherwise, because vulnerability is a major part of poverty. poverty reduction—one main goal of the Millennium Development Goals (UNDP 2006)—will not be achieved (Prowse 2003).

There are many threats to livelihoods of the people in the LMB, and they are not new. Literature documents similar stories. What is new is that threats are happening now and will happen in the future, unless appropriate measures, including climate change adaptation measures, are taken to reduce them and minimize potential impacts. In terms of potential impacts of development activities, old mistakes made by developed countries or even developing countries could be avoided based on lessons learned.

Numerous methods for vulnerability assessment have been developed and continue to be developed, including those developed specifically to fit the context of water resources management, such as the water poverty index (Sullivan and Meigh 2003). The methods are highly adaptable to meet specific objectives, as reflected by vulnerability assessments undertaken in different parts of Asia in which different assessment methods yielded interesting and useful findings. This suggests that no single method fits all circumstances (FÜssel 2006), but many methods exist and are adaptable.

Chapter 3. Approach

3.1. Research problem

It has been documented that people in the LMB are highly dependent on rice and fish for livelihoods and food security and so are highly vulnerable to changes in these resources. However, we do not know enough about this to make policy recommendations (Eckman and Bouapao 2005). For example, the MRC (2010b) in a general way states that "throughout the basin, households rely on capture fisheries, agriculture … NTFPs and a number of other natural resources based activities, or ancillary services associated with them … for their livelihoods." It is known that people in the LMB are highly dependent on fish as a main source of animal protein. However, it is not known specifically who is most dependent and vulnerable and where they are located. It is known that in eight provinces of Cambodia in 1995–96, over 90% of households depend on products and benefits from resources in flooded forests, big rivers and lakes, flooded rice fields, and riverbanks (Ahmed et al. 1998), but the information does not show how much they depend on the resources. Also, this does not tell us if the dependence is the same for other countries of the LMB. Most studies of social vulnerability have been based on case studies, often local in nature, and it is not easy to assess the degree to which conclusions of such studies are of general relevance (Luong et al. 2009, p. 377). Moreover, research has tended to be limited to a single country, neglecting the improvement in understanding that could result from comparison across national boundaries (ibid).

I hope to contribute to the understanding of how rice and fish availability affect occupation and food security of people in the LMB. My research describes and explains which, how, when, and why people are vulnerable to disruptions in resources by comparing data from four study sites in the four LMB countries.

3.2. A method to assess vulnerability

I will use the inductive method to undertake the study. Inductive research refers to working from specific observations to broader generalizations and theories, in contrast to the deductive approach, which works from the more general to the more specific (Trochim 2006). Inductive research begins with observations and look for patterns and development theories from the ground up without preconceptions (Babbie 2001). At this early stage of the development of social impact monitoring and vulnerability assessment for the LMB, cross tabulations may yield more valuable information than hypothesis testing. I will begin with observations derived from field studies, and will use detected patterns and regularities for conclusions and/or theories. I will use thick description to support this: ”In anthropology and other fields, a thick description of a human behavior is one that explains not just the behavior, but its context as well, such that the behavior becomes meaningful to an outsider” (Wikipedia 2010).

Normally a dam is built and impacts are studied later. On other natural resources development projects, often donors and project decision-makers are unaware of unintended socioeconomic and environmental impacts of projects until a crisis occurs (Eckman 1994). In her dissertation, Eckman examined some of the conventional methodologies used to plan and monitor projects, and considered whether there were opportunities for building safeguards into projects to anticipate, detect, and mitigate potential negative impacts. Her conclusion was that application of the precautionary approach is helpful in capturing the impacts (ibid).

Applying the precautionary concept in this research, I am trying to capture impacts before projects start. In other words, conceptually, I am looking at how to preserve practices, social structures, and farming systems in the face of development activities. The perspective of the study is to anticipate what might go wrong and reflect back to inform dam managers and influence flow regimes. It is precautionary, rather than reactionary. The precautionary approach is useful for stakeholders to anticipate socioeconomic and environmental implications, and hence provide a mechanism for feedback, warning, and correction or mitigation (Eckman 1994). Based on the findings and data, guidelines can and should be developed for policy makers. The importance of this work is its implications for policies. The inductive research method should be useful for this purpose.

My research provides the first basinwide survey conducted across several countries in the LMB using the same methodology with the same objectives. This is reflected by the available literature:

> *"Gathering comparable data for socio-economic indicators across four countries with differing social conditions, levels of development, and systems for the gathering and processing of statistics is necessarily a very difficult task.*

Given that data has been collected in Cambodia, Lao PDR, Thailand, and Viet Nam at different times using differing definitions and methodologies, it is often impossible to generate a dataset for an indicator that is perfectly comparable across the four countries. One major problem comes from having to compare data values that come from different years" (MRC 2003).

My study aims to gather *baseline information* about people who are most concerned with rice and fish, the two most important water-based foods and sources for income. The study also aims to develop a *basic understanding* about the people likely to be most dependent on fish and rice production.

One way to look at adaptation is to look for long-term trends in indebtedness and savings. Longitudinal research is beyond the scope of this study. However, MRC will repeat the survey in three to five years. Eventually, the repeated surveys will document adaptation and coping strategies. For example, repeated surveys can indicate adaptation if people have more money to save. The repeated surveys will also be able to capture how policy makers adapt relevant policy and change policies. Overall, data produced by this study will be useful for measuring long-term changes in human vulnerability. In addition, MRC can compare the data with flow regime data to predict a variety of potential outcomes.

In fact, information from this study already has been used by other MRC programs such as the BDP, the SEA of the Initiative on Sustainable Hydropower, and the Climate Change and Adaptation Initiative (CCAI), and will be useful to other MRC activities.

BDP states that “monitoring represents a key instrument in the planning cycle” and that “a cornerstone of this process is that each cycle includes monitoring of how the implementing the plans has impacted on the basin” (BDP 2010). BDP social assessment issues include a) number of people at risk of loss of livelihoods and b) severity of impact on livelihoods (ibid). My study contributes new knowledge in both of these areas. In fact, these areas are the subject of this study, to be analyzed and discussed in detailed in the following chapters.

The study and monitoring (longitudinal study) processes will help identify areas with a high proportion of vulnerable resource users, where proposed projects are likely to have a high impact, and the study could provide inputs into the impact assessments of these projects over time. The study can also help monitor social trends and assess the extent to which projects maintain local livelihood opportunities. Ultimately, results of the study can be used to assess whether projected changes under each scenario of the BDP have taken place so planners can refine scenarios (Hall and Bouapao 2010). Results of the study will support considerations of social impacts of hydropower development. They will be useful in determining the extent to which modeled downstream changes in flow actually impact resource users. They can be useful for measuring changes in people’s livelihoods through opportunities created by the dam (e.g., reservoir fisheries, employment during construction and operation, improved road and power networks, greater access to social services and tourism). The study also can be useful to quantify losses in resources and to attribute economic values to these (ibid).

Analytical framework

Stratified sampling will be used to guide the analysis. As shown by Figure 5, the sampling frame will focus on four strata of analysis: subsistence farmers (sale of rice produced < 25%), commercial farmers (sale > 25%), subsistence fishers (sale of fish caught < 25%), and commercial fishers (sale > 25%). Analysis of farmers and fishers will be provided for the whole LMB with break-down study sites as shown in Table 3.

Figure 5: Sampling frame: Who most concerns us?

Table 3: Analysis of farmers and fishers by country study sites

Strata	LMB	Cambodia study sites	Lao PDR study sites	Thailand study sites	Vietnam study sites	Total
1. SFa						
2. CFa						
3. SFi						
4. CFi						
Total						

Methodology

Research focus: derived from MRC assignment (stated in Chapter 1)

As stated in Chapter 1, the research focus for my study is derived from an MRC assignment of SIMVA, which aims to develop indicators and baseline data for long-term monitoring. SIMVA also aims to provide data for other MRC programs such as the BDP and SEA of the Sustainable Hydropower Initiative. Study data already have been used by the programs, underscoring the importance of the SIMVA in continuing to provide updated data and information over time.

To reiterate, the study will focus on the severity of impacts of changes in the availability of rice and fish on subsistence and commercial fishers and farmers through an examination of the proportion of related income and food derived from rice and fish.

This will be achieved by analyzing total income earned and food consumed by the households. It is assumed that the more households' income and food depend on rice and fish, the more they will be affected by declining in the resources. Resilience will depend on a number of factors, including degree of dependence and assets possessed.

Conceptualization of vulnerability

For the purpose of this study, vulnerability is defined as the degree to which people in the LMB are *dependent* on the availability of rice and fish, and their *capacity to recover* from food and income shortages. Dependence can be referred to as *sensitivity*. A third factor must also be considered: *exposure,* which refers to the specific groups of people within specific space and time frame. Thus, my study will cover exposure, dependence/sensitivity, and resilience.

Exposure will include the number of people potentially affected, defined by their location (L) and their related occupation (RO).

Dependence/sensitivity will include an analysis of the levels of dependence of people in the LMB on rice and fish, measured by the proportion of income from rice and fish (I) and the proportion of food from rice and fish (F). *Resilience* is about the capacity of the population to recover from shortages of food and income including livelihood assets (LA), income diversity (ID), food diversity (FD), and supporting environment, particularly institutions (SEI).

Thus, vulnerability will be seen as a function of these variables:

V=f(L, RO, I, F, LA, ID, FD, SEI)/time.

Where:

V = vulnerability

L = location

RO = related occupation

I = income

F = food

LA = livelihood assets

ID = income diversity

FD = food diversity

SEI = Supporting environment: institutions

How does this study measure vulnerability?

I will balance sensitivity and resilience (Alwang et al. 2001) to arrive at conclusions about who is most vulnerable, where they are located, and why they are vulnerable. According to Alwang et al. (2001), high vulnerability systems are characterized as having low resilience and high sensitivity, while low vulnerability systems have low sensitivity and high resilience (Table 4).

Table 4: Two dimensions of vulnerability

		Resilience	
Sensitivity		High	Low
	High		
	Low		

Source: Alwang et al. 2001, adapted from Davies

Surveys in four countries completed in 2009

The data were collected at four sites in the four LMB countries in 2009. These are in Cambodian Tonle Sap Lake, Lao Siphanedone, Thai Chiang Rai and UdonThani, and Vietnamese Mekong Delta. Although all the study sites have a similar number of sample villages (17–20 villages per country) and households (17–20 households per village), they vary in spatial size, administrative units, and population size. These range from two districts in the Cambodian Tonle Sap Lake site to seven provinces in the Mekong Delta of Vietnam. Overall, 71 villages with 1,360 households were visited. All sample villages are within 15 km of the mainstream Mekong (Figure 6).

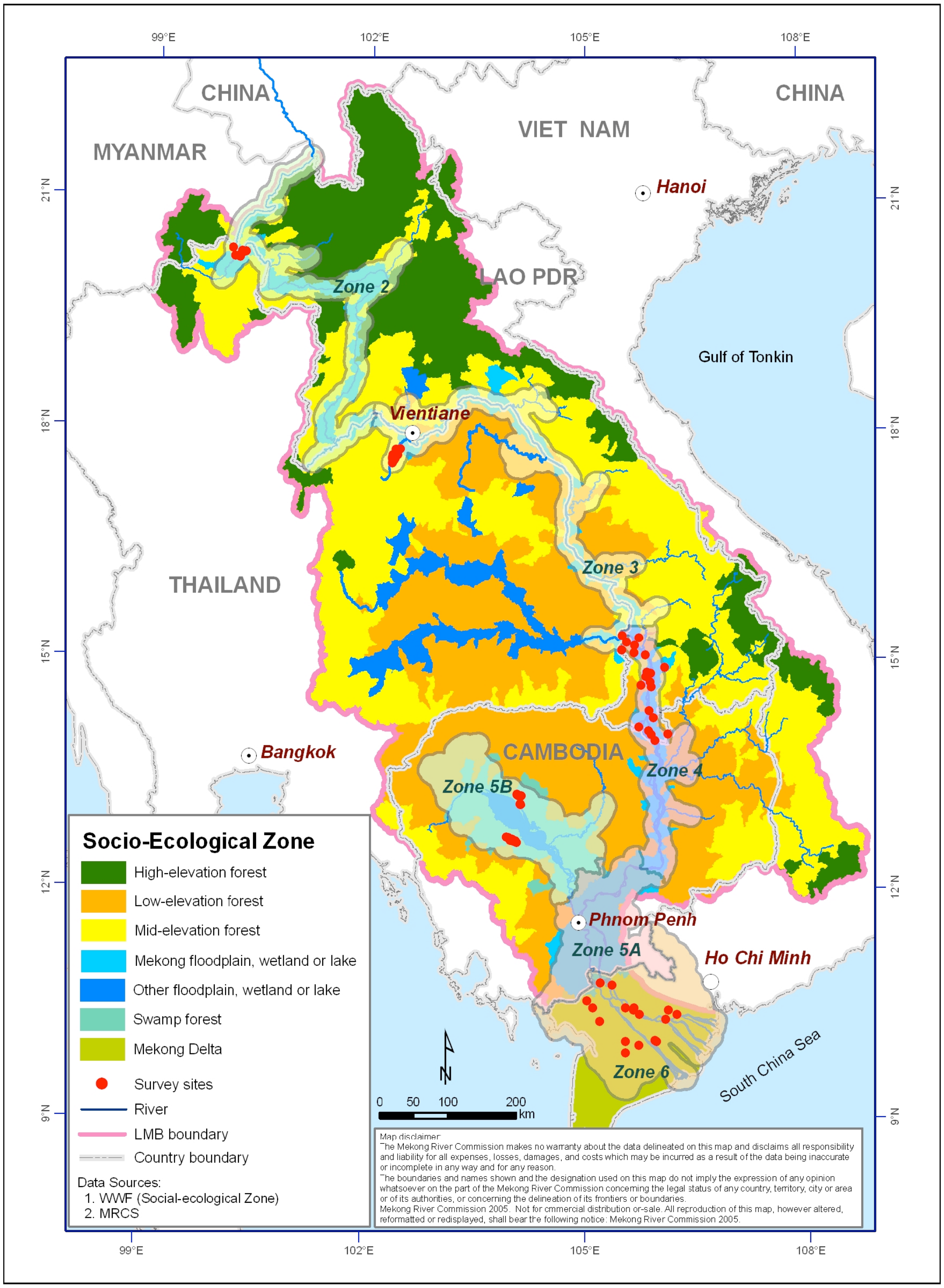

Figure 6: Study sites in the four LMB countries (Source: Hall and Bouapao 2010)

Study surveys were taken by four local teams, each led by a national expert. The questionnaire was developed in English. Once completed, the questionnaire was then translated into national languages. The final database was submitted in Statistical Package for the Social Sciences (SPSS) format.

Tonle Sap Lake, Cambodian study site

In Cambodia, the study took place in two districts located on two opposite sides of Tonle Sap Lake: Kandieng district in Pursat Province, and SoutrKikom district in Siem Reap province. The Cambodian National Mekong Committee (CNMC) selected the study sites. The limited coverage (only two districts and not all seven provinces around Tonle Sap Lake) was partly due to the limited budget. Seventeen villages in the two districts were randomly selected by the national expert. Figure 7 shows the distribution of the sample villages in the two districts.

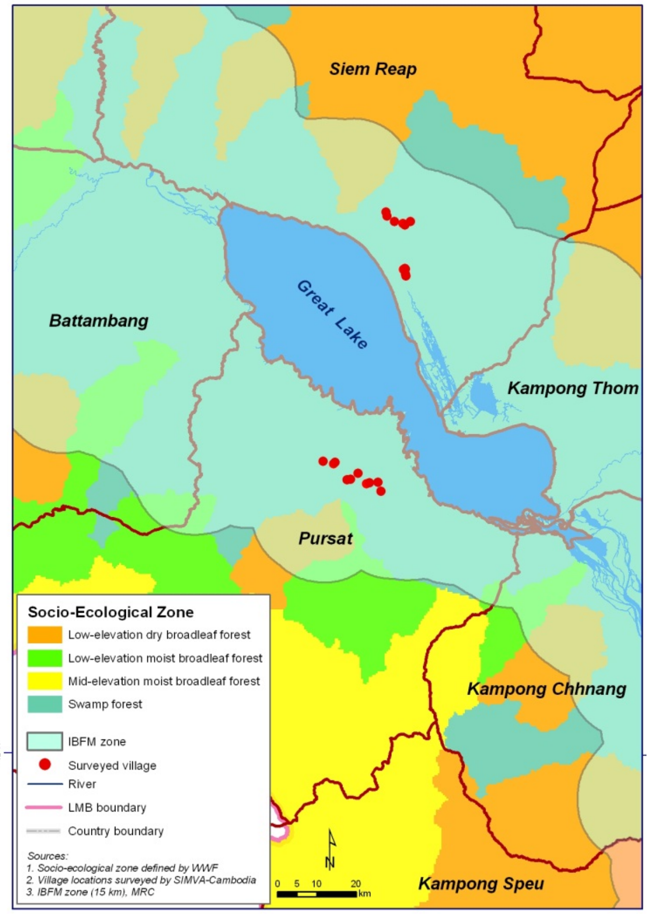

Figure 7: Study sites near Cambodian Tonle Sap Lake (Source: Hall and Bouapao 2010)

Tonle Sap Lake is exceptionally productive due to the annual flood pulse that makes 30-fold changes between the dry and rainy seasons. The pulse reverses the flow from the Mekong River up to Tonle Sap Lake, increasing water levels 8–9 meters and widening the lake surface area from 2,500 km^2 to 15,000 km^2. The floods create an ideal environment for feeding and breeding for many species of wild animals and plants of the Mekong (MRC 2006b, Vannak 2010). This supports livelihoods of an estimated 1.2

million people around the lake and beyond. The area sees strong seasonal migration for fishing and fish processing. Much of the fish caught in Tonle Sap Lake are sold elsewhere in the country such as Phnom Penh. This implies that people elsewhere in the country also depend on the lake productivity.

Siem Reap, a province in which the study area falls, despite being a tourist destination (Angkor Wat, a World Heritage Site) and bordering the richest freshwater fishing grounds in the world, is one of the poorest provinces in Cambodia. Half of children under 5 are underweight (the second worst in the country) and nearly 90% of households lack sanitation. In Pursat, another province of the study site, the situation is not much different. There, 46% of children under 5 are underweight, and just over 90% of the total households do not have sanitation (Hall and Bouapao 2010).

Siphandone, Lao PDR study site

In Lao PDR, the study took place in Champasak Province, the southernmost province of Lao PDR, which borders on Strung Teng province of Cambodia. To be able to link to data obtained by the Department of Statistics through the Lao Expenditure and Consumption Survey 4 (LECS 4), the Lao team used sample villages from the LECS 4 samples. Thus, the SIMVA sample villages within Champasak province are the same as those used/selected by LECS 4, and the LECS 4 households were included in this study. LECS 4 used only 17 households per village for its survey, however, so to sample the same number of households as were sampled in other countries (340 per study site), the Lao team had to visit 20 villages.

Siphandone (literally means 4,000 islands) made up most of the study site. It is a complex network of braided river channels, seasonally flooded habitats, and rocky rapids. It covers the largest complex of waterfalls in Asia (Mather et al. 2009). The waterfalls include HouSahong falls, where the government is considering constructing a hydropower dam. If built, the dam will have dramatic impacts on fish migration and on the rare Mekong Irrawaddy dolphins that live in the deep pool not far from the falls. The dolphins live in part of the Mekong in the Lao territory during the wet season and cross the border to the Cambodian side in the dry season. The narrow, fast-flowing channels (hou) have been known as significant bottlenecks for fish migration in the dry season, providing remarkable fishing opportunities. To use these opportunities in and around the falls, fishers have developed elaborate, and often risky, fishery traditions and technologies. These are based on a remarkable knowledge of the Mekong local ecology, transferred from generation to generation (ibid). In 1960s–1980s, the Lao government banned fishing in the HouSahong to protect fish migration.

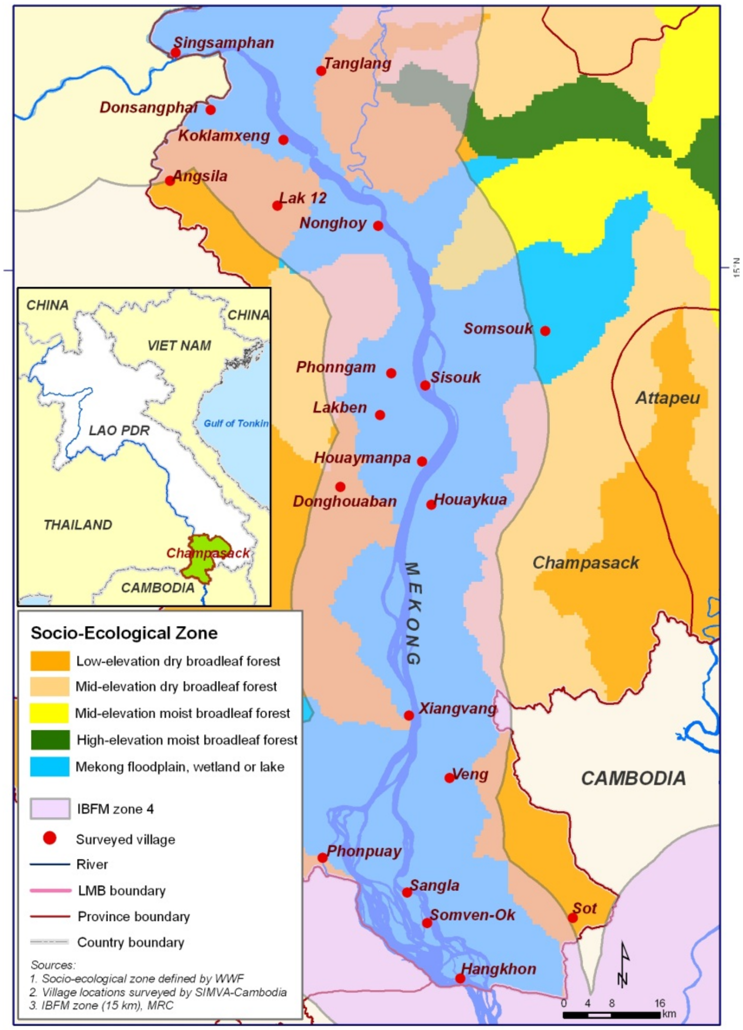

Figure 8: Map of the Lao PDR study sites (Source: Hall and Bouapao 2010)

More than half of the Siphandone is flooded each year during the wet season, providing wider feeding and spawning grounds for many species of fish. About 200 fish species are reported to reside in Siphadone for part of the year. Approximately 80% of fish sold in markets of Champasak are from Khong district, which includes parts of Siphandone. Cash income from sale of fish contribute up to 90% of the total households income in

Hou Sahong (Baird et al. 2001). Part of Siphandone is suitable for rice cultivation during the dry season (Phouthavongs 2007). However, land suitable for rice farming on the islands is limited, forcing local people to rely primarily on fishing.

While it is clear that Siphandone fisheries are important for the livelihoods of more than 70,000 people in the area, it is also increasingly being recognized that the importance of the Siphandone extends well beyond its boundaries to many millions of people downstream of the Mekong (Hall and Bouapao 1010). It has been reported that approximately 75% of the fish catch in Tonle Sap Lake relies on the fish migration to the deep pools found in Siphandone and beyond (Mather et al. 2009). Changes in fisheries in other parts of the Mekong will consequently impact fish catch in Siphandone. Similarly, a decline in the Siphandone will have an impact on fishers in other parts of the Mekong (Hall and Bouapao 2010).

Thailand study sites

In Thailand, the Thai National Mekong Committee selected two districts under two different provinces for the study. These are the Chiang Rai district in Chiang Rai province, and Ban Phu district in Udon Thani province (Figure 9). The former district is on the mainstream Mekong, while the latter is on its tributary. Chiang Rai is a priority area, associated with high potential impacts of hydropower dams built in Yunan Province, China. Although Udon Thani is located on a tributary, it is within 15 km of the mainstream Mekong.

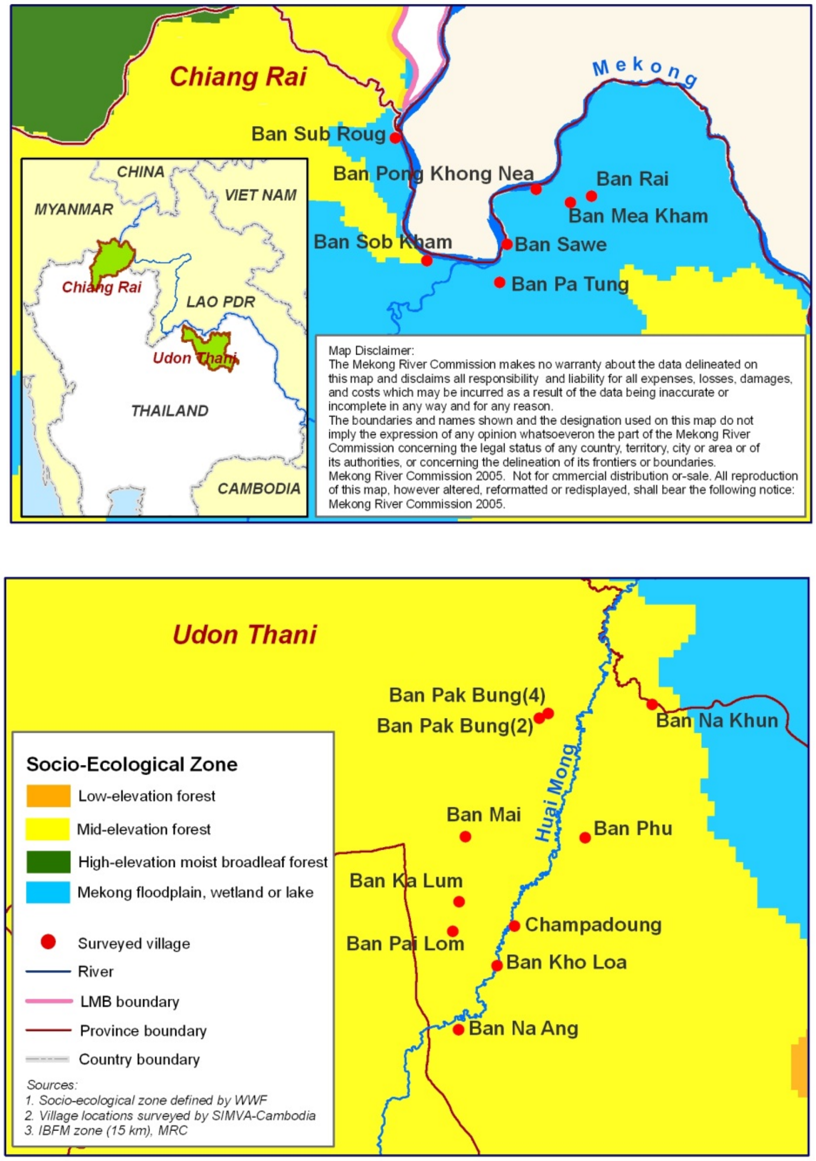

Figure 9: Study sites in Thailand (Source: Hall and Bouapao 2010)

In Chiang Rai province, child malnutrition rates are at approximately 11% for 5- to 6-year-olds, below the national average. Access to electricity and water supply is high, about 96% (Boromthanarat 2010). The area is well known as a home to the rare giant catfish, but the numbers have declined and the fish is no longer caught (MRC 2006b).

Livelihoods in the province are diverse, with a wide range of lowland and highland crops. Riparian residents reported high dependence on fish and vegetation such as weed (*khai*). Even in fishing communities, however, surveys found more part-time than full-time fishers (ibid).

In Udon Thani province, one alternative for riparian households along the Mong River is to engage in fishing when problems occur in agriculture, especially drought. Local people reported a trend of declining fish yields, with some species disappearing, while agricultural production trended in the opposite direction. For most of the households, fishing has become secondary occupation (Hall and Bouapao 2010).

Case studies in Ban Na Aang, Udon Thani province (Boromthanarat 2010, Hall and Bouapao 2010), showed that rice cultivation is the main livelihood, followed by cultivation of crops such as rubber, eucalyptus, vegetables, and soybeans. There is not enough irrigation for a second rice crop. Villagers reported engaging in fishing when they experienced problems in their agricultural activities, such as low yields caused by drought. Over time, agricultural production has increased while fishing activities have declined. Villagers reported more food availability, but some fish species such as the giant snake head fish have been negatively affected by infrastructure development. Aquatic animals were reported to be fewer than they were five years earlier. During the agricultural off-season, adults in most households look for employment outside the village.

In Ban Pak Bung, villagers are concerned about the emergence of new species of weeds and pests resulting from the use of chemicals and pesticides for agricultural activities. As a result, agricultural production has declined. Villagers become laborers or engage in temporary or part-time jobs after harvest each year. Fish are caught for household consumption only, and not for sale. Aquatic animals are reported to have declined due to the excessive use of chemicals and pesticides.

Mekong Delta, Vietnam study sites

In Vietnam, the Mekong Delta freshwater zone was chosen for the study. The Mekong Delta consists of fresh and coastal (saltwater) sub-zones. The sample frame of the Mekong Delta study site was designed to cover the whole freshwater zone, 35% of the total Mekong Delta area, and seven provinces (An Giang, Dong Thap, Can Tho, HauGiang, TienGiang, and Vinh Long), more than half of the 13 total provinces of the delta (Figure 7). To obtain a representative sample, the national expert drew 17 villages randomly from the list of villages of these provinces (Pham 2010).

The two zones are characterized by the endless interaction between freshwater from the Mekong and salt water from the sea. About one-and-a-half centuries ago, this interaction took place within a vast wetland, which was sparsely populated and barely affected by human intervention.

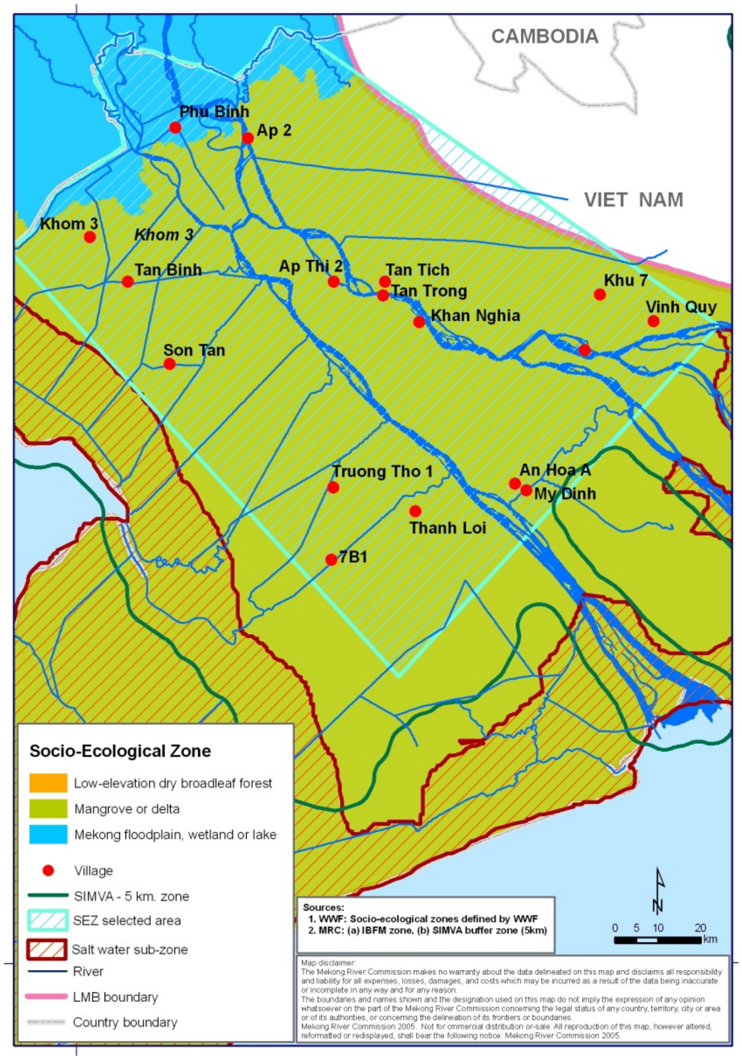

Figure 10: Study sites in the Mekong Delta freshwater zone, Vietnam

The historical time line used by the Vietnamese team in this study (Pham 2010, Hall and Bouapao 2010) shows that many villages with few people were established after the unification of Vietnam in 1975. Agricultural productivity was low. Severe floods and acid sulfate water intrusion during the rainy season were common. As a coping strategy to the floods, low-yield floating rice varieties were planted. In the dry season, drought was long. Irrigation systems were underdeveloped. During the centrally planned economy period in the late 1970s and the 1980s, infrastructure was poor. Villagers said that boats were the main source of transportation during the rainy season. In the dry season, transportation was difficult. There was a lack of clean water, electricity, good health care, and education. Natural resources, however, were abundant. Livelihoods of the delta people highly depended on the collection of fish and other aquatic animals.

Today the delta is a highly regulated ecosystem with approximately 18 million residents. As a result of the “DoiMoi” (a socialist-oriented market economy) from 1986, it has been transformed into canals, paddy fields, shrimp farms, roads, urban centers, and villages (Chu 2009). Floodplains have been turned into resettlement areas. There have been improved roads, more clinics and schools, and more connection to the national electricity network. Flood control structures and new canal systems have been constructed. Paddy fields have been expanded and improved with irrigation, making it possible to grow two to three rice crops a year. This also means that vast wetlands have been converted into agricultural fields. Intensification of rice requires more inputs of water, fertilizer, and pesticide. Annual rice production increased three to five times compared to the time when floating rice was planted.

Quality of life improved as a result of development. However, villagers said that the dike network prevented migration of aquatic organisms to the fields, and the increased use of chemicals in agriculture reduced the productivity of aquatic biological communities. The conversion of wetlands into agricultural fields reduced habitats for many aquatic species. To adapt to the decline in aquatic animals, the local people who once depended on fishing have had to shift to work as rice farmers or as hired laborers, often as construction workers or as migrants to cities (Hall and Bouapao 2010).

By 2007, almost 88% of the 3.9 million hectares of the Mekong Delta was agricultural land. The delta accounts for 12% of the total area of the country, but its agricultural land makes up 34.6% of the country's total agricultural land. Aquaculture land increased significantly in the past decade, accounting for 13.3% of the delta and 69% of the total aquaculture land in the country (Pham 2010).

The study process and the questionnaire

The study process took 1.5 years to complete, starting with drafting technical guidelines (MRC 2008) and outlining methodology and tools for use in the study. The technical guidelines were drafted by the study team, composed of an internationally hired consultant, four national experts from the four LMB countries, and MRC Secretariat staff members from the BDP and Environment Division (me). The technical guidelines were presented to a regional workshop in early August 2008 involving National Mekong Committees (NMCs) and relevant line agencies. The regional workshop approved in principle the methodology. With this in hand, the study team jointly designed, pretested, and refined the research tools, including the questionnaire (Appendix 1).

The pretest of the questionnaire took place in Pakse, a town in the southern Lao PDR, where teams from Cambodia, Lao PDR, and Thailand participated. The draft questionnaire, an output of the team effort, was translated into four national languages before the group split into three teams for the field pretest. The pretest was carried out in two villages for each team: 1) just under and over the Mekong Khone Falls in Lao PDR, 2) in Strung Teng, Cambodia, and 3) near Pak Mun Dam in Thailand. The pretest took five days. The teams returned to Pakse after they finished the pretest. The questionnaire was revised based on lessons learned from the pretest. The questionnaire was finalized based on results of a separate pretest undertaken by a Vietnamese team in the Mekong Delta. The finalized version was translated into national languages.

As a preparation for the survey initiated in early 2009, each national team recruited four research assistants. National consultants consulted their respective NMCs for advice and agreement on the study sites. Once agreed, the national expert selected the sample villages using “probability proportionate to size” (PPZ) (Babbie 2001), presented subsequently. For comparability and ease of merging of data from the four study sites, a common template from Microsoft Access was developed by the Lao team and distributed to all teams.

To ensure that every team member contributed to delivery of the data needed, a separate training was organized for each team. The purpose of the training was to build a common understanding among enumerators (the actual surveyors) of the methods and tools, including each question of the questionnaire. The training took around five days, with two days for classroom discussion and clarification, two days for practice in two villages (a situation similar to the real survey), and one day for discussion and correction of mistakes made after the practice. The national experts provided support and supervision during the fieldwork to minimize errors by the enumerators.

Data from the fieldwork were entered into the Microsoft Access template by the enumerator teams with the supervision of the national experts. Once completed, the data were sent to the MRC activity coordinator (me) and international expert for preparation of the regional report. At the same time, the national experts prepared their national reports to be submitted to NMCs and MRCS.

The University of Minnesota requires that research involving human subjects be reviewed by the Institutional Review Board (IRB) (Regents of the University of Minnesota 2010). I did not go through the IRB process because my research uses data from the MRC project as described earlier, called "Social Impact Monitoring and Vulnerability Assessment or SIMVA." I requested and was authorized by the MRC to use the data. Note that I was a senior social science specialist, responsible for this project. Procedures included careful training for enumerators to ensure that data and information collected would be treated with complete confidentiality and anonymity. The data were analyzed and presented at an aggregate level. No individual would be able to be identified. For example, one of the statements provided in the questionnaire, which enumerators were required to read or say before the interview, is, "the information collected during our discussions will be used for planning purposes for the benefits of people living in the Mekong Basin….everything you say will be strictly confidential" (Appendix 1). The data are stored in SPSS format by the MRC Secretariat in Vientiane, Lao PDR.

Sampling

Defining geographical focus/boundaries for the study

A good representative sample is a well-defined population or sampling frame. The first consideration for the sampling frame was that all households to be interviewed had to be within 15 km of the Mekong, in the selected sites. The sites are 1) Cambodian Tonle Sap Lake (Kandieng district in Pursat province, and SoutrKikom district in Siem Reap province), 2) Lao Siphanedone, 3) Thai Chiang Rai and UdonThani, and 4) Vietnamese Mekong Delta. One challenge was how to draw the sampling frame of the population because the 15 km corridor. Demographic data are usually available by administrative units, not physical boundaries such as the 15 km corridor. Thanks to GIS technology, we were able to demarcate the boundaries of the 15 km corridor of all zones and then list all settlements (towns/villages/hamlets) and their populations (but not households) within these boundaries based on administrative or statistical data. Cities were then excluded from the list before the random selection because the focus of the study was on rural residents, who are more concerned with the impacts of environmental degradation on biomass for fuel, arable land, forest products, etc. (UNDP-UNEP 2008, p. 16). The list of rural villages/communes then provided us with an overall sampling frame from which to draw our sample.

Sampling took place in two steps due to issues of data availability. National statistical offices or relevant administrative offices had lists of villages. Sample villages had to be selected from these lists before the survey because they needed to be selected in a way that represents the whole zones. Up-to-date lists of households, however, were often available only at the village level, so it was deemed best for household selection to be done at the village level, when the enumeration teams arrived in the village. For this reason, the village sampling was drawn by the national team leader or statistician, while households samples were selected by enumeration teams.

Village selection

We wished to have 680 sample households per site. However, due to budget constraints, the size of the sample was reduced to 340 households. This implies that the study had 340*4=1,360 households for all sites. National statistics in the LMB usually draw 15–20 sample households from each sample village. The study took 17 households from each village.

In selecting the 17 sample villages in each site, our main objective was to obtain a representative sample of the site that would enable us to make inferences (draw conclusions) about the population in the site as a whole. Purposive sampling, while generally useful for developmental or pilot phases of research, would not have allowed us to make inferences for the whole area. For this reason, purposive sampling of specific interest was not suitable.

There are many methods of sampling, but for the purpose of this study, the Probability Proportionate to Size (PPS) was appropriate because the scale of the study sites was very large, covering several districts/provinces with different sizes of villages. This approach ensures that densely populated villages are not missed out by giving each village a chance to be selected proportionate to its size (Babbie 2010). A village with 300 households has three times the chance to be selected as one with 100 households. One example of the use of the PPS is shown in Table 5.

We needed 17 sample villages from the Mekong Delta for the study. The total number of villages is 200. We gave each village a unique number, ranging from 1–200. We recorded the number of households for each village, and used this to compute the cumulative total running through the list. The table is similar to Table 5. The final total came to about 85,000 households. Thus, Village A in the table was assigned the numbers 1 through 2,000; village B was assigned 2,001 through 7,000; Village C was assigned 7,001 through 7,500, and so on.

With this arranged, the next step was to use a systematic sampling approach (Babbie 2001). We set the sampling interval at 5,000 (85,000/17), and selected a random start between 1 and 7,500. The village assigned the range of numbers within which that random number fell was then selected. Increments of the sampling interval (5,000) were added to the random start to obtain the next samples until we selected 17 villages.

Table 5: Villages under Sub-zone A

Village ID	Village Name	Number of Households	Cumulative Number of Households
1	Village A	2,000	2,000
2	Village B	5,000	7,000
3	Village C	500	7,500

Household selection

We needed 20 households only from each sample village. Stakeholders of the SIMVA in the LMB on many occasions commented that the SIMVA needed to avoid biases to be representative. Examples of biases are:

- Occupation – busy people can easily be systematically excluded. But once selected, appointments or revisits can be arranged.
- Selection by an authority could result in "preferred" households being put forward.
- Accessibility – some households are hard to get to. These maybe excluded systematically.
- Geography – Some villages are spread out or concentrated in particular areas. Some part of the village maybe excluded due to their isolation (Hall and Bouapao 2010).

A truly representative sample gives each household in the sample frame an equal and known chance of being selected. In other words “because each household would have the same chance of selection, the sample so selected should be representative of all households” (Babbie 2010). To avoid biases, we used the systematic sampling method (a systematic sample with a random start) to select the 20 households. For systematic sampling, the following steps needed to be completed:

1. Obtain the list of households in the village. Exclude any household that has permanently moved out from the village.
2. Divide the number of households by 20 to get the interval.
3. Use any approach to randomly select the first households.
4. Use the interval determined by step 2 for random selection by adding the interval to the first households randomly selected, and so forth until 20 sample households have been selected.

Illustration

For example, if the total number of households in the village is 200, we will have an interval of 10 (200/20). A number randomly picked by one of the team members is 25. As discussed, the first sample is household No. 25. Our next sample will be 25+10=35. Table 6 shows the list of sample households selected.

Table 6: Sample households of village A

Sample households No.	Number of households in the list	Name of the head of the household
1	25	Seng Duean
2	35	Doung
3	45	Panh
4	55	Dalavong
5	65	Bounthanh
6	75	Bounchanh
7	85	Bouadeng
8	95	Thatsana
9	105	Sali
10	115	Xaysongkham
11	125	Padek
13	135	Apaivanh
14	145	Chaleun
15	155	Faxay
16	165	Gao
17	175	Isan
18	185	Keo

The lists of the households in the villages and sample households selected were submitted to the survey supervisors for supervision purposes. Enumerators were to try at least twice to find the household; if households were not available (or refused), the enumerators then took the first household after the sample in the village list. Field supervisors were to check all questionnaires completed in the field because it is very costly to go back to ask missing questions or to fix errors. Field supervisors have to ensure quality control by checking if the data obtained make sense and by back-checks. A back-check involves the field supervisors going to the households where the interviews are conducted to confirm that the questions have been asked correctly and that answers are recorded accurately. The questionnaire and questions for back-check can be done randomly.

Training to enumerators

Enumerators were trained before the field survey. A major purpose of the training was to build a common understanding about the survey methodology, key terms, questions, role, responsibilities, and other clarifications for all the people involved in the survey. The training was undertaken in national/local languages so that all the materials would be fully understood and implemented.

The number of days for the training varied across countries, depending on the education and experience of the team members. However, training was not less than five days. For example, the first two days were spent for classroom discussion and clarifications. Day 3-4 were for practice in one or two villages to give team members a chance to experience contacting, interviewing, and problem solving. Enumerators and supervisors/trainers then return to the classroom on day 5 for discussion of lessons learned and to allow supervisors/trainers to evaluate whether all enumerators are ready for the field survey.

Key topics covered during the training included sampling and completing the questionnaire. Detailed descriptions on how to do sampling were provided in the sampling section. Detailed instructions for each section and question of the questionnaire were provided by technical guidelines prepared for the SIMVA (MRC 2010). During the training, trainers used the guidelines and walked enumerators thoroughly through the questionnaire for each section and question. The technical guidelines were provided for all fieldwork teams.

The questionnaire was carefully structured, with each question the outcome of detailed discussions and tested in the field. To maintain consistency and comparability, team members were instructed to try not to modify the wording of the questions during the interview. Team members were also instructed to not modify question numbers because numbers are assigned to specific variables in the database, where they serve as codes and can replace variable names. No part of the questionnaire was to be left blank. Rather, "not applicable" codes were to be used as indicated in the technical guidelines. Although households ultimately chose who met with enumerators and answered questions, enumerators were instructed to ensure that respondents be either the head of the household or a well-informed adult.

Logistics: paperwork

Obtaining permission and cooperation of the administrations within the sampling boundaries was a must. MRCS issued an official letter to each NMC providing information and requesting authorization that it could use as reference for issuing its own official letter to relevant provincial authorities. Based on the NMC letter, a letter from the relevant provincial department was issued and in most cases a staff member from the department accompanied the survey team to the districts and sample villages.

Arrangement of resources

Testing of the questionnaire indicated that on average one questionnaire required two hours to complete. This means one enumerator could complete four interviews per day. To sample 20 households in one day (so the team could move on to the next village to minimize expenses) there must be five enumerators on each team excluding the team leader/supervisor, who takes care of quality control measures such as back-checking for the team as whole. In other words, a team must consist of six people: one team leader and five enumerators.

Because of the large size of each site (covering a few districts to a few provinces), sample village were far from each other. In addition, some villages were not accessible by a car. As a result, time required for travel from one village to the other was approximately one day. Assuming the project provides one car per team and communication with relevant authorities is arranged well in advance, this implies a need to allow two days per village or 34 days per site (2days*17villages).

This analysis of the requirement for time and human resources provides the basis for budgeting. The compensation rate for each position was subject to negotiation, while other expenses such as daily subsistence allowance were based on MRC procedures and regulations.

After fieldwork: data entry

A common data entry template was used by all countries to facilitate merger of site level data into one regional database for all sites. The template was arranged by the MRC secretariat and distributed to each survey team. Numeric and spelling of variables and cases were required to be exactly the same. All databases were submitted to MRCS (me) in SPSS format.

Quality control

Quality control was provided in each stage of the study: preparation, fieldwork, and post-fieldwork.

At the preparation stage, a two-way translation of the questionnaire was used to ensure accuracy. First, the national experts translated the questionnaire from English to their national languages. Next, the translated version was sent to MRCS for approval. At this stage, the MRCS assigned a staff member of the same nationality as the national expert to check whether the translation of each question had the same meaning as in the original version. A second step to ensure correct translation of the questionnaire was to have the data gathered during the training (practice) entered into the template and have the national experts and MRC staff member check whether the data made sense.

During the fieldwork, questionnaires from interviews were randomly checked for mistakes. This allowed us to identify gaps for support and to make corrections where necessary while it was still feasible to revisit the sample households.

After the fieldwork, attention was paid to data entry. The template was designed to limit the digits to be entered to an appropriate amount. For example, digits for months in the year must not be more than 2 digits. National experts had to clean the data before submission to the international expert and MRCS in SPSS format. The international expert made a last check of the data to ensure comparability so it could be used at the regional level.

Data analysis

With data stored in SPSS, I used various commands such as “Data” to merge cases or variables, “Transform” to compute or recode variables, and “Analyze” to run frequencies, crosstabs, or regression. Crosstabs and frequencies have been mostly used to explore data with strongest relationships.

The unit of analysis was the household, not individual household members, for two reasons. First, the use of the household as a unit of analysis was agreed to by representatives of member countries at the regional workshop held before the survey started. Second, income, food, and asset data are easier to collect at the household level. For example, land area, annual rice production, and livestock apply to households, rather than to individual household members. They are usually owned by the head of the households and used for the households. Income from the sale of these resources is also seen as household income, rather than income of individual household members, although the sale may be intended to address the need of a certain member, such as a daughter or son who needs cash for clothes, books, or medicines.

3.3. Limitations of the study

Due to budget and time constraints, the study took a snapshot of the income and consumption data; addressing seasonal variability in income and consumption remains for future research. Because this was a pilot study, a learning process, the sample was small. There is a need to include a larger number of study sites to represent all sections of the LMB. Also it is not possible to disaggregate all data by ethnicity, gender, and age.

The use of GIS and Landscan data methods to focus on the corridor physically defined as 15 km from either side of the mainstream Mekong produced useful data. This approach, however, is limited to physical delineation, and does not take into account terrain and access. Terrain could be taken into account by involving GIS expertise, while access could be taken into account through consideration of resource users living beyond the 15 km corridors, such as seasonal fishers.

The SIMVA methods generated valuable data and information on the degree of dependence on water resources (e.g., high, medium, low). It was able to provide detailed information on livelihood activities, consumption, and income related to water resources to a degree not usually provided by regular national surveys and censuses. Improvement of the method, however, is needed to be able to assess vulnerabilities further down the value chain from changes in resource availability.

The method was able to generate useful data for resilience assessment, easily monitored over time by stakeholders. It is not, however, sufficiently comprehensive to cover major dimensions of resilience such as social, natural, physical, human, and financial assets. Further research on indicators representing each major aspect is important.

3.4. Validity

This assessment of the validity of the methods used for the study focuses on two areas: the overall concept of the study and the research questions.

The study field-tested a variety of approaches to obtaining data to meet its objectives. In connection with the key research questions, drawn from Hall and Bouapao (2010), evaluation of methodological validity is as follows.

How many people live within reach of the Mekong River resources?

GIS was used to draw corridors of 5, 10, and 15 km from either side of the mainstream Mekong and to calculate the number of people living within these corridors. The population was obtained from Landscan 2007 data. The approach produced results close to data generated by national population censuses. For example, data from national censuses for the LMB as a whole shows a population of 60 million, while data produced by the use of GIS based on Lanscan data show a population of 61 million. Mirella et al. (2005) discuss the strengths and weakness of the Landscan data as compared to other global geo-referenced population data sets. Dobson et al (2001) provide a detailed technical description of how Landscan data work.

The use of GIS and Landscan data together makes it possible to approximate the number of people living within each study site, specific corridors, sub-basins, countries, and the entire LMB. Results of these calculations show the importance of the 5 km corridor, where most people live. The approach thus is useful to estimate the number of people who are exposed to threats/risks in certain areas (Hall and Bouapao 2010).

Although the use of GIS with Landscan data generated useful results, it is not capable of identifying dependence on the river and its resources because it cannot capture information on the dependence of people living outside the corridors (e.g., people who travel long distances to become seasonal fishers in Tonle Sap Lake).

Even within the corridors defined by the use of GIS technology, distinguishing between urban and rural populations is difficult. Although the study was able to separate urban and rural populations, it did so based on one criterion only: capital cities of provinces and districts were considered urban. In reality, a number of factors are involved in defining urban and rural areas. In Lao PDR, for example, urban areas are defined by the Department of Statistics as having three out of five traits: designation as a capital of a province or district, electricity, water supply, markets, and access by a track all year. The GIS-based designation did not take into account these national criteria, so it would not yield the same results as administrative records or population censuses would.

What proportion of this population makes use of the resources?

The questionnaire was designed to capture the proportion of population in the study sites who depend on rice and fish for food and income. There might be two or more occupations in the households, with some of them more important than others. To accommodate this, interviewees were asked about the first- and second-most important occupations for the household as a whole. Analysis of the data obtained by this approach shows multiple livelihood strategies of the sample population and variety levels of dependence on rice and fish. High, medium, low, and no dependence on water resources as opposed to other sources of food and income can be observed. Results showed clearly what proportion of the population uses what sources. It can be concluded that the approach effectively addresses the key question of how availability of rice and fish affect occupation and food security. The approach makes it possible to analyze uses of fish and rice by strata. Analysis indicates that fisher and farmers account for the majority (80%) of the population, which is consistent with findings in the literature that state that most people in the LMB live in rural areas and are engaged in agricultural activities (MRC 2003).

One weakness of the approach is that it is not possible to break down the population by ethnicity, gender, and age in relation to sources and sizes of fish and other aquatic animals. The unit of analysis for the questionnaire is the household rather than the individual. Hence, in considering gender, the approach only makes it possible to distinguish between households with male and female heads.

To what extent do the people depend on the resources, as opposed to other livelihood strategies?

To address this question, we obtained data on income and food from different sources, including rice and fish. Questions about consumption by sources (own products, purchased) were also posed. Results show clearly the use for each strata. Fish and rice constituted the majority (81%) of daily calorie intake, consistent with findings of other studies in the LMB (Ahmed et al. 1998). However, the availability of fish and rice did not affect cash income of all strata in all sites. For example, in Thailand and Vietnam, only commercial fishers would be affected by declining in fish availability, while only farmers would be affected by changes in the availability of rice.

Questions regarding sources of food for consumption proved to be valuable, revealing considerable variations across sites. The food consumed by the residents of the Mekong Delta site is highly diverse with a high proportion purchased, while in Lao PDR this most of the food consumed is self-produced. Conversion into calories, however, is of questionable validity because of the complexity of measurement. For example, the questions asked the amount of rice consumed, but amount cooked was reported.

Despite the fact that income is generally thought to be understated in household surveys, results of the study proved to be very valuable from the perspective of sources of income and relative importance of water versus non-water sources. Unfortunately, data obtained by this approach do not allow for analysis of the value chain beyond catch and consumption of the resources. Moreover, due to limited resources, particularly money and time, the approach does not cover seasonal variability in the use of the resources.

How resilient to change are resource users likely to be?

It has been quite widely agreed in the LMB that livestock and lands are key livelihood assets of value for coping with and recovering from impacts. One adult cow or buffalo can be sold to buy rice for a household of four to five people to eat for one year. The study questionnaire asked about numbers of livestock and size of lands. Using population data for each household, number of household members per animal and size of land for each household by wealth category were calculated. This makes it possible to see the resilient capacity of each group. For example, data analysis shows that poorer households across the study sites possess smaller rice fields, which produce lower yields, and less livestock. In many cases, few if any of the very poor households own such livestock. Further, the poorer households have more household members to feed. This approach is very useful for vulnerability categorization. It is quite simple and straightforward enough for any stakeholder to do monitoring. The approach, however, is not comprehensive enough to capture all the major dimensions of resilience (social, physical, environmental, financial, and human assets) to be able to provide a complete picture for the assessment.

Overall concept

Overall, the qualitative and quantitative research methods of this study address very well the three major dimensions of vulnerability: exposure, sensitivity, and resilience (Turner et al. 2003, Prowse 2003, Alwang et al. 2001). Figure 11 provides visualization of the concept. Assumptions (Figure 11) were used to guide the questionnaire construction and field test. The questionnaire generated valuable data consisting of 500 variables and fitting into the three major aspects of vulnerability. The evaluation summarized above suggests the methods use for the study are valid in a number of aspects, including face, construct, and content validities (Babbie 2001, Wikipedia 2010, Trochim 2006).

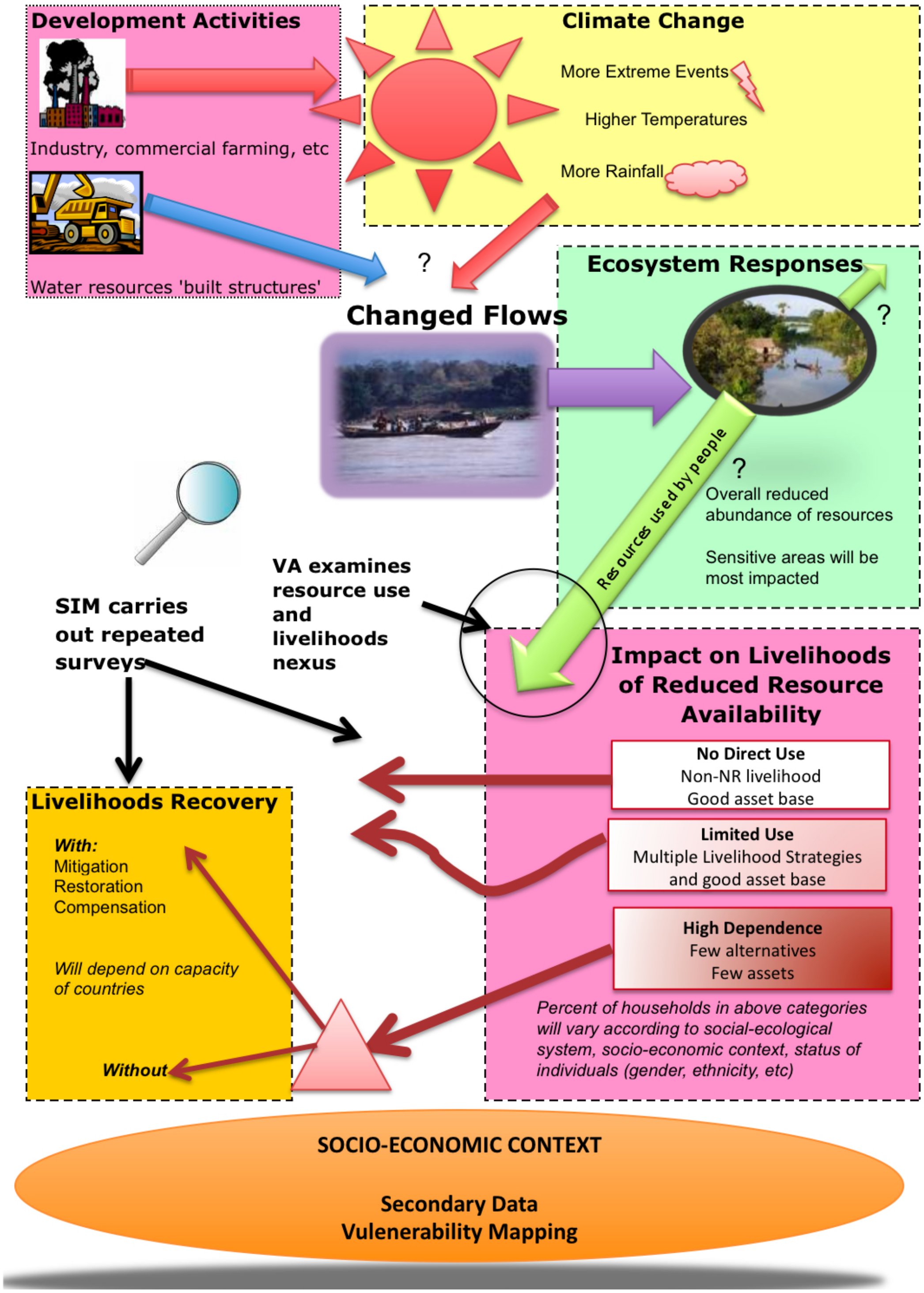

Figure 11: Basic assumptions and focus the study (Source: MRC 2010).

Chapter 4. Data Analysis and Findings

4.1. Number of people affected by changes in the availability of rice and fish

Overall number of people in the study sites

The study sites cover 29% of the total 15 km corridor population, equal to 8.6 million people or 1.7 million households (Table 7). The population number is a result of the SIMVA study teams and was obtained through the use of Landscan. The number of households was obtained by dividing the total number of people by the average household size (Table 8).[4]

In the Mekong Delta, the sample frame accounted for more than half of the total corridor population (55.8%). The Lao site covered almost a quarter of the total 15 km corridor population (22.8%). The Cambodian and Thai sites reflect the spatial scope of the sample frame (1.7% and 3.9% respectively), with two districts per country.

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[4] The average household size in the study site of Cambodia is higher than the national average, 5.1 (WFP 2010a). Household size is generally lower in urban areas compared to rural areas. Household size is somewhat lower in rural areas with access to roads compared to areas without road access (NSC 2007).

Table 7: Population of the study sites

Study sites	Corridor Population	Population of the study sties	% of corridor population
Cambodia	9,895,525	170,371	1.7
Thailand	3,430,040	133,545	3.9
Lao PDR	2,499,395	570,004	22.8
Vietnam	13,851,600	7,729,273	55.8
Total	29,676,560	8,603,193	29.0

Source: Landscan 2007, Hall and Bouapao 2010

Table 8: Number of people and households by study sites

Study sites	Number of people in sample HH	Number of HH	Average HH size	Population of the study sties	Number of HH of the study sites
Cambodia	1,817	340	5.3	170,371	31,880
Lao PDR	2,089	340	6.1	133,545	21,735
Thailand	1,372	340	4.0	570,004	141,255
Vietnam	1,585	340	4.7	7,729,273	1,658,014
Total	6,863	1,360	5.0	8,603,193	1,704,844

Source: Landscan 2007, Hall and Bouapao 2010

Population by occupation: fishing and farming as main and secondary occupation

Table 9 shows that farming households accounted for almost 73% of the total sample households (1,356 households) in all sites. Although the proportion of fishing households was only 8%, this was the second largest proportion of all occupations. This suggests that 136,387 households in all the study sites were fishing households. If fish declined, more than half a million people (681,935 people)[5] would be directly affected, along with others who fish occasionally or as a secondary occupation.

The proportion of farming households ranged from 62.5% at Tonle Sap Lake in Cambodia to 87.6 in Siphandone, Lao PDR. The proportion of farming households was similar in Cambodia and Vietnam (62.5% and 63.4% respectively).

Cambodian sites had the highest proportion of fishing households (25.6%), followed by the Lao study site (3.2%). Less than 1% of the sample households in Thailand considered fishing their most important occupation, while a quite high proportion of households (77.6%) reported farming as their most important occupation.

Looking at the second-most important occupation (Table 10), fishing becomes very important, with more than 26% of the total households reporting fishing as their second-most important occupation. Fishing as second occupation was most common in Lao PDR (63.9%), followed by Cambodia (41.6%).

[5] Average household size 5.0*136,387 households

Table 9: Most important occupation of households by country sites

	Study sites				
	Cambodia	Lao PDR	Thailand	Vietnam	Total
Inactive			0.3%		0.1%
Farming	62.5%	87.6%	77.6%	63.8%	72.9%
Fishing	25.6%	3.2%	0.9%	2.6%	8.0%
Collecting other aquatic animals				0.3%	0.1%
Collecting edible plants				0.3%	0.1%
Collecting fuelwood			0.3%		0.1%
Fish processing	0.3%				0.1%
Fish marketing	0.9%		2.1%		0.7%
Marketing other water-dependent products				0.3%	0.1%
Net making or repairing	0.6%				0.1%
Boat making and or repairing				0.3%	0.1%
Farm laborer	1.8%			9.7%	2.9%
Other irregular work	0.9%	0.3%	6.5%	3.2%	2.7%
Government officers or civil servants	0.6%	2.1%	1.5%	3.8%	2.0%
Other permanent employment	0.3%	1.5%	2.1%	6.2%	2.5%
Business	3.3%	3.2%	7.4%	4.4%	4.6%
Housework	0.3%	0.3%		0.6%	0.3%
Other	3.0%	1.8%	1.5%	4.4%	2.7%
Total	100.0%	100.0%	100.0%	100.0%	100.0%

Table 10: Second-most important occupation of households by study sites

	Cambodia		Laos		Thailand		Vietnam		Total	
	Count	%	Count	%	Count	%	Count	%	Count	%
Inactive	3	1.3	0	0.0	83	24.4	5	1.6	91	7.7
Farming	21	9.1	10	3.3	26	7.6	33	10.7	90	7.6
Fishing	96	41.6	195	63.9	17	5.0	5	1.6	313	26.5
Collecting other aquatic animals	2	0.9	2	0.7	1	0.3	28	9.1	33	2.8
Collecting edible plants	1	0.4	3	1.0	8	2.4	11	3.6	23	1.9
Collecting other useful plants	1	0.4	0	0.0	0	0.0	0	0.0	1	0.1
Collecting fuelwood	2	0.9	0	0.0	1	0.3	0	0.0	3	0.3
Aquaculture	2	0.9	0	0.0	2	0.6	8	2.6	12	1.0
Fish processing	0	0.0	1	0.3	0	0.0	0	0.0	1	0.1
Fish marketing	2	0.9	0	0.0	13	3.8	1	0.3	16	1.4
Marketing other water-dependent products	0	0.0	0	0.0	0	0.0	1	0.3	1	0.1
Net making or repairing	4	1.7	0	0.0	0	0.0	3	1.0	7	0.6
Boat making and or repairing	1	0.4	0	0.0	0	0.0	0	0.0	1	0.1
Farm labourer	2	0.9	0	0.0	5	1.5	39	12.7	46	3.9
Other irregular work	20	8.7	10	3.3	111	32.6	26	8.5	167	14.1
Government officers or civil servants	5	2.2	4	1.3	4	1.2	22	7.2	35	3.0
Other permanent employment	1	0.4	14	4.6	13	3.8	39	12.7	67	5.7
Students	0	0.0	1	0.3	2	0.6	0	0.0	3	0.3
Business	18	7.8	28	9.2	32	9.4	25	8.1	103	8.7
House work	20	8.7	3	1.0	0	0.0	7	2.3	30	2.5
Other	30	13.0	34	11.1	4	1.2	54	17.6	122	10.3
99	0	0.0	0	0.0	18	5.3	0	0.0	18	1.5
Total	231	100.0	305	100.0	340	100.0	307	100.0	1183	100.0

4.2. Severity of impacts of changes in fish and rice availability on income and food security

To analyze the severity of impacts changes in fish and rice availability would cause, I focused on subsistence and commercial farming and fishing. Subsistence farming (s-farming) and subsistence fishing (s-fishing) households are those that sold less than 25% of their rice produced and fish caught, respectively, in the year preceding the survey, while commercial farmers (c-farmers) and commercial fishers (c-fishers) are those who sold more than 25% of their products in the same period. A total of 1,166 fishers and farmers were included in the analysis (Table 11). S-farmers account for the highest percentage (37.6%), and s-fishers the lowest (4.3%) (Table 12).

Table 11: Number of fishers and farmers by study sites

	Cambodia	Laos	Thailand	Vietnam	Total
S-fishers	0	41	8	1	50
C-fishers	165	107	22	28	322
S-farmers	126	59	135	118	438
C-farmers	53	119	117	67	356
Total	**344**	**326**	**282**	**214**	**1166**

Table 12: Percent of fishers and farmers by study sites

	Cambodia	Laos	Thailand	Vietnam	Total
S-fishers	0.0%	12.6%	2.8%	0.5%	4.3%
C-fishers	48.0%	32.8%	7.8%	13.1%	27.6%
S-farmers	36.6%	18.1%	47.9%	55.1%	37.6%
C-farmers	15.4%	36.5%	41.5%	31.3%	30.5%
Total	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**

Looking at strata separately for each set of study sites (Table 13), most fishing households (86.6%) were commercial fishing households. At the Cambodian sites, all fishing households were commercial. At the Lao, Vietnamese, and Thai sites, commercial fishing households accounted for the majority of the sample. This makes sense: Fishing households need to sell more than 25% of their fish so they have enough money to buy rice and meet other needs.

Table 13: Subsistence and commercial fishing households by study sites

Study sites	S-fishers	C-fishers	Total
Cambodia	0.0%	100.0%	100.0%
Laos	27.7%	72.3%	100.0%
Thailand	3.4%	96.6%	100.0%
Vietnam	3.4%	96.6%	100.0%
Total	13.4%	86.6%	100.0%

Table 14: Subsistence and commercial farming by study sites

Study sites	S-farmers	C-farmers	Total
Cambodia	70.4%	29.6%	100.0%
Laos	33.1%	66.9%	100.0%
Thailand	53.6%	46.4%	100.0%
Vietnam	63.8%	36.2%	100.0%
Total	55.2%	44.8%	100.0%

When it comes to farmers (Table 14), however, less than half of the farming households (44.8%) produced at a commercial level. The rest were subsistence farmers (55.2%). Although Thailand and Vietnam are the first and second largest rice exporters, respectively, in the world, fewer than half of the farming households in this study (46.4% at the Thai study site, and 36.2% at the Vietnamese study site) were commercial farming households. Perhaps not all households are able to produce for exports. Surprisingly, commercial households at the Lao site accounted for more than half of the total samples (66.9%). At the Cambodian study site, the majority of the rice producers were subsistence farmers (70.4%).

4.2.1. Proportion of total income from rice and fish (by strata and study sites)

Data from question 13, "Key sources of income," were used to calculate the proportion of income from rice and fish. Table 15 presents the way in which the data were obtained. During the fieldwork, each team was asked to collect the average price for each item in their national currencies. The currency was later converted into U.S. dollars for comparison and analysis purposes.

Table 15: Key sources of cash income of households

Source	Amount last month	Source	Amount last month
Sales of own fish catch		Employment (full-time)	
Sales of others' fish catch		Employment (irregular/seasonal)	
Sale of rice/other crops		Pensions	
Sale of fish from aquaculture		Credit/loans	
Sale of Other Aquatic Animals (OAA)		Savings (in bank or not)	
Sale of livestock		Remittances (money sent by family members)	
Business (profit)		Other	

Based on the amount and price, income in cash for each source was computed, and the proportion of the total income was obtained. Overall, fishers were more dependent on fish for cash income at all sites, while farmers were more dependent on rice for cash income. The highest dependence on fish, however, was for c-fishers in Cambodia and Thailand. Meanwhile, the highest dependence on rice for cash income was for c-farmers in Cambodia, Lao PDR, and Thailand, and for s-farmers in Vietnam. Table 13 shows that subsistence fishers at the Thai and Vietnam study sites did not depend on rice and fish for cash income at all. In contrast, subsistence fishers at the Lao site had the highest share (30.8%) of income from these sources.

As expected, the Thai sample earned the highest income (Table 16), and the income was significantly higher than the poverty line ($1.00 per day). Here, surprisingly, s-farmers earned more than c-farmers and c-fishers. The least earners were s-fishers ($1.80), yet this was higher than the highest cash income earners in Cambodia and Vietnam. Similar to the Thai case, per capita income of s-farmers was the highest in the Mekong Delta (but lower than the lowest strata in Thailand). In the Vietnam site, c-fishers earned the least ($0.79 per capita per day), much lower than the poverty line, followed by s-fishers. In other words, farmers are better off than fishers at the Vietnam but the poorest strata in the Lao site. S-farmers' income was just slightly above the poverty line ($1.02), followed by the c-farmers' income ($1.53). In Cambodia, s-farmers earned least ($0.77), below the poverty line of $1.00 per day. This was followed by c-fishers ($1.30).

Table 16: Proportion of income from fish and rice/crops for subsistence and commercial fishers and farmers

		Total income per capital per day in US dollars	Proportion of income from fish	Proportion of income from rice	Proportion of income from both fish and rice
		Mean	Mean	Mean	Mean
Cambodia study sites	S-fishers	.	.	.	
	C-fishers	1.30	34.8	6.8	41.5
	S-farmers	0.77	17.7	8.1	25.8
	C-farmers	1.49	11.7	27.2	38.9
Lao study sites	S-fishers	2.08	20.6	10.2	30.8
	C-fishers	1.72	19.0	6.2	25.2
	S-farmers	1.02	14.5	5.9	20.3
	C-farmers	1.53	7.4	18.9	26.3
Thai study sites	S-fishers	1.80	0.0	0.0	0
	C-fishers	2.22	11.3	1.4	12.8
	S-farmers	3.90	0.7	4.3	5
	C-farmers	3.18	1.6	19.7	21.3
Vietnam study sites	S-fishers	1.03	0.0	0.0	0
	C-fishers	0.79	45.3	0.7	46
	S-farmers	1.74	1.0	23.0	24
	C-farmers	1.47	3.0	12.4	15.4

While c-fishers in the Mekong Delta earned the least cash income per day (below the poverty line), they had the highest dependence on fish for cash income, 45.3% (Table 16). If fish catch declined by 100%, this strata would have $0.40 per capita income per day, well below the poverty line of $1.00 per day (Table 17). Other vulnerable groups that would fall below poverty line if fish catch declined 100% include two strata in Cambodia (s-fishers and s-farmers) and one stratum in Lao PDR (s-farmers).

Table 17: If fish catch declined by 100%, who would be the most vulnerable?

		Total income per capital per day in US dollars	Total income per capita, if fish decline by 100%
		Mean	Mean
Cambodia study sites	S-fishers	.	
	C-fishers	1.3	0.8
	S-farmers	0.77	0.6
	C-farmers	1.49	1.3
Lao study sites	S-fishers	2.08	1.7
	C-fishers	1.72	1.4
	S-farmers	1.02	0.9
	C-farmers	1.53	1.4
Thai study sites	S-fishers	1.8	1.8
	C-fishers	2.22	2
	S-farmers	3.9	3.9
	C-farmers	3.18	3.1
Vietnam study sites	S-fishers	1.03	1
	C-fishers	0.79	0.4
	S-farmers	1.74	1.7
	C-farmers	1.47	1.4

If rice were to decline, c-farmers in Cambodia, Lao PDR, and Vietnam would be additional vulnerable groups because their income was just over the poverty line, but their dependence on rice for cash crops was high (27.2%, 18.9%, and 12.4%, respectively). Fishers were more dependent than farmers on cash income from fish and rice combined in Cambodia, Lao PDR, and Vietnam. In contrast, in Thailand, c-farmers were more dependent on the resources for cash income. S-fishers in Cambodia, Thailand, and Vietnam did not depend on rice and fish for cash income at all.

4.2.2. Proportion of food in the food baskets (by strata and study sites)

To calculate the proportion of food derived from fish and rice, a number of steps were taken. Data were obtained from question 10 (Appendix 1 Questionnaire), recording food consumed the day before the survey. The amount of each type of food was converted into calories using standard practice of national statistical offices of the countries. The list of food items and their calorific values is provided in Box 4. Calories per kilogram of rice and fish are 3,550 and 530 calories, respectively. Amount of each item then is multiplied by its calorific value. Results of the calculation using SPSS are provided in Table 18.

While the total calorie intake varied greatly across study sites, ranging from about 1,400 calories per capita per day (s-fishers) in the Mekong Delta to about 3,400 calories per day (c-fishers) in Siphandone, Lao PDR, [6] the proportion of calorie intake from rice was quite similar for all groups across all sites, ranging from 70% to 80%, except for one case in the Mekong Delta.

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[6] The high calorific values consumed by households in the study sites confirm the fact that "not all poor are food insecure" (WFP 2005).

Box 4 : Calories in the food bundle

Food Item	Calories per kg
Rice	3550
Bread	2820
Noodle vermicelli	900
Other noodles	3100
Pork	1470
Beef	1990
Duck, turkey, Poultry	1470
Chicken	1240
Fresh fish	530
Canned and frozen fish	1080
Dried fish	2990
Fermented fish	2100
Condensed milk	3250
Chicken egg, duck egg	1470
Bananas	860
Papayas	370
Oranges	280
Beans	340
Cabbage	90
Morning Glory	190

Cucumber	110
Tomatoes	220
Spinach	210
Fresh chili	280
Bamboo	110
Sugar	3800
Sweets	3810
Salt	0
Fish sauces	1370
Spices and seasoning	0
Beverages	420
Beer	470

Source: National Statistical Center, Lao PDR

Table 18 shows that overall calorie intake was more than the 2,100 calories per capita per day recommended minimum in the countries. [7] Exceptions exist, however. S-fishers and s-farmers in the Mekong Delta, Vietnam, and s-fishers in Thailand consumed less than the minimum requirement, only *1,418, 1,943, and 1,996* calories per capita per day, respectively. [8]

If fish were to decline by 100%, all strata in the Mekong Delta would fall below the minimum calorie requirement. S-fishers in Thailand and Vietnam, and c-fishers in Cambodia would be hit the hardest (Table 19).

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[7] The poverty line is the amount of cash needed to buy the minimum required daily calorie intake—around 2,100 calories—plus an allowance for other nonfood basic necessities. It is approximately 45 U.S. cents per day in Cambodia, 25 U.S. cents per day in Laos, 70 U.S. cents per day in Thailand, and 35 U.S. cents per day in Vietnam (Rososudarmo et al. 2009).

[8] Calorie norms vary from country to country, depending on factors such as activity, climatic conditions, race, etc. For example, the National Statistical Center, Laos, accepts that 2,100 calories per capita per day is adequate. “The energy requirement of an individual is the level of energy intake from food that will balance energy expenditure when an individual has a body size and composition and level of physical activity, consistent with long-term good health; and that will allow for the maintenance of economically necessary and socially desirable physical activity. In children and pregnant or lactating women the energy requirement includes the energy needs associated with the deposition of tissues or the secretion of milk at rates consistent with good health” (Naiken, undated).

Table 18: Proportion of calorie intake from fish and rice

		Total calories per capita per day	Percent of fish calories	Percent of rice calories	Percent of calorie from fish and rice
		Mean	Mean	Mean	
Cambodia	S-fishers	.	.	.	
	C-fishers	2,211	12.1	73.7	85.8
	S-farmers	2,474	11.2	75.4	86.7
	C-farmers	2,529	11.0	74.8	85.7
Laos	S-fishers	2,808	9.6	76.0	85.7
	C-fishers	3,424	7.9	74.5	82.4
	S-farmers	2,848	6.9	80.4	87.4
	C-farmers	3,272	8.1	74.2	82.3
Thailand	S-fishers	1,996	11.2	70.5	81.7
	C-fishers	2,694	6.9	75.1	82.1
	S-farmers	2,580	10.5	71.1	81.5
	C-farmers	2,597	9.7	71.5	81.2
Vietnam	S-fishers	1,418	0.0	93.9	93.9
	C-fishers	2,147	14.7	74.7	89.4
	S-farmers	1,943	14.0	77.4	91.4
	C-farmers	2,185	12.0	72.8	84.8

Table 19: Total calorie intake per capita per day if fish drop by 100%

		Total calories per capita per day	Percent of fish calories	Percent of rice calories	Total calorie intake per capita per day, if fish drop by 100%
		Mean	Mean	Mean	
Cambodia	S-fishers	.	.	.	
	C-fishers	2,211	12.1	73.7	1,944
	S-farmers	2,474	11.2	75.4	2,196
	C-farmers	2,529	11.0	74.8	2,251
Laos	S-fishers	2,808	9.6	76.0	2,538
	C-fishers	3,424	7.9	74.5	3,154
	S-farmers	2,848	6.9	80.4	2,652
	C-farmers	3,272	8.1	74.2	3,007
Thailand	S-fishers	1,996	11.2	70.5	1,773
	C-fishers	2,694	6.9	75.1	2,508
	S-farmers	2,580	10.5	71.1	2,309
	C-farmers	2,597	9.7	71.5	2,345
Vietnam	S-fishers	1,418	0.0	93.9	1,418
	C-fishers	2,147	14.7	74.7	1,831
	S-farmers	1,943	14.0	77.4	1,671
	C-farmers	2,185	12.0	72.8	1,923

In short, from the perspective of calorie intake, populations in the Mekong Delta will be more vulnerable to fish decline than populations in other sites, except for c-fishers at the Tonle Sap Lake sites and s-fishers at the Thai sites.

4.3. Resilience

Vulnerability is closely linked to asset ownership (Moser 1996, Castro 2002, WFP 2005). The more assets people own, the less vulnerable they are. Assets are an important means of resilience (Moser 1996). Households with welfare-generating assets are considered less vulnerable to welfare losses associated with extreme events such as floods and droughts (Alwang, J., *et al.*, 2001). “Not surprisingly, poor people tend to be more vulnerable because they have fewer means, resources and options to respond proactively to reduce risks and respond reactively once shocks occur” (WFP 2005). Assets included for examination in this section include land, livestock, and farm equipment (tractor, boat with engines).

Land ownership

Table 20 shows that c-farmers in Cambodia and Lao sites owned the most land (2.7 and 2.2 hectares respectively). Except for Vietnam, rice yield of c-farmers was also highest. The Mekong Delta sites had the smallest size of land, surprisingly with the smallest area for c-farmers, followed by c-fishers. The Vietnamese grow multiple rice crops each year, so the rice yield per year is many times higher. With the methodology used by the study, however, breaking down the yield for each crop is not possible. This makes it difficult to make comparisons across sites.

Table 20: Land ownership

Study sites		Size of area (hectares)	Production in last year (kgs)	Rice Yields (kgs/hectare)
		Mean	Mean	Mean
Cambodia	S-fishers	.	.	.
	C-fishers	1.5	4,915	2,122
	S-farmers	1.4	2,054	1,781
	C-farmers	2.7	7,914	2,449
Laos	S-fishers	1.5	2,792	1,957
	C-fishers	1.7	3,320	2,139
	S-farmers	1.8	3,376	2,213
	C-farmers	2.2	5,139	2,301
Thailand	S-fishers	2.8	5,544	2,151
	C-fishers	1.6	2,884	2,587
	S-farmers	1.4	3,116	2,938
	C-farmers	2	6,091	3,506
Vietnam	S-fishers	.	.	.
	C-fishers	0.7	10,615	17,608
	S-farmers	1.1	14,579	14,959
	C-farmers	0.3	4,348	14,770

Livestock

Livestock, including buffalos and cattle, are an important way of saving in LMB countries. When unexpected expenses arise, households depend on the sale of livestock to cover them. Hence, livestock are often valuable assets and a safety net for households (WFP 2005). In rural Lao PDR, the income derived from the sale of one buffalo provides enough cash to buy the rice needed for four to five people for an entire year (WFP 2001).

Livestock was most common in the Cambodian and Lao study sites. Table 21 shows that in Cambodia, 92.2% of c-farmers owned livestock, followed by s-farmers (66.4%), and c-fishers (37.1%). In Lao PDR, 83.1% of s-farmers raised livestock. A lower rate, but similar, applies to other strata, ranging from 73.2% to 76.5%. On the Thai sites, although a very small proportion of the population (all groups) raised livestock, the percentage of each stratum was higher than Vietnam, where no s-fishers raised livestock and only 3.6% of c-fishers were engaged in this activity.

Table 21: Percentage of population with and without livestock (%)

Study sites		Cattle/Buffalo		Total
		No	Yes	
Cambodia	C-fishers	62.9	37.1	100
	S-farmers	33.6	66.4	100
	C-farmers	7.8	92.2	100
Laos	S-fishers	26.8	73.2	100
	C-fishers	24.3	75.7	100
	S-farmers	16.9	83.1	100
	C-farmers	23.5	76.5	100
Thailand	S-fishers	75	25	100
	C-fishers	90.9	9.1	100
	S-farmers	85.9	14.1	100
	C-farmers	81.2	18.8	100
Vietnam	S-fishers	100	0	100
	C-fishers	96.4	3.6	100
	S-farmers	94.1	5.9	100
	C-farmers	91	9	100

Farming equipment: tractor

Tractors, especially, two-wheel tractors used for multiple purposes, including land preparation, water pumping, and rice transportation, are most common in the Lao study site (Table 22), with the least ownership by c-fishers followed by s-fishers (17.8% and 24.4%, respectively). In Cambodia, very few c-fishers and c-farmers own tractors (2.5% and 2.4%, respectively). In Thailand, surprisingly, significantly more fishers than farmers owned tractors. Only 11.1% and 23.9% of s-farmers and c-farmers, respectively, possessed tractors, compared to 50.0% and 40.9% of s-fishers and c-fishers, respectively. Vietnam Mekong Delta had the least percentage of population possessing tractors, with no fishers having a tractor and the percent of farmers who owned tractors not more than 1.7%.

Table 22: Percentage of fishing and farming households with a tractor

Study sites		Tractor		Total
		No	Yes	
Cambodia	C-fishers	97.5%	2.5%	100
	S-farmers	97.6%	2.4%	100
	C-farmers	90.2%	9.8%	100
Laos	S-fishers	75.6%	24.4%	100
	C-fishers	82.2%	17.8%	100
	S-farmers	64.4%	35.6%	100
	C-farmers	56.3%	43.7%	100
Thailand	S-fishers	50.0%	50.0%	100
	C-fishers	59.1%	40.9%	100
	S-farmers	88.9%	11.1%	100
	C-farmers	76.1%	23.9%	100
Vietnam	S-fishers	100.0%		100
	C-fishers	100.0%		100
	S-farmers	98.3%	1.7%	100
	C-farmers	98.5%	1.5%	100

Fishing equipment: boat with engine

Almost all c-fishers at all study sites owned a boat with engine, except for Lao PDR, where a similar percentage of s-fishers and c-fishers owned boats with engines (63.4% and 63.2%, respectively). In Vietnam, no s-fishers possessed such a fishing equipment (Table 23).

Table 23: Percentage of fishing households with a boat with engine

Study sites		Boat with engine		Total
		No	Yes	
Cambodia	C-fishers	64.6	35.4	100
	S-farmers	96.8	3.2	100
	C-farmers	88.2	11.8	100
Laos	S-fishers	36.6	63.4	100
	C-fishers	36.8	63.2	100
	S-farmers	62.7	37.3	100
	C-farmers	63.6	36.4	100
Thailand	S-fishers	87.5	12.5	100
	C-fishers	86.4	13.6	100
	S-farmers	98.5	1.5	100
	C-farmers	97.4	2.6	100
Vietnam	S-fishers	100	0	100
	C-fishers	39.3	60.7	100
	S-farmers	85.6	14.4	100
	C-farmers	91	9	100

Income diversity

Table 24 suggests that the Lao PDR site had the most diversified sources of income, and the diversification was quite similar for all strata. The lowest diversification of income was found at the Tonle Sap Lake sites, particularly for c-farmers (1.6 sources). In Thailand, s-fishers and s-farmers had fewest sources of income, compared to c-fishers and c-farmers. In Vietnam, s-farmers had fewer sources of income (2.7) compared to other strata within the site.

Table 24: Average number of income sources earned in the year preceding the survey

		Average income sources earned in the year	Standard Deviation
Cambodia	S-fishers	.	.
	C-fishers	2.0	1.2
	S-farmers	1.9	1.2
	C-farmers	1.6	1.1
Laos	S-fishers	3.9	1.4
	C-fishers	3.7	1.6
	S-farmers	3.6	1.6
	C-farmers	3.3	1.9
Thailand	S-fishers	2.6	1.8
	C-fishers	3.8	2.0
	S-farmers	2.7	1.4
	C-farmers	3.3	1.6
Vietnam	S-fishers	3.0	.
	C-fishers	2.9	1.3
	S-farmers	2.7	1.0
	C-farmers	3.1	1.3

Food diversity

Similar to the income diversity, food items consumed the day before the survey were more diverse at the Lao PDR and Thai sites. The average number of food items consumed was not much different between strata. Although the Vietnam site had the lowest food diversity, very little difference between strata existed, ranging from 3.0 to 3.5 (Table 25). Similarly, all groups in the Cambodian site ate a similar average number of food items.

Table 25: Average food items consumed the day before the survey

		Mean	Standard Deviation
Cambodia	S-fishers	.	.
	C-fishers	3.7	1
	S-farmers	3.7	1
	C-farmers	3.6	1.1
Laos	S-fishers	4.7	1.3
	C-fishers	4.7	1.4
	S-farmers	4.7	1.3
	C-farmers	5	1.4
Thailand	S-fishers	4.3	0.7
	C-fishers	5.2	1.4
	S-farmers	4.4	1.4
	C-farmers	4.5	1.3
Vietnam	S-fishers	3.0	.
	C-fishers	3.3	0.9
	S-farmers	3.3	0.6
	C-farmers	3.5	0.8

Indebtedness

To obtain data on indebtedness, two questions were asked: "Please indicate in which months you had to do any of the following (if at all)?" and "Have you gone into debt to maintain crop production?"

Action	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
b. Borrow rice												
c. Borrow money to buy rice												

Table 26 shows the results. Cambodia and Vietnam sites emerged as most indebted, but for different purposes. At the Cambodia site, indebtedness was more about short-term need, while at the Thai site it was about longer term (production). At the Cambodia sites, c-fishers were most indebted, followed by s-farmers and c-farmers. In Thailand, a similar percentage of each stratum was indebted to maintain crop production, ranging from about 55% to 66%. A small proportion of the s-farmers also went into debt to buy or borrow rice. At the Lao site, indebtedness to maintain crop occurred with c-fishers and s-farmers. These groups also saw a longer period of time in the year when they had to borrow rice or money to buy rice. At the Vietnam site, the only stratum that had to borrow rice was s-farmers, with only very small proportion needing to do so.

Table 26: Indebtedness

Study Sites		Borrow money to buy rice		Borrow rice for consumption		Debt to maintain crop
		Mean months	Standard Deviation	Mean months	Standard Deviation	%
Cambodia	S-fishers	.	.	.	.	
	C-fishers	0.9	2	1.3	2.2	1.8%
	S-farmers	0.62	1.51	0.98	1.77	7.1%
	C-farmers	0.23	0.85	0.43	1.2	5.7%
Laos	S-fishers	0.02	0.16	0.02	0.16	
	C-fishers	0.02	0.19	0.08	0.48	1.9%
	S-farmers	0	0	0.07	0.37	3.4%
	C-farmers	0	0	0.01	0.09	
Thailand	S-fishers	0	0	0	0	62.5%
	C-fishers	0	0	0	0	54.5%
	S-farmers	0.01	0.17	0.08	0.71	57.8%
	C-farmers	0	0	0	0	65.8%
Vietnam	S-fishers	0	.	0	.	
	C-fishers	0	0	0	0	
	S-farmers	0	0	0.03	0.26	
	C-farmers	0	0	0	0	

Savings

The opposite of indebtedness is saving; more saving generally means more resilience. Table 27 shows almost no saving in the Mekong Delta, and a very small percent of households (3.0% to 4.8%) in the Tonle Sap Lake sites had bank or non-bank savings in the 12 months before the survey. A greater percent in the Lao sample had saved compared to Cambodia and Vietnam sites, but significantly less than the Thai sites. In Lao PDR, strata having saved the least percent are s-farmers (5.1%), followed by s-fishers (7.3%). At the Thai site, the least-percent saving of the strata was s-farmers (31.1%) followed by c-fishers (31.8%).

Table 27: Bank or nonbank savings in the12 months before the survey

Study sites		No	Yes	Total
Cambodia	C-fishers	97.0%	3.0%	100.0%
	S-farmers	95.2%	4.8%	100.0%
	C-farmers	96.2%	3.8%	100.0%
Laos	S-fishers	92.7%	7.3%	100.0%
	C-fishers	87.9%	12.1%	100.0%
	S-farmers	94.9%	5.1%	100.0%
	C-farmers	89.9%	10.1%	100.0%
Thailand	S-fishers	62.5%	37.5%	100.0%
	C-fishers	68.2%	31.8%	100.0%
	S-farmers	68.9%	31.1%	100.0%
	C-farmers	58.1%	41.9%	100.0%
Vietnam	S-fishers	100.0%		100.0%
	C-fishers	100.0%		100.0%
	S-farmers	99.2%	0.8%	100.0%
	C-farmers	100.0%		100.0%

Supporting environment including institutions (by strata and study sites)

To address the issue of institutional support, the study used data from the question on support that households receieved in times of flooding in the five years before the survey, presented in Table 28. The most diversified in terms of support was the Cambodian study site, where some received assistance from local NGOs and others in addition to central and local governments. In Lao PDR, 100% of affected households reported they received assistance from the central governments, while 100% of s-farmers said they had support from local governments. In Thailand, besides the central and local governments, some households received assistance from community and family/friends. In Vietnam, almost all households said they received no support, except for 1.5% of c-farmers who reported receiving support from the government and 3.6% of c-fishers who said they received support from family/friends.

Table 28: Support received in times of flooding in the past 5 years

		Loss because of flooding in the last 5 years	Support received								
			None	National Govern-ment	Local govern-ment	Interna-tional NGOs	Local NGOs	Family/ Friends	Com-munity	Other	Total
Cambodia	C-fishers	75.6%		65.7%	12.9%		12.9%			8.6%	100%
	S-farmers	81.0%		65.5%	6.9%	3.4%	8.6%	3.4%		12.1%	100%
	C-farmers	76.5%		62.5%	6.2%		12.5%			18.8%	100%
Laos	C-fishers	18.9%		20.0%	80.0%						100%
	S-farmers	15.3%			100.0%						100%
	C-farmers	12.6%		100.0%							100%
Thailand	S-fishers	37.5%		25.0%	75.0%						100%
	C-fishers	59.1%	15.4%	38.5%	30.8%			7.7%	7.7%		100%
	S-farmers	46.7%	23.8%	25.4%	47.6%				3.2%		100%
	C-farmers	46.2%	14.5%	32.7%	40.0%			7.3%	3.6%	1.8%	100%
Vietnam	S-fishers		100.0%								100%
	C-fishers	10.7%	96.4%					3.6%			100%
	S-farmers	4.2%	100.0%								100%
	C-farmers	13.4%	98.5%		1.5%						100%

4.4. Adaptability

Adaptation in the past 5–10 years

The study included a question on changes in the occupation in the five years before the survey: "Have any household members had to change occupation in the last five years because of declining productivity of natural resouces, such as fish, other aquatic animals or collected plants? *[Prompt to make sure change was due to declining productivity and not other factors.]*". Results are presented in Table 29.

Overall, 14% of households had to change their occupation over the previous five years specifically because of declining productivity of natural resources (although not necessarily fish productivity). The most significant change had been in the Mekong Delta, where 37.3% of the c-farmers, 21.2% of s-farmers, and 17.9% of c-fishers reported at least one member of the household had changed occupation for this reason. This reflects the rapid economic development in Vietnam in the last five years, which created many new jobs. In Lao PDR and Thailand, the highest change occurred in the households of s-fishers, while at Tonle Sap Lake, Cambodia, s-farmers' households had the highest change. It is not surprising that occupational change is highest in the Mekong Delta, Vietnam.

Table 29: Change of occupation because of decline in natural resources

		Changed	No changed	Total
Cambodia study sites	C-fishers	9.7%	90.3%	100.0%
	S-farmers	13.7%	86.3%	100.0%
	C-farmers	9.4%	90.6%	100.0%
Lao study sites	S-fishers	14.6%	85.4%	100.0%
	C-fishers	11.2%	88.8%	100.0%
	S-farmers	6.8%	93.2%	100.0%
	C-farmers	7.6%	92.4%	100.0%
Thai study sites	S-fishers	12.5%	87.5%	100.0%
	C-fishers	4.5%	95.5%	100.0%
	S-farmers	10.4%	89.6%	100.0%
	C-farmers	11.1%	88.9%	100.0%
Vietnam study sites	S-fishers		100.0%	100.0%
	C-fishers	17.9%	82.1%	100.0%
	S-farmers	21.2%	78.8%	100.0%
	C-farmers	37.3%	62.7%	100.0%

Recovery from flood

People in the Mekong Delta have adapted to flood, and consider floods as usual phenomena, often referred to as "living with floods." Not surprisingly, all the s-fishers, and the majority of the other strata, reported they did not experience floods in the last 5 years (Table 30).

In contrast, at the Lao study site, all the households experienced floods in the last 5 years. All also have recovered from the impacts. Average time taken to recover was 2 months for c-fishers and s-farmers, while s-fishers and c-farmers took only 1 month.

In Cambodia, the majority of all strata experienced floods in the last 5 years, but have since recovered. S-farmers took the longest time to recover (8 months), followed by c-fishers (6 months). In Thailand, all s-fishers experienced floods. S-fishers took the longest time to recover (7 months), followed by c-fishers (6 months), and s-farmers (5 months).

Table 30: Have you recovered from floods in the last 5 years?

			Yes, experienced floods in the last 5 years		
		Not experienced flooding	Yes, but have recovered	Time taken to recover (months)	Yes and not recovered yet
Cambodia	C-fishers	0.0%	82.3%	6	17.7%
	S-farmers	0.0%	77.9%	8	22.1%
	C-farmers	0.0%	94.3%	2	5.7%
Laos	S-fishers	0.0%	100.0%	1	0.0%
	C-fishers	0.0%	100.0%	2	0.0%
	S-farmers	0.0%	100.0%	2	0.0%
	C-farmers	0.0%	100.0%	1	0.0%
Thailand	S-fishers	0.0%	100.0%	7	0.0%
	C-fishers	7.7%	53.8%	6	38.5%
	S-farmers	3.2%	68.3%	5	28.6%
	C-farmers	3.6%	74.5%	3	21.8%
Vietnam	S-fishers	100.0%	0.0%	0	0.0%
	C-fishers	89.3%	3.6%	0	7.1%
	S-farmers	96.6%	0.8%	0	2.5%
	C-farmers	86.6%	11.9%	0	1.5%

Future adaptation

When asked, “If your household members were no longer able to engage in the activities you have just mentioned due to a decline in their productivity, what would you do?”, more than three-quarters of the respondents in all strata at the Cambodia study site reported they couldn’t think of any other livelihood alternatives (Table 31). Although Thailand is the most economically developed country in the LMB, samples from this site ranked second in terms of “cannot think of any alternatives.” This is highest with s-farmers (45.5%). At the Lao study site, s-farmers accounted for the highest percent who said they could not think of anything. In Vietnam, c-fishers ranked first (14.3%) in terms of “cannot think of any alternatives,” followed by s-farmers (10.9%).

Overall, if productivity in their current activity declines, it is likely that very few people in the Tonle Sap Lake area would have other livelihood alternatives. In Lao PDR, a substantial number of people would shift to another natural resource activity and livestock, and only a small proportion would shift to local employment. In Thailand, the options would be a shift to other natural resources (highest proportion), followed by seeking local employment, starting a business, and raising livestock. In Vietnam, shifting to other natural resources is no longer an option. All s-fishers would shift to livestock, while other strata would seek local employment or migrate. A small proportion of s-farmers and c-farmers would start their own business.

By strata, s-farmers in Cambodia and Thailand have the highest percentage of all farmers in the sample who said they could not think of any alternatives. In Lao PDR, there is not much difference between s-fishers and c-farmers in terms of “no other alternatives.” In Vietnam, no s-fishers would be concerned. All would shift to livestock. Local employment and migration would be an option for many of the other strata.

Table 31: What would they do if productivity decreases?

		Can't think of anything	Shift to another natural resource activity	Shift to livestock	Shift to farming	Seek employ ment locally	Migrate	Start business	Borrow money or food	Depend on help from others	Other	Total
Cambodia	C-fishers	77.3%	5.5%	4.7%	5.5%	3.1%		2.3%		0.8%	0.8%	100.0%
	S-farmers	77.9%	3.5%	4.7%	4.7%	3.5%		5.8%				100.0%
	C-farmers	75.8%	3.0%		6.1%	3.0%		9.1%			3.0%	100.0%
Laos	S-fishers	6.1%	39.4%	33.3%		9.1%		9.1%		3.0%		100.0%
	C-fishers		51.9%	35.4%	2.5%	6.3%		3.8%				100.0%
	S-farmers		41.7%	38.9%		8.3%		2.8%		2.8%	5.6%	100.0%
	C-farmers	5.3%	41.3%	40.0%	1.3%	4.0%	1.3%	4.0%		2.7%		100.0%
Thailand	S-fishers	25.0%	50.0%	12.5%		12.5%						100.0%
	C-fishers	36.4%	27.3%	4.5%		18.2%		13.6%				100.0%
	S-farmers	45.5%	28.8%	0.8%	0.8%	14.4%	2.3%	6.8%		0.8%		100.0%
	C-farmers	28.9%	32.5%	7.0%		12.3%	0.9%	13.2%		4.4%	0.9%	100.0%
Vietnam	S-fishers			100.0%								100.0%
	C-fishers	14.3%		14.3%		47.6%	14.3%		4.8%		4.8%	100.0%
	S-farmers	10.9%		24.8%	2.0%	31.7%	6.9%	20.8%			3.0%	100.0%
	C-farmers	9.1%	1.8%	14.5%	3.6%	32.7%	18.2%	12.7%	1.8%	1.8%	3.6%	100.0%

Summary

Table 32 provides a summary of the indicators discussed in this chapter, showing differences across strata and sites.

At the Cambodia study site, c-fishers were more vulnerable than other strata at the site. They were more dependent on fish for income and for food and had less land area, and fewer people owned livestock. Although their income and food were more diverse, they appeared to be more indebted for short-term needs, particularly for rice. S-farmers were highly dependent on fish and rice for income and for food, although the level of dependence was lower than c-fishers. C-farmers were least vulnerable because they were least dependent on fish for income and for food. They owned the largest land area, and a greater percentage owned livestock. A greater percentage of the sample was affected by floods, but they took the least time to recover.

At the Lao site, s-fishers had the highest level of dependence on fish for income and for food. They had the least land area and livestock. They had a greater percentage of households that would change occupation due to declining in productivity of natural resources. C-farmers were next in terms of dependence on fish for income and for food. They took a longer time, however, to recover from impacts of floods.

At the Thai study site, c-fishers were most highly dependent on fish for income, but their dependence on fish for food was low. Fish as food was most important for s-fishers; s-fishers were also highly indebted and had more households that would change occupation if the natural resources on which they depend productivity declined. They also had a longer recovery period. They had the lowest income and food diversity.

At the Vietnam site, the largest percent of income and food from fish was for c-fishers, yet average land area was quite small. C-fishers, however, had more savings than farmers. The stratum of second greatest concern would be s-farmers. Although they did not depend much on fish for cash income, a substantial proportion of calorie intake was from fish. They had the highest dependence on rice for income and for food. Their income diversity was the lowest. C-farmers were not so different in terms of dependence on fish and rice for income and for food. Their dependence on rice for income was substantially lower than that of the s-farmers. However, a greater percentage of this group would change occupation because of declining productivity in natural resources. They also had the highest proportion of population affected by floods.

Table 32: Summary of dependence and resilience indicators

		Dependence				Resilience												Impacts			
		Income from fish	Income from rice	Calorie from fish	Calorie from rice	Land area	Tractor ownership	Livestock ownership	Boat with engine ownership	Income diversity	Food diversity	Borrow money to buy rice	Borrow rice for consumption	Debt to maintain crop production	Saving	Chance of support received	Lack of alternative livelihoods	Changed occupation in the last 5 years	Impacts from floods	Average number of losses due to floods	Time taken to recover
		%	%	%	%	ha	%	%	%	items	items	Month	Monh	%	%	%	%	%	%	Items	month
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Cambodian study sites	S-fishers	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	C-fishers	34.8	6.8	12.1	73.7	1.5	2.5	37.1	35.4	2.0	3.7	0.9	1.3	1.8	3.0	29.3	77.3	9.7	82.3	2.5	6.0
	S-farmers	17.7	8.1	11.2	75.4	1.4	2.4	66.4	3.2	1.9	3.7	0.6	1.0	7.1	4.8	29.3	77.9	13.7	77.9	2.7	8.0
	C-farmers	11.7	27.2	11.0	74.8	2.7	9.8	92.2	11.8	1.6	3.6	0.2	0.4	5.7	3.8	29.3	75.8	9.4	94.3	2.2	2.0
Lao study sites	S-fishers	20.6	10.2	9.6	76.0	1.5	24.4	73.2	63.4	3.9	4.7	0.0	0.0		7.3	2.8	6.1	14.6	100.0	2.1	1.0
	C-fishers	19.0	6.2	7.9	74.5	1.7	17.8	75.7	63.2	3.7	4.7	0.0	0.1	1.9	12.1	15.4		11.2	100.0	2.5	2.0
	S-farmers	14.5	5.9	6.9	80.4	1.8	35.6	83.1	37.3	3.6	4.7	0.0	0.1	3.4	5.1	28.7		6.8	100.0	3.2	2.0
	C-farmers	7.4	18.9	8.1	74.2	2.2	43.7	76.5	36.4	3.3	5.0	0.0	0.0		10.1	1.2	5.3	7.6	100.0	2.5	1.0
Thai study sites	S-fishers	0.0	0.0	11.2	70.5	2.8	50.0	25.0	12.5	2.6	4.3	0.0	0.0	62.5	37.5	100.0	25.0	12.5	100.0	1.7	7.0
	C-fishers	11.3	1.4	6.9	75.1	1.6	40.9	9.1	13.6	3.8	5.2	0.0	0.0	54.5	31.8	84.0	36.4	4.5	53.8	2.0	6.0
	S-farmers	0.7	4.3	10.5	71.1	1.4	11.1	14.1	1.5	2.7	4.4	0.0	0.1	57.8	31.1	75.6	45.5	10.4	68.3	1.8	5.0
	C-farmers	1.6	19.7	9.7	71.5	2.0	23.9	18.8	2.6	3.3	4.5	0.0	0.0	65.8	41.9	76.6	28.9	11.1	74.5	2.0	3.0
Vietnam study sites	S-fishers	0.0	0.0	0.0	93.9	.		0.0	0.0	3.0	3.0	0.0	0.0			.			0.0	0.0	0.0
	C-fishers	45.3	0.7	14.7	74.7	0.7		3.6	60.7	2.9	3.3	0.0	0.0			50.0	14.3	17.9	3.6	0.1	0.0
	S-farmers	1.0	23.0	14.0	77.4	1.1	1.7	5.9	14.4	2.7	3.3	0.0	0.0		0.8	0.0	10.9	21.2	0.8	0.0	0.0
	C-farmers	3.0	12.4	12.0	72.8	0.3	1.5	9.0	9.0	3.1	3.5	0.0	0.0			20.0	9.1	37.3	11.9	0.2	0.0

Chapter 5. Findings, Analysis, and Discussion

In the context of the preceding examination of the extent to which each stratum depended on fish and rice and its capacity to cope with and adapt to changes in resources, this chapter 1) explores variables that affect each sample stratum, each country, and the four countries; 2) relates findings to the vulnerability function; 3) identifies variables and results with the most significant outcomes; and 4) notes any unexpected findings or results that I cannot explain. Unless otherwise stated, discussion in this chapter is based on Table 32 (summary of results).

5.1. Variables that affect each sample stratum, each country, and the four countries

Variables that affect each sample stratum

This section discusses variables affecting each stratum separately, starting with s-fishers, followed by c-fishers, s-farmers, and c-farmers. The term *stratum* here refers to the same stratum across the four countries, not just within one country.

Variables are considered as not relevant if they do not apply to all the four strata (except for s-fishers, where the sample is too small for Cambodia and Vietnam). Frequency will also be used to assess variables affecting each stratum. Although variables of impacts are provided, discussion will focus on dependence and resilience.

S-fishers:

Because s-fishers are missing at the Cambodia and Vietnam sites, to discuss the level of relevance I will consider variables common to two or more countries rather than all four.

Table 33 shows that two variables under the dependence factor (calories from fish, calories from rice), and 10 variables for resilience (land area, tractor, livestock, boat with engines, income diversity, food diversity, saving, chance of support received, alternative livelihoods) are relevant. Note that while colors are used in the graphs, the colors do not carry any meaning. The colors are used for ease in reading each variable.

Interestingly, the proportion of income from fish and rice in Thailand was next to zero. This might be because most of fish caught was consumed by the households. In fact, s-fishers are distinguished from c-fishers by the sale of less than 25%, explaining the lack of cash income from this source.

Although 16 variables are shared by this stratum across the countries, households in the Lao site raised more livestock, owned more boats with engines, had more sources of income, and had more households that would change occupation in the face of resource shortages. Households at the Thai site, on the other hand, owned more land area and tractors, had a greater percentage of households that went into debt to maintain crops, had more households with savings, and received more support in times of hardship. The biggest proportion of the sample population received support from local government, followed by national government.

Table 33: S-fishers

		Dependence				Resilience											
		Income from fish	Income from rice	Calorie from fish	Calorie from rice	Land area	Tractor ownership	Livestock ownership	Boat with engine ownership	Income diversity	Food diversity	Borrow money to buy rice	Borrow rice for consumption	Debt to maintain crop production	Saving	Chance of support received	Lack of alternative livelihoods
		%	%	%	%	ha	%	%	%	items	items	Month	Monh	%	%	%	%
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Cambodian study sites	S-fishers	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Lao study sites	S-fishers	20.6	10.2	9.6	76.0	1.5	24.4	73.2	63.4	3.9	4.7	0.0	0.0		7.3	2.8	6.1
Thai study sites	S-fishers	0.0	0.0	11.2	70.5	2.8	50.0	25.0	12.5	2.6	4.3	0.0	0.0	62.5	37.5	100.0	25.0
Vietnam study sites	S-fishers	0.0	0.0	0.0	93.9	.		0.0	0.0	3.0	3.0	0.0	0.0			.	

C-fishers:

According to Table 34, c-fishers shared four variables of dependence (income from fish, income from rice, calorie from fish, calorie from rice), six variables of resilience (land area, livestock, boat with engine, income diversity, food diversity, chance of support received), and three variables of impacts (changed occupation, impacts by floods, and average number of losses due to floods). Fish was an important source of cash income for c-fishers, ranging from 11% to 45% of the total income. Income from rice was considerably more important for c-fishers in Cambodia and Lao PDR than for those in the other countries. The share of fish in the total calorie is highest in Vietnam, followed by Cambodia and Lao PDR. Contribution of rice to total calories is very high and similar across sites. One big difference among countries in this stratum was support received. Households at the Thai site received very high support (84% of each loss), while those in Lao PDR received little (15%).

Table 34: C- fishers

		Dependence				Resilience											
		Income from fish	Income from rice	Calorie from fish	Calorie from rice	Land area	Tractor ownership	Livestock ownership	Boat with engine ownership	Income diversity	Food diversity	Borrow money to buy rice	Borrow rice for consumption	Debt to maintain crop production	Saving	Chance of support received	Lack of alternative livelihoods
		%	%	%	%	ha	%	%	%	items	items	Month	Monh	%	%	%	%
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Cambodian study sites	C-fishers	34.8	6.8	12.1	73.7	1.5	2.5	37.1	35.4	2.0	3.7	0.9	1.3	1.8	3.0	29.3	77.3
Lao study sites	C-fishers	19.0	6.2	7.9	74.5	1.7	17.8	75.7	63.2	3.7	4.7	0.0	0.1	1.9	12.1	15.4	
Thai study sites	C-fishers	11.3	1.4	6.9	75.1	1.6	40.9	9.1	13.6	3.8	5.2	0.0	0.0	54.5	31.8	84.0	36.4
Vietnam study sites	C-fishers	45.3	0.7	14.7	74.7	0.7		3.6	60.7	2.9	3.3	0.0	0.0			50.0	14.3

S-farmers:

S-farmers (Table 35) shared four variables of dependence (income from fish, income from rice, calorie from fish, calorie from rice), seven variables of resilience (land area, tractor, livestock, boat with engines, income diversity, food diversity, saving), and one variable of impact (changed occupation due to decline in natural resources). Fish contributed income to this stratum in all countries, but much more in Cambodia (18%) and Lao PDR (15%) than in Thailand and Vietnam. Although Thailand is the world's largest rice exporter, the share of income from this source was even less than that of Lao PDR. The number of calories from fish was highest for Vietnam, followed by Cambodia. Food diversity was less than Lao PDR. Land area was quite similar, ranging from 1.1 to 1.8 ha on average. Tractors were more common in Lao PDR than in other countries. Livestock ownership was highest in Lao PDR, followed by Cambodia. Only a small proportion of the survey population in Thailand and Vietnam raised livestock. A large proportion of the s-farmers in Lao PDR owned a boat with an engine, while a very small proportion of households at other sites did. The percentage of households with savings was large at the Thai site, and very small at other sites. High rates of change in occupation anticipated with loss of natural resources were found in Vietnam, followed by Cambodia and Thailand.

Table 35: S-farmers

		Dependence				Resilience											
		Income from fish	Income from rice	Calorie from fish	Calorie from rice	Land area	Tractor ownership	Livestock ownership	Boat with engine ownership	Income diversity	Food diversity	Borrow money to buy rice	Borrow rice for consumption	Debt to maintain crop production	Saving	Chance of support received	Lack of alternative livelihoods
		%	%	%	%	ha	%	%	%	items	items	Month	Month	%	%	%	%
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Cambodian study sites	S-farmers	17.7	8.1	11.2	75.4	1.4	2.4	66.4	3.2	1.9	3.7	0.6	1.0	7.1	4.8	29.3	77.9
Lao study sites	S-farmers	14.5	5.9	6.9	80.4	1.8	35.6	83.1	37.3	3.6	4.7	0.0	0.1	3.4	5.1	28.7	
Thai study sites	S-farmers	0.7	4.3	10.5	71.1	1.4	11.1	14.1	1.5	2.7	4.4	0.0	0.1	57.8	31.1	75.6	45.5
Vietnam study sites	S-farmers	1.0	23.0	14.0	77.4	1.1	1.7	5.9	14.4	2.7	3.3	0.0	0.0		0.8	0.0	10.9

S-farmers:

Variables that were shared by the s-farmer stratum in all the countries are four variables of dependence (income from fish, income from rice, calorie from fish, calorie from rice) and eight variables of resilience (land area, tractor, livestock, boat with engine, income diversity, food diversity, chance to receive support, and livelihood opportunities). The share of income from fish was highest in Cambodia, followed by Lao PDR. Cash income from this source was minor for Thailand and Vietnam. Rice contribution to cash income was much higher than fish in all countries. Calorie intake from fish and rice was not very different across sites. Livestock ownership was highest in Cambodia, followed by Lao PDR. Income diversity was very similar among Lao PDR, Thailand, and Vietnam. The Cambodian site population had very few income sources. Again, chance of receiving support was very high in Thailand compared to other countries. The majority of households in Cambodia did not see other livelihood alternatives if their current livelihood activities were no longer available them (Table 36).

Table 36: C-farmers

		Dependence				Resilience											
		Income from fish	Income from rice	Calorie from fish	Calorie from rice	Land area	Tractor ownership	Livestock ownership	Boat with engine ownership	Income diversity	Food diversity	Borrow money to buy rice	Borrow rice for consumption	Debt to maintain crop production	Saving	Chance of support received	Lack of alternative livelihoods
		%	%	%	%	ha	%	%	%	items	items	Month	Monh	%	%	%	%
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Cambodian study sites	C-farmers	11.7	27.2	11.0	74.8	2.7	9.8	92.2	11.8	1.6	3.6	0.2	0.4	5.7	3.8	29.3	75.8
Lao study sites	C-farmers	7.4	18.9	8.1	74.2	2.2	43.7	76.5	36.4	3.3	5.0	0.0	0.0		10.1	1.2	5.3
Thai study sites	C-farmers	1.6	19.7	9.7	71.5	2.0	23.9	18.8	2.6	3.3	4.5	0.0	0.0	65.8	41.9	76.6	28.9
Vietnam study sites	C-farmers	3.0	12.4	12.0	72.8	0.3	1.5	9.0	9.0	3.1	3.5	0.0	0.0			20.0	9.1

Table 37 summarizes variables for each stratum. The number *1* indicates that the variable is applicable to the respective stratum across all countries. Column A is the sum of all 1. An empty column indicates irrelevant variables or no value for one or more of the strata. With this approach, all the strata share similar number of variables, but not necessarily the same variables. For example, income from fish and rice were not significant for s-fishers, while they were important for all others. Surprisingly, savings was relevant to s-fishers and s-farmers, and not c-fishers and c-farmers.

Table 37: Summary of common variables for each stratum of all sites

		Dependence				Resilience											
	Total variables applicable to the stratum in all countries	Income from fish	Income from rice	Calorie from fish	Calorie from rice	Land area	Tractor ownership	Livestock ownership	Boat with engine ownership	Income diversity	Food diversity	Borrow money to buy rice	Borrow rice for consumption	Debt to maintain crop production	Saving	Chance of support received	Lack of alternative livelihoods
		%	%	%	%	ha	%	%	%	items	items	Month	Monh	%	%	%	%
	A	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
S-fishers	10			1	1	1	1	1	1	1	1				1		1
C-fishers	10	1	1	1	1	1		1	1	1	1					1	
S-farmers	12	1	1	1	1	1	1	1	1	1	1				1		1
C-farmers	11	1	1	1	1	1	1	1	1	1	1						1

Variables that affect each country

Variables that affect all strata will be considered as most relevant in each country. Exceptions, however, exist, particularly for dependence, since very limited variables are included for dependence and this is the main part of the study.

Cambodia:

Based on Table 38, all of the strata except for s-fishers shared similar levels of dependence on fish and rice for food, and similar levels of resilience in terms of food diversity and support opportunities. What makes them different, however, is the dependence on fish and rice for income. C-fishers depended on fish for income the most, followed by s-farmers and c-farmers. Exactly the opposite was true for rice as a source of income. If fish decline, c-fishers would be affected the most, followed by s-farmers and c-farmers. The reverse order would occur if rice declines.

C-farmers, however, had the highest capacity to cope with the impacts. C-farmers had the biggest land area and had more households with tractors and livestock. They also were less indebted in terms of money borrowed to buy rice and to maintain crop production. This suggests that c-farmers have the largest capacity for resilience. C-fishers and s-farmers shared similar resilience: land area and tractors. Although more s-farmers owned livestock, they were less indebted; while more c–fishers owned boats with engines, many fewer of them owned livestock. C-fishers were also indebted for longer periods. In short, all the variables provided in Table 38 affected each stratum in the country, although the extent to which the strata were affected vary.

Table 38: Variables for Cambodia

		Dependence				Resilience											
		Income from fish	Income from rice	Calorie from fish	Calorie from rice	Land area	Tractor ownership	Livestock ownership	Boat with engine ownership	Income diversity	Food diversity	Borrow money to buy rice	Borrow rice for consumption	Debt to maintain crop production	Saving	Chance of support received	Lack of alternative livelihoods
		%	%	%	%	ha	%	%	%	items	items	Month	Monh	%	%	%	%
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Cambodian study sites	S-fishers	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	C-fishers	34.8	6.8	12.1	73.7	1.5	2.5	37.1	35.4	2.0	3.7	0.9	1.3	1.8	3.0	29.3	77.3
	S-farmers	17.7	8.1	11.2	75.4	1.4	2.4	66.4	3.2	1.9	3.7	0.6	1.0	7.1	4.8	29.3	77.9
	C-farmers	11.7	27.2	11.0	74.8	2.7	9.8	92.2	11.8	1.6	3.6	0.2	0.4	5.7	3.8	29.3	75.8

Lao PDR:

The first 10 variables of dependence and resilience as provided in Table 39 highly affected all strata in Lao PDR. The rest of the variables of resilience, except for saving and chance of support received, are relevant for some strata, but not significant. Variable 12 is relevant to c-fishers and s-farmers, but the duration is very short. The rest of the resilience variables had low frequencies. With this, in assessing vulnerability, four variables of dependence and seven variables of resilience are relevant for Lao PDR.

All strata shared a number of similarities: calories from fish, calories from rice, percent of households with livestock, income diversity, and food diversity. The strata, however, differed highly in their dependence on fish and rice for income. S-fishers were most dependent on fishing for income, while c-farmers were most dependent on rice for cash income. C-farmers also owned the most land, followed by s-farmers and c-fishers. Similar pattern held true for tractor ownership, but a greater percent of s-fishers than c-fishers appeared to have tractors.

Another clear distinction between fishers and farmers is the ownership of a boat with engine. The proportion of fishing households with a boat with engine was double that of farmers. With regard to savings, a larger percentage of both c-fishers and c-farmers had savings, compared to s-fishers and s-farmers. Both c-strata groups and s-strata groups had a similar percentage of households with savings.

In short, four variables of dependence (income from fish, income from rice, calories from fish, calories from rice), and seven variables of resilience (land area, tractor ownership, livestock ownership, boat with engine ownership, income diversity, food diversity, and savings) are highly relevant for all strata in Lao PDR.

Table 39: Variables for Lao PDR

		Dependence				Resilience											
		Income from fish	Income from rice	Calorie from fish	Calorie from rice	Land area	Tractor ownership	Livestock ownership	Boat with engine ownership	Income diversity	Food diversity	Borrow money to buy rice	Borrow rice for consumption	Debt to maintain crop production	Saving	Chance of support received	Lack of alternative livelihoods
		%	%	%	%	ha	%	%	%	items	items	Month	Monh	%	%	%	%
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Lao study sites	S-fishers	20.6	10.2	9.6	76.0	1.5	24.4	73.2	63.4	3.9	4.7	0.0	0.0		7.3	2.8	6.1
	C-fishers	19.0	6.2	7.9	74.5	1.7	17.8	75.7	63.2	3.7	4.7	0.0	0.1	1.9	12.1	15.4	
	S-farmers	14.5	5.9	6.9	80.4	1.8	35.6	83.1	37.3	3.6	4.7	0.0	0.1	3.4	5.1	28.7	
	C-farmers	7.4	18.9	8.1	74.2	2.2	43.7	76.5	36.4	3.3	5.0	0.0	0.0		10.1	1.2	5.3

Thailand:

Overall, 14 variables are relevant to all strata in Thailand (Table 40). Changes in income from fish would affect c-fishers the most, while changes in income from rice would affect c-farmers the most, due to their high level of dependence on these resources for cash income. In terms of food, all strata would be affected similarly if fish and rice declined.

This suggests that the strata of most concern for Thailand are c-fishers and c-farmers because they had the highest dependence on fish and rice for cash income along with weak resilient capacities, particularly a high percentage of households with debt to maintain crop production, uncertain livelihood alternatives, and low percentage of households with savings.

Table 40: Variables for Thailand

		Dependence				Resilience											
		Income from fish	Income from rice	Calorie from fish	Calorie from rice	Land area	Tractor ownership	Livestock ownership	Boat with engine ownership	Income diversity	Food diversity	Borrow money to buy rice	Borrow rice for consumption	Debt to maintain crop production	Saving	Chance of support received	Lack of alternative livelihoods
		%	%	%	%	ha	%	%	%	items	items	Month	Monh	%	%	%	%
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Thai study sites	S-fishers	0.0	0.0	11.2	70.5	2.8	50.0	25.0	12.5	2.6	4.3	0.0	0.0	62.5	37.5	100.0	25.0
	C-fishers	11.3	1.4	6.9	75.1	1.6	40.9	9.1	13.6	3.8	5.2	0.0	0.0	54.5	31.8	84.0	36.4
	S-farmers	0.7	4.3	10.5	71.1	1.4	11.1	14.1	1.5	2.7	4.4	0.0	0.1	57.8	31.1	75.6	45.5
	C-farmers	1.6	19.7	9.7	71.5	2.0	23.9	18.8	2.6	3.3	4.5	0.0	0.0	65.8	41.9	76.6	28.9

Vietnam:

A very low percentage of the Vietnamese households surveyed owned a tractor or livestock. In addition, no household went into debt both for consumption and production. At the same time, very few households had savings. Similar to Thailand, c-fishers depended largely on fish for cash income, and comprised the only stratum whose cash income is from this source. Unlike other countries, s-farmers had the highest dependence on rice for cash income, followed by c-farmers. S-fishers did not depend on fish for calories at all. But this should be considered as unrepresentative because only one household was included in the analysis. The percent of calories from rice is more than 72% for all strata. In short, all four variables of dependence and seven variables of resilience were relevant for Vietnam (Table 41).

Table 42 summarizes results of the discussion regarding variables that affect each country. Nine variables are shared by all countries (income from fish, income from rice, calorie from fish, calorie from rice, land area, livestock, boat with engines, income diversity, and food diversity). The rest are specific to particular countries.

Table 41: Variables for Vietnam

		Dependence				Resilience											
		Income from fish	Income from rice	Calorie from fish	Calorie from rice	Land area	Tractor ownership	Livestock ownership	Boat with engine ownership	Income diversity	Food diversity	Borrow money to buy rice	Borrow rice for consumption	Debt to maintain crop production	Saving	Chance of support received	Lack of alternative livelihoods
		%	%	%	%	ha	%	%	%	items	items	Month	Monh	%	%	%	%
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Vietnam study sites	S-fishers	0.0	0.0	0.0	93.9	.		0.0	0.0	3.0	3.0	0.0	0.0			.	
	C-fishers	45.3	0.7	14.7	74.7	0.7		3.6	60.7	2.9	3.3	0.0	0.0			50.0	14.3
	S-farmers	1.0	23.0	14.0	77.4	1.1	1.7	5.9	14.4	2.7	3.3	0.0	0.0		0.8	0.0	10.9
	C-farmers	3.0	12.4	12.0	72.8	0.3	1.5	9.0	9.0	3.1	3.5	0.0	0.0			20.0	9.1

Table 42: Summary of variables for each country

		Dependence				Resilience											
	Total variables applicable to the stratum in all countries	Income from fish	Income from rice	Calorie from fish	Calorie from rice	Land area	Tractor ownership	Livestock ownership	Boat with engine ownership	Income diversity	Food diversity	Borrow money to buy rice	Borrow rice for consumption	Debt to maintain crop production	Saving	Chance of support received	Lack of alternative livelihoods
		%	%	%	%	ha	%	%	%	items	items	Month	Monh	%	%	%	%
	A	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Cambodia	16	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Laos	11	1	1	1	1	1	1	1	1	1	1				1		
Thailand	14	1	1	1	1	1	1	1	1	1	1			1	1	1	1
Vietnam	10	1	1	1	1	1		1	1	1	1						1

Variables that affect four countries

Because the sample of s-fishers for Cambodia and Vietnam is very small (0 and 1, respectively) I ignored these strata in the consideration of variables applicable to all four countries. With this in mind, according to Table 32 and Table 42, nine variables are relevant to all strata of the four countries: income from fish, income from rice, calories from fish, calories from rice, land area, livestock, boat with engine, income diversity, and food diversity.

The share of income from fish was considerable for all strata of Cambodia and Lao PDR, while in Thailand and Vietnam this was important mainly for c-fishers. Similarly, rice as a source of income was important for all strata in Cambodia and Lao PDR, although variation exists. In Thailand and Vietnam this was mainly true for farmers, indicating more division of labor. Thailand and Vietnam were more advanced economically. The difference in calories from fish between countries is quite narrow. Vietnam had the highest share, followed by Cambodia and Thailand. Similarly, the share of calories from rice was very similar across countries, mostly 70–80%. Livestock was highly important in Lao PDR and Cambodia, while in Thailand and Vietnam livestock was raised by a very small percentage of the population. Ownership of a boat with engine was important mostly for fishers. Food sources were more diverse than income sources in all countries.

5.2. Relationship of findings to vulnerability function

As discussed in the previous chapters, the vulnerability function for this study is set to include eight composite variables over time:

V=f(L, RO, I, F, LA, ID, FD, SEI)/time.

Where:

V = vulnerability

L = location

RO= related occupations

I = income

F = food

LA = livelihoods assets,

ID = income diversity,

FD= food diversity,

SEI= supporting environment: institutions

The variables can be either dependent or independent. They are dependent in the sense that location determines the extent of fishing and rice farming, hence exposure to impacts. Rice farming and fishing-related occupations determine the extent of income and food from rice and fish, hence decline in these resources affect income and food. Occupations also determine specific types of assets possessed, although some livelihood assets are common, such as land, livestock, and social networks. The variables are also independent because they all separately define vulnerability and are the subject of this dissertation as discussed subsequently.

L = location

Rural people who live closer to aquatic ecosystems were more dependent on the resources than those who live further away, with the exception of those who undergo long-distance migration for seasonal fishing (Bouapao and Hall 2010). Although dependence on fish increases with proximity to the Mekong, the loss of fish brings about indirect impacts on people well beyond the 15 km corridor (ibid). The fact that 75% of the catch at the Tonle Sap Lake site sold by local households (Hall and Bouapao 2010) and approximately 80% of fish sold in the local markets of Champasak were from the Mekong in the district of Khong (Baird, I., et al. 2001) suggests the indirect dependence of people beyond the lake and river corridors. Direct dependence on fish and rice varies across study sites. For example, dependence of c-fishers on fish for both cash income and calories was highest in Vietnam, followed by Cambodia. While fish was an important source of cash income and of food for all strata in Cambodia and Lao PDR, it was important for c-fishers only in Thailand and Vietnam. Thus, people in different locations are differentially vulnerable. People with the same occupation (e.g., farmers and fishers) in different locations would be affected differently by changes in the availability of fish and rice. If a fisher were to move from 15km to 5 km from the Mekong, his/her vulnerability would be different.

RO = related occupations

Occupation is highly connected with natural resources, including rice and fish availability. Fishers and farmers living the same distance from the Mekong would be affected differently if fish or rice production were to decline. Earlier analysis shows that both occupations depend on fish and rice differently. Another indication of the linkages between vulnerability and occupation is the relationship between change in occupation as a result of changes in the productivity of natural resources (Table 29). Also, as fish catch goes down, giving up fishing goes up, indicating a strong relationship between fishing and livelihood activity. The study included a question: at what point would you give up fishing altogether and switch to another activity?

Table 43: Percent of households giving up fishing and switch to another activity

		0	0.01 to 0.49	0.5 to 1	>1	Total
Cambodia study sites	C-fishers	26.1%	5.1%	54.3%	14.5%	100.0%
	S-farmers	34.4%	12.5%	51.6%	1.6%	100.0%
	C-farmers	38.1%	9.5%	52.4%		100.0%
Lao study sites	S-fishers	27.5%	32.5%	32.5%	7.5%	100.0%
	C-fishers	25.2%	34.0%	37.9%	2.9%	100.0%
	S-farmers	36.4%	40.9%	22.7%		100.0%
	C-farmers	28.3%	39.1%	30.4%	2.2%	100.0%
Thailand study sites	S-fishers	62.5%		25.0%	12.5%	100.0%
	C-fishers	59.1%	4.5%	31.8%	4.5%	100.0%
	S-farmers	55.4%	7.7%	23.1%	13.8%	100.0%
	C-farmers	56.2%	7.8%	29.7%	6.2%	100.0%
Vietnam study sites	C-fishers	3.7%	18.5%	55.6%	22.2%	100.0%
	S-farmers	8.3%	16.7%	66.7%	8.3%	100.0%
	C-farmers			71.4%	28.6%	100.0%

As Table 43 shows, giving up fishing increased as fish catch went down from more than a kilogram a day to zero. More than half of farmers and fishers surveyed in Thailand would keep fishing until there are no fish left, while more than half of the sample households in Cambodia and Vietnam would stop fishing if catches fell to 0.5–1.0 kilogram per day. In Lao PDR, the distribution of giving up fishing as fish declines was quite even in between 0 and 1 kilogram per day. The high rate of giving up fishing as the catch falls to 0.5–1.0 kilogram in the Tonle Sap and Mekong Delta is perhaps because of the high cost of fishing, in particular fuel for engine boats. With the low catch, people simply cannot afford to cover the cost of fuel.

RI = related income

Table 13 shows that not all strata depended on fish for cash income. At the Thai and Vietnamese sites, except for c-fishers, the share of income from this source was negligible. This suggests that declining fish availability would not affect strata other than c-fishers. All strata in Cambodia and Lao PDR, however, would be highly vulnerable to decline in fish availability. Likewise, dependence of fishers on rice for cash income was low. Rice is a source of income mainly for farmers. In Cambodia and Lao PDR, however, both fishers and farmers obtained some cash income this way. This suggests that decline in fish and/or rice would not have impacts on all strata, but specific strata with related source of income would be affected. Meanwhile, changes in one of the resources would have impacts on all strata in Cambodia and Lao PDR, although the degree of impacts would vary between strata.

RF = related food

Rice is staple food for all strata, making up at least 71% of total calorie intake. Fish contribution to the daily diet was significant for all strata. (Although the value of fish calories for s-fishers at the Vietnam study sites was zero, this was because of the small sample size and short—one-day—time period considered.) It could be concluded that, unlike the impacts on income, calorie intake for all strata would be highly vulnerable to declines in these resources.

LA = livelihoods assets

Based on Table 44, variables with a 0.2 or greater Pearson's correlation with household capacity to recover from losses caused by floods include 1) land area, 2) livestock, 3) food diversity, and 4) duration of borrowing rice. Although these livelihood assets are helpful in term of household capacity to recover, not all are correlated with how quickly households can recover. The fact that the highest correlation with recovery time was livestock ownership confirms that livestock is a safety net for households (WFP 2005) and that income derived from the sale of one buffalo can produce enough cash to buy rice for a household of four to five members for an entire year (WFP 2010b).

Table 44: Livelihood assets: Pearson's Correlation

		Have you recovered from the loss?	How long it takes to recover? (Month)
Size of area (hectares)	Pearson Correlation	.227**	0.068
	Sig.	0	0.17
	N	495	414
Cattle/Buffalo	Pearson Correlation	.283**	.271**
	Sig.	0	0
	N	751	644
Tractor	Pearson Correlation	.127**	0.066
	Sig.	0	0.092
	N	751	645
Boat with engine	Pearson Correlation	0.037	-.105**
	Sig.	0.306	0.008
	N	752	645
Income items earned in the year	Pearson Correlation	-.077*	-0.041
	Sig.	0.034	0.301
	N	755	647
Total food items eaten in the last 7 days	Pearson Correlation	.342**	.129**
	Sig.	0	0.001
	N	755	647
Savings (in bank or on hand) (last month)	Pearson Correlation	0.006	-0.016
	Sig.	0.876	0.681
	N	755	647
Total months in the year when rice has to be borrowed	Pearson Correlation	.243**	.165**
	Sig.	0	0
	N	755	647
Total months in the year when money has to be borrowed to buy rice	Pearson Correlation	.170**	.121**
	Sig.	0	0.002

	N	755	647
Debt to maintain crop production	Pearson Correlation	0.031	0.01
	Sig.	0.719	0.924
	N	142	86
Chance of support received	Pearson Correlation	0.025	0.1
	Sig.	0.633	0.094
	N	373	282

*Correlation significant at the 0.05 level (2-tailed)

**Correlation significant at the 0.01 level (2-tailed)

5.3. Explanatory/descriptive power of variables and results with the most significant outcomes

Proximity to aquatic resources and location of the resource users, related occupation, related food, and livestock reveal strongest and most obvious connection with vulnerability. They are highly explanatory and descriptive. Distance from the aquatic ecosystems (rivers, lakes, and wetlands) plays an important role in the extent of dependence of people in the resources. People who live closer to the ecosystems are more dependent on the resources and hence more vulnerable to changes in the resources (Bouapao and Hall 2010). People who live far from the ecosystems but migrate seasonally for fishing, such as at the Tonle Sap Lake site, are also vulnerable but less so than people who live closer to the aquatic ecosystems. Another vulnerable group is consumers who live far away but consume products of the rivers, wetlands, and lakes. They would be indirectly affected by declines in the resources due to the accompanying increase in price.

Fishing and rice farming as an occupation will be most affected if fish and rice decline. Results of this study show that although not all changes in occupation are caused by declines in rice and fish, a substantial number of sample households had at least one member change occupation, including fishing and rice farming, due to a decline in natural resources. It is therefore expected that any decline in the resources will make household members change their occupation in the future. Recall that the majority of the samples count farming or fishing (73% and 8% respectively) as their main occupation. Altogether, this accounts for more than 80% of the total population.

Livelihood assets are important sources of resilience (Moser 1996, Castro 2002, WFP 2005, Alwang, J., *et al.*, 2001). This study shows that livestock possession has the strongest correlation with the time needed for recovery from the impacts of floods, and other assets such as food diversity have the strongest correlation with the capacity of a household to recover from the impacts, followed by the size of land area. Indebtedness such as borrowing rice for consumption and borrowing money to buy rice also correlates with the sample households' ability to recover.

5.4. Unexpected findings and difficult-to-explain results

It is surprising that in Vietnam, c-farmers earned half as much income from rice as did s-farmers. One possible explanation might be that income sources of c-farmers are more diverse. Another is that income from other sources such as remittances might be more important, overshadowing income from rice.

A second surprising result is that variables of resilience (size of lands, livestock, tractor, boat with engine, income diversity, food diversity, saving, and debts) individually were not strongly correlated with resiliency variables such as ability to recover from losses and time taken for the recovery. Perhaps even though a single factor is not strongly correlated, multiple factors might be. This, however, is beyond the scope of this study, and data used for this study are not suitable for such analysis.

C-farmers in Vietnam said they did not experience impacts of flood in the past five years, while other strata did. My assumption is that c-farmers have adapted to floods and hence were not affected. However, further investigation is needed to understand this finding. If it is true that adaptation is part of the answer, this could be a valuable lesson to be transferred to other strata and possibly other countries.

5.5. Conclusion

In short, some variables are more relevant to specific strata, although a number of the variables are shared by all strata. S-fishers and c-fishers share the same number of variables, but five of them are different. For example, income from rice and fish were important for c-fishers, but not for s-fishers. Although S-farmers and c-farmers had different numbers of variables, they shared most of the variables. Only one variable, saving, was relevant for s-farmers but not for c-farmers.

The number of variables for each country differs, ranging from 10 to 16. Cambodia has the biggest number (16), followed by Thailand (14), Lao PDR (11), and Vietnam (10). Of these, 8 variables are shared. These are income from fish, income from rice, calories from fish, calories from rice, land area, livestock, boat with engine, and food diversity. The rest are specific to individual countries.

All the composite categories of variables (L, RO, I, F, LA) affect occupation and food security. Changes in one of the categories would have impacts on overall vulnerability. Fish and rice are common sources of food. Changes in these sources would highly affect all strata in the four countries. Changes in fish availability would mainly affect c-fishers in Thailand and Vietnam. In Cambodia and Lao PDR, however, changes in these sources would have impacts on all strata. Resilience of households with RO, I and F, separately, will depend on the livelihood assets (land area, livestock, food diversity) they possess. Other assets such as tractors and boats with engine are used by specific strata and will be useful means for those strata. The assets need to be considered together with the level of debts households have. Different sites have different type of debts, such as borrowing money to buy rice and going into debt to maintain crop production.

Chapter 6: Conclusions and Recommendations

In conclusion, the availability of fish and rice affects occupation and food security in the LMB through the high dependence of people on these resources for livelihood activities and for food. People whose primary occupation is fishing or farming comprise the majority (80%) of the population, and others fish and farm as a secondary occupation and/or as a supplementary activity. Fish and rice contribute most (81%) of the daily calorie intake. However, the availability of fish and rice would not affect cash income in any strata, except for those in Cambodia and Lao PDR. In Thailand and Vietnam, only c-fishers would be affected by a decline in fish availability, while only farmers would be affected by changes in the availability of rice. Nevertheless, it should be kept in mind that these resources are the most readily available and easiest to sell to help in times of hardships or to meet basic needs such as medications or school supplies.

By strata and study sites

The extent of impacts and resilient capacities vary between strata and across sites, however. In Cambodia, c-fishers were most vulnerable. They were most dependent on fish for income and for food. They had fewer livelihood assets, particularly less land area and fewer livestock. They also were more indebted. In Lao PDR, s-fishers would be affected the most by declining in the fish availability because they had the highest dependence on fish for income and for food, the lowest capacity for resilience, the smallest average size of land area, and the least likelihood of owning livestock. In

Thailand, c-fishers would most affected by declining fish availability, while c-farmers would be most affected if rice declines, simply because they depended highly on these resources for cash income while other strata did not. Similarly, in Vietnam, c-fishers would be most affected if fish decline, while farmers would be most hit by declining in rice production.

Occupation

From the perspective of occupation, the highest impacts of changes in the rice and fish availability would be on s-farmers because of their highest number, followed by c-farmers and c-fishers. Differences exist between countries, however. In Cambodia, the stratum of most concern is c-fishers, while in Lao PDR it is c-farmers. Thailand and Vietnam follow the regional average, with s-farmers accounting for the highest proportion.

Cash income

From the perspective of cash income, s-fishers in Cambodia and Vietnam would be affected the most by changes in the fish availability. Cash income from rice and fish is highest for s-fishers in Lao PDR, while it is highest for c-farmers in Thailand.

When looking at each resource separately, almost all the countries share the same concern. Contribution of fish to cash income is highest for c-fishers in Cambodia, Thailand, and Vietnam, and second for Lao PDR, where c-fishers ranked after s-fishers. In terms of rice as a source of cash income, c-farmers in Cambodia, Lao PDR, and Vietnam earn the highest income this way, while in Vietnam, c-farmers were second to s-farmers.

If fish and rice decline at a common rate across the whole LMB, two strata (c-fishers and s-farmers) in Cambodia and one stratum in Lao and Vietnam (s-farmers and c-fishers, respectively) will be most vulnerable because cash income will easily fall below $1.00 per capita per day.

Food

From the perspective of food, all the strata of all countries would be highly affected if rice declines. Rice is the single most important source of calories in the LMB, accounting for as high as 70–80% of the total daily calorie intake. Altogether, fish and rice account for more than 81% of the total calorie intake. On average, the sample households consumed more than the minimum 2,100 calories per capita per day, although variation exists. By countries, Vietnam Mekong Delta would be most severely affected by a decline in rice. Half of the four strata (s-fishers and s-farmers) consumed less than the minimum requirement, while others consumed just above it.

Vulnerability

All the composite categories of variables (L, RO, I, F, LA) affect vulnerability. Changes in one of the elements will have impacts on the overall vulnerability. The further the households lived from the Mekong, the less dependent they were. Only households with related occupations, cash income, and food sources were affected by changes in rice and fish availability. Capacity of the affected households to recover, however, depends largely on their livelihood assets, including saving and debts. Certain groups of people may depend on the resources similarly, hence would be affected similarly, but the capacity to be resilient is different. Some households took a month while others a year to recover from the impacts of floods.

Recommendations and policy implications

To reiterate, the objectives of this study have been to contribute to the MRC BDP and the long-term SIM. Research requirements for the BDP have been: 1) location to determine the number of people affected in the study areas (*exposure*), 2) severity of the impacts (*sensitivity*), and 3) capacity of the population to recover from food and income shortages (*resilience*). Variables analyzed in this study represent and address each of these dimensions. Thus, this study has achieved its objective of contributing to the BDP objective.

Variables for long-term social impact monitoring

I will recommend MRC use the variables with highest frequencies as indicators for the long-term SIM effort. Table 45 shows frequencies of variables used by the countries. Although only nine variables share the highest value of 4, implying that they are applicable to all countries, variables with frequencies of 3 should be monitored since they are applicable to more than half of the countries. Over time, the variables may change. Taking this into account, the total variables for long-term monitoring are 12. However, as shown by the discussion in the preceding section, location and related occupations are important variables of vulnerability, and distance to the Mekong as well as occupations of people need to be monitored as separate variables. Also, to be comprehensive analysis should include SEI. Chance of support would be an important variable to be included. Thus, a total of 15 variables are important for monitoring: 1) distance from the Mekong, 2) proportion of population dependent on the resources, 3) proportion of income from fish, 4) proportion of income from rice, 5) proportion of calorie intake from fish, 6) proportion of calorie intake from rice, 7) average land area per household, 8) average proportion of population who own a tractor, 9) average proportion of population with livestock, 10), average proportion of population with boat with engine, 11) income diversity, 12) food diversity, 13) savings, 14) chance of getting support, and 15) livelihood alternatives the households have.

Variables of dependence (variables 1–6) are self-explanatory. Although people who live farther away from rivers also depend on the river resources for food (through consumption and hence price) or income (such as dealers), people living closer to the Mekong are more directly dependent and so need special attention (i.e., monitoring).

Some improvement to the variables of resilience (7–15), however, could be made. Variables 8–10 could be improved through the inclusion of number and values of tractors, livestock, and boats with engines. Variables 11 and 12 could be improved with sources of income and food (e.g., sources dependent or independent of water, sources purchased or produced). Variable 13, saving, could be improved by inclusion of total values. Variable 15 would be better as an average number of alternatives available.

Table 45: Frequencies of variables relevant to the four countries

		Dependence				Resilience											
	Total variables applicable to the stratum in all countries	Income from fish	Income from rice	Calorie from fish	Calorie from rice	Land area	Tractor ownership	Livestock ownership	Boat with engine ownership	Income diversity	Food diversity	Borrow money to buy rice	Borrow rice for consumption	Debt to maintain crop production	Saving	Chance of support received	Lack of alternative livelihoods
		%	%	%	%	ha	%	%	%	items	items	Month	Monh	%	%	%	%
	A	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Cambodia	16	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Laos	11	1	1	1	1	1	1	1	1	1	1				1		
Thailand	14	1	1	1	1	1	1	1	1	1	1			1	1	1	1
Vietnam	10	1	1	1	1	1		1	1	1	1						1
Total		4	4	4	4	4	3	4	4	4	4	1	1	2	3	2	3

A baseline survey of the SIM for the whole LMB corridor is currently underway. However, SIM is monitoring 65 variables, which is seen as too many by the member countries. The member countries of the MRC have requested that the MRC Secretariat find a way to reduce the number of indicators. Results of this study show that 15 variables are highly useful. This should be able to contribute to the need of the countries for a short list of indicators.

Moreover, I suggest the MRC use the analysis, conclusions, and variables in a number of its other programs. These include, but are not limited to, the SEA; Trans-boundary Environmental Impact Assessment (TbEIA); Hydropower Initiative; Fisheries, Wetland, Food Management and Mitigation Program (FMMP); and Climate Change and Adaptation Initiative (CCAI). The SEA released in 2010 by the MRC used some results from the SIMVA, but lacks detailed analysis. The EIA provided by the current hydropower dam proposed by the Lao government, the Xayabouri Dam, and being discussed within or consulted with the MRC member countries, is seen by MRC and its member countries as lacking a livelihood impact assessment. This is particularly true with respect to trans-boundary impacts. No assessments of trans-boundary impacts on livelihoods have been undertaken for the Xayabouri Dam.

Examples of the use of data, results, and conclusions of this study for other MRCS programs include: 1) comparison for triangulation purposes (e.g.,Fisheries Programme (MRC 2008b) and wetland programs), 2) determining the nature and severity of losses as a result of flooding [e.g.,Climate Change and Adaptation Initiative (MRC 2008c), Flood Management and Mitigation Program], 3) determining the extent to which modeled downstream changes in flow impacts resource users (Hydropower Initiative), 4) measurement of change in livelihoods through opportunities created by dams through activities such as reservoir fisheries, employment, and improved social infrastructure (Hydropower Initiative), 5) assessing whether projected changes in the availability of water resources have taken place (e.g., Basin Development Plan) or if corrective actions are needed, and 6) informing operational rules and rule curves for discharging water from dams and for maintenance flow regimes at certain times of the year. Rule curves "provide target pool elevations that vary with the season; their purpose is to provide operational guidelines that allow the most efficient use of reservoir storage" (Brooks et al. 2003).

How can this data analysis and conclusions inform the rule curve to minimize unintended negative impacts on people downstream? The results suggest that:

1) Rule curves that take into account the fishery and agricultural sectors are necessary to avoid impacts on livelihoods and food security of rural people in the LMB corridors. Water levels or level of flow that affect the availability of fish and rice will have dramatic impacts on livelihoods and food security of people downstream. What local people are concerned about are not about regular or normal floods, but man-made fluctuation that would cause drought or flood to rice fields, affect spawning in fish, and cause other ecosystem disruption. This suggests that rule curves that take into account fishery and agricultural sectors are needed.

2) Rule curves need to be developed with the participation of a wide range of groups of people, including, but not limited to, related experts and stakeholders, including all strata of fishers and farmers.

3) Rule curves need to be developed that take into account cumulative impacts of groups of dams, rather than one single dam. People in the LMB corridor are affected not only by one single dam, but many dams and/or cascades, including dams in the mainstream Mekong as well as tributaries.

4) Rule curves need to be developed taking into account trans-boundary impacts, not just local impacts. It is very well recognized that hydropower development in the LMB has dramatic trans-boundary impacts.

Information provided by the rule curves must be seen beyond the MRC Procedure for Information Exchange. Sharing of information on the operation of each dam would not meet these requirements. A joint effort involving a number of stages, including numerous workshops, consultations, and participation, initiated by the MRC to develop these highly complex rule curves for each dam will be necessary. Participants would include people who manage flow regime (especially people who manage water release from dam operation), related experts, and stakeholders (including various strata of fishers and farmers). Once the rules curves are developed, agreed on by all the stakeholders, and implemented by dam operators, monitoring systems must be in place to track changes and to provide corrective actions.

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Appendix 1 Questionnaires

Please see separate PDF files.