WORKSHOP REPORT

Assessing Climate Change Risks, Vulnerabilities, and Responses in the Siphandone/Stung Treng Area with a Focus on Protecting Vulnerable Ecosystems

Elizabeth Kistin*
Peter McCornick†

* *Water Policy Associate, Nicholas Institute for Environmental Policy Solutions, Duke University*
† *Director of Water Policy, Nicholas Institute*

Bangkok, Thailand
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Cover photo: Sunset on the Mekong river in Vientiane, Laos/iStockphoto.com

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1. Introduction

This workshop report reflects discussions and analysis conducted by 16 regional experts who gathered to test the methodology outlined in Flowing Forward with reference to the Siphandone/Stung Treng area in the Mekong River basin. The findings presented here highlight the significant effects of both climate change and development pressures on ecosystems and livelihoods in the case study area and discuss the ongoing and potential future policy and infrastructure responses to changing circumstances.

The workshop was convened by the World Wildlife Fund (WWF) Greater Mekong Office and WWF-US with the assistance of the Nicholas Institute for Environmental Policy Solutions. Over the course of the workshop, the aim was to:

- characterize the key ecological attributes of the Siphandone/Stung Treng Area;
- understand the ecosystem sensitivities based on the interaction of climate change and other drivers of change (e.g., infrastructure development, agricultural growth, demographic trends);
- assess specific risk and vulnerability (both ecological and human);
- identify responses to that risk for the Siphandone/ Stung Treng Area, including changes to relevant policies, institutions, infrastructure, practices, etc.; and
- test an evolving methodology for assessing climate change vulnerability and adaptation in freshwater systems.

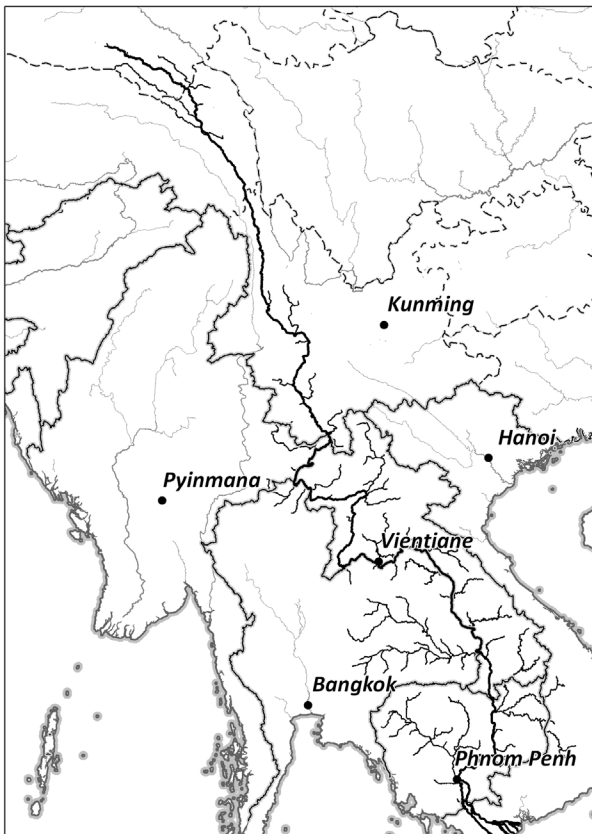
Information gathered at the workshop is being used to support WWF's work in the Mekong region and assist in building knowledge for use by governments and regional institutions. A condensed version of the Siphandone/ Stung Treng case study will also contribute to a wider engagement between the WWF and the World Bank aimed at developing principles, processes, and methodologies for incorporating an understanding of changing climatic, demographic, economic, and environmental circumstances into the evaluation of water sector projects. The workshop also supports WWF's wider work in the Mekong region and assists in building knowledge for use by governments and regional institutions.

2. Overview of the Siphandone/Stung Treng Area

2.1. Physical description and ecological state

The Siphandone/Stung Treng area is located on the main stem of the Mekong River, 50 km upstream and downstream of the international border between Lao People's Democratic Republic (PDR) and Cambodia (Figures 1 and 2). The Siphandone/Stung Treng area, well-known for its biological importance and fish productivity, encompasses roughly 21,000 km^2 of the Mekong River and supports populations on both sides of the border.

Figure 1. Map of the Mekong River basin.

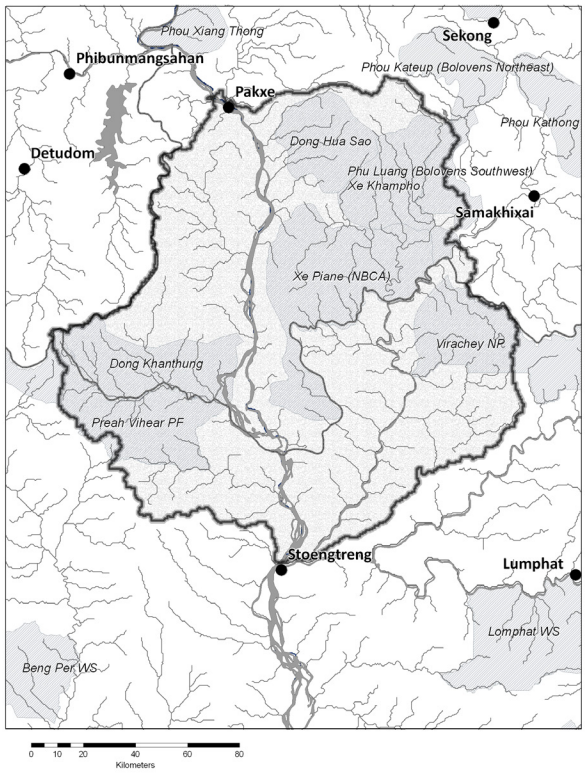


The name Siphandone is Lao for "four thousand islands" and describes the stretch of the Mekong in Lao PDR's southern Champassak Province as it widens into a unique landscape of channels, alluvial islands, and rapids (Khone Falls). The river reaches a maximum width of 14 km during monsoon season (Daconto 2001). The Mekong then crosses into Cambodia's Stung Treng Province. Stung Treng, or "Reed River," is one of Cambodia's most remote provinces, situated in the northeastern part the country (Try and Chambers 2006).

The Siphandone/Stung Treng area is characterized by extraordinary biodiversity, including unique and

diverse wetland habitats and remarkable physical landscapes and waterscapes ranging from islands to rapids and gorges (Daconto 2001; Try and Chambers 2006). In 1999, Cambodia designated a portion of the Stung Treng area a protected Ramsar site. Efforts are under way to lobby the Lao PDR government to apply the same designation to the Siphandone area (IUCN 2008d). Other protected areas—including important transboundary protected forests and nature reserves also have been designated (see Figure 2).

Figure 2. Map of the Siphandone/Stung Treng case study area.



The Siphandone/Stung Treng area is home to a rich array of species. The Siphandone is home to nearly 20,000 waterfowl as well as several iconic endangered species, including rare turtles, Siamese crocodiles, the Giant Mekong catfish, and the Irrawaddy dolphin (IUCN 2008c). The Siphandone also harbors more than 205 fish species, 87% of them migratory, making it one of the most diverse and productive fisheries in Lao PDR (Warren et al. 1998; Baran 2006). The biodiversity in the region is particularly important for the livelihoods of local populations; the fisheries provide food for a much larger area, the wetlands provide plants for traditional medication to treat disease and fuelwood for cooking and heating, and the waterways provide transportation for local communities (Try and Chambers 2006: 8). The overall landscape in the Siphandone/Stung Treng area is increasingly influenced by human activity; in particular, the conversion of forested land into settlements and paddy agriculture and the extraction of timber, peat, sand, and gravel (Daconto 2001: 12).

The climate in the Siphandone/Stung Treng area, as in the whole of the Greater Mekong Subregion (GMS), is dominated by the southwest monsoon, which commences in May and lasts until October. Within the Siphandone/Stung Treng area, heavy precipitation and considerable cloud cover mark the wet season from June to October (Daconto 2001). The dry season, which has higher temperatures, runs from November to May. Transitions between the seasons are short. Erratic rainfall contributes to both droughts and floods in the region (Daconto 2001). Annual floods within the Siphandone/Stung Treng area and all of the GMS drive freshwater ecosystem productivity and peak between August and September (MRC 2003b).

The Mekong River flows 4,500 km south from the Tibetan plateau and crosses six countries en route to the South China Sea (Figure 1). The mean annual discharge of the Mekong is approximately 475,000 million cubic meters (mcm). Of this total, roughly 35% originates in Lao PDR and 18% originates in Cambodia (MRC 2003b) (Table 1).

Table 1. Territory and flow contributions of the six Mekong River basin countries.

Country	Area within the basin (km^2)	Area % of basin	Flow % of basin
China	165,000	21	16
Myanmar	24,000	3	2
Lao PDR	202,000	25	35
Thailand	184,000	23	18
Cambodia	155,000	20	18
Vietnam	65,000	8	11
TOTAL	**795, 000**	**100**	**100**

Source: MRC 2003.

The Mekong's flow regime reflects the seasonal variation of rainfall in the basin. In the Siphandone/Stung Treng area, water levels are highest in August or September. Annual flooding in the basin, occasionally extensive and severe, can cause considerable damage to the populations living and growing rice along the banks of the Mekong River, but are also critical for the riverine ecosystem, providing nutrients for growth and reproduction of the river's food webs (Daconto 2001: 9–10). At the end of the monsoon season in November, water levels fall rapidly, reaching lows in March, April, and May.

Given its position in the basin, the Siphandone/Stung Treng area is largely affected by water resources development and contamination both up- and downstream. As Section 3.3 will discuss in more detail, the construction of upstream dams influences the timing of flows in the case study area. Additionally, water quality in the Siphandone/Stung Treng area is influenced by upstream pollution, primarily industrial and municipal waste, agricultural fertilizer runoff and pesticides, hydroelectric dams, and stormwater discharge (MRC 2007a).

2.2. Socioeconomic considerations

Within Lao PDR, the Siphandone is home to just over 100,000 people, who live in dense rural settlements spread along the river banks and on the islands (Daconto 2001). The population in this area makes up less than 2% of the population of the Champassak Province and roughly 0.02% of the national population of Lao PDR. According to the 2008 census, the population of Stung Treng province, Cambodia, is nearly 112,000 people, constituting less than 1% of Cambodia's national population (RGS 2008). Approximately 13,000 people live within the Thalaboriwat and Stung Treng districts that comprise the Stung Treng Ramsar site (Try and Chambers 2006: 5). The overall population within Lao PDR and Cambodia is growing rapidly (2.32% and 1.54%, respectively), contributing to rising demands for water, food, and electricity. The annual population growth of Cambodia's Stung Treng province is 3.21% (3.71% in rural areas and 0.67% in urban areas) and the population density is 10 people per km^2, which is low compared to the national density average of 75 people per km^2.

Poverty levels within both the Siphandone and Stung Treng areas are high. In Mounlapamok District, where the Siphandone area lies, between 40% to 50% of households fall below the village-level poverty line (Epprecht et al. 2008).[1] While market exposure and access is growing, there is very little commercial or industrial production in the Siphandone/Stung Treng area. As a result individuals and communities within the area depend heavily on the rivers for sustaining livelihoods comprised largely of rice and vegetable cultivation and fishing (Try and Chambers 2006). According to the International Union for Conservation of Nature (IUCN) (2008), roughly 80% of households in southern Lao PDR participate in wild-capture fisheries, which in turn contribute to 20% of gross income in the area (IUCN 2008c). Furthermore, while there is limited year-round agricultural land within the case study area, hundreds of kilometers of river banks and exposed alluvial deposits in the Siphandone area are used to cultivate extensive seasonal vegetable gardens (Daconto 2001). Ecotourism also makes minor contributions to livelihoods in the area as increasing numbers of tourists arrive to admire the waterfalls and watch the Irrawaddy dolphins. Between 2006 and 2007, the number of visitors to Lao PDR's Champassak Province increased by roughly 45% and contributed to an estimated economic benefit of $14 million USD (IUCN 2008c). Eco-tourism on the Cambodian side of the border is less developed, but domestic tourism has been growing in the last few years mostly as a result of better road accessibility and the opening of a border checkpoint in the area (Try and Chambers 2006).

2.3. Institutional arrangements

Given the position of the Siphandone/Stung Treng as a transboundary area embedded in a larger transboundary basin, multiple organizations and policies influence natural resources management and economic development in the case study area. At the provincial level, the Governors of Champassak Province in Lao PDR and Stung Treng Province in Cambodia have signed an agreement recognizing the connectivity and interdependence of their jurisdictions and committing to communication and cooperation.

At the national level, the Laos government operates based on a principle of national direction with local implementation. Laws and policies are set at the national level; the provinces are responsible for disseminating laws and policies; and districts and villages are responsible for implementing laws and policies. Four primary national institutions maintain mandates for natural resource management in Lao PDR:

- ***Ministry of Energy and Mines (MEM).*** This agency oversees all energy and mining projects, including hydropower development.
- ***Ministry of Agriculture and Forestry (MAF).*** This agency is responsible for all forest, watershed, and agricultural land in Lao PDR and overall wildlife and aquatic life management.
- ***Water Resources and Environment Agency (WREA).*** Located within the Prime Minister's Office, this agency's mandate overlaps with the MEM and MAF. It does not, however, have the same operational power as a Ministry and its authority is often challenged by other ministries.
- ***National Land Management Authority (NLMA).*** Located within the Prime Minister's Office, this authority is partially responsible for riparian areas

1 The village-level poverty line "corresponds to the per capita expenditure (including the value of home production and adjusted to regional and seasonal price differences) required to purchase 2,100 Kcal per person per day using the food basket of households in the third quintile, plus a non-food allowance equal to what these households spend on non-food items." In 2003, the poverty line was set at the village level and ranged from $10–$15 (USD) per person per month (Epprecht et al. 2008: 10).

but shares that mandate with the MAF.

Within Lao PDR, economic development and resource management within the basin are further guided by a collection of core policies and planning frameworks:

- National Socioeconomic Development Plan 2006–2010[2]
- 2008 Aquatic Animals and Wildlife Law, No. 7/NA
- 2008 Forestry Law
- 1996 Water and Water Resources Law; Water Resources Policy
- National Adaptation Program of Action (2009)
- National Biodiversity Strategy to 2020 and Action Plan to 2010[3]
- Fishery Law 2009[4]

Downstream in Cambodia, the state administration is structured around a hierarchy of national (*cheat*), provincial (*khet*), district (*srok*), commune (*khum*), village (*phum*), and group (*krom*) organizations. Laws and policies are set at the national level by the Royal Government of Cambodia (RGC) and disseminated and implemented at the provincial, district, and commune levels. Within Cambodia several national-level organizations share mandates for resource management:

- ***Ministry of Water Resources and Meteorology (MOWRAM)***
- ***Ministry of Rural Development (MRD)***
- ***Ministry of Environment (MoE)*** – This agency is responsible for managing protected areas and fulfilling commitments under the Ramsar Convention and the Convention on Biodiversity
- ***Ministry of Agriculture, Forestry and Fisheries (MAFF)*** – This agency is responsible for all fisheries legislation and enforcement
- ***Fisheries Administration*** – Located within the MAFF, this semi-autonomous government agency is charged with the management and conservation of fisheries resources[5]
- ***National Climate Change Committee***

In addition to the national organizations operating in Cambodia, development and resource management in the country are further guided by a core collection of policies and planning frameworks:

- Fishery Law (1999; 2006)
- Second Socioeconomic Development Plan (SEDP II) (2002)
- Law on Environmental Protection and Natural Resources Management (1996)
- The Royal Decree on the Creation and Designation of Protected Areas
- Forestry Law (2002)
- National Adaptation Program of Action (2007)

At the multilateral level both Cambodia and Lao PDR are members of eight regional institutions designed to support economic development and/or resource management in the region (Table 2):

- ***Asian Development Bank (ADB).*** The ADB's Greater Mekong Subregion (GMS) initiative was formed in 1992 as an economic cooperation scheme designed to physically link countries through economic development corridors. Through the GMS regional cooperation scheme, the ADB also currently administers a range of regional financing mechanisms aimed at adaptation and resource management including: the Climate Change Fund (CCF), the Clean Energy Financing Partnership Facility (CEFPF), the Water Financing Partnership Facility (WFPF), and the Poverty and Environment Fund (PEF).
- ***Association of South East Asian Nations – Mekong Basin Development Cooperation (ASEAN-MB).*** Formed in 1967 to accelerate economic growth, social progress, and cultural development in the region, the (ASEAN–MB) aims to (i) enhance economically sound and sustainable development of the Mekong Basin; (ii) encourage a process of dialogue and common project identification which can result in firm economic partnerships for mutual benefit; and (iii) strengthen the interconnections and economic linkages between the ASEAN member countries and the Mekong riparian countries. ASEAN–MB is also increasingly engaged in efforts to promote interstate cooperation around issues of economic development, environmental protection, and responses to climate change (Suchindah and Mueller 2009).
- ***Mekong River Commission (MRC).*** The MRC is mandated to pursue international water resources management in the Lower Mekong basin (LMB). The MRC Secretariat is currently engaged in a Basin Development Process (BDP) and Climate Change and Adaptation Initiative (CCAI) to explore methods for improving water management and adaptation. National Mekong Committees have also been established in the four member

2 This is the guiding document for nationwide development in Lao PDR. Generally it is seen to supersede all other policies.

3 This was drafted to comply with Lao PDR's obligations under the Convention on Biological Diversity. Implementation is fragmented, and responsibility is widely dispersed through various government ministries.

4 This law has been approved but has not yet been ratified.

5 See http://www.maff.gov.kh/eng/depts/fia.html.

states to improve communication between the MRC Secretariat and national governments.[6]

- ***Forum for the Comprehensive Development of Indochina (FCDI).*** This forum was established in the early 1990s to foster cooperation in the areas of trade, investment, infrastructure, and industrial development.
- ***Quadripartite Economic Cooperation (QEC).*** The QEC was established in 2000 with the aim of utilizing the river as a means for navigation to facilitate trade and tourism.
- ***Development Triangle Initiative (DTI).*** Established in 2000, this initiative aims to promote economic cooperation and reduce poverty in the border areas of member countries.
- ***Working Group on Economic Cooperation in Cambodia, Laos, and Myanmar (AEM–METI).*** An ASEAN collaboration established in the early 1990s, this working group aims to promote coordination in trade, infrastructure, and industrial development.
- ***Ayeyawady-Chao Phraya-Mekong Economic Cooperation Strategy (ACMECS).*** Developed in 2003, this group aims to implement a Plan of Action for cooperation in the areas of trade and investment facilitation, agriculture and industry, transport linkages, tourism, and human resources development.
- ***Emerald Triangle.*** Established in 2003, this group focuses on tourism development in member states.

Despite the rich array of institutional arrangements pertaining to the Siphandone/Stung Treng area, workshop participants noted that governance of natural resources in the case study area is hindered by a lack of implementation and coordination among riparian countries and among government ministries and authorities at the national, provincial, and village levels within Lao PDR and Cambodia.

3. Ecosystem Components and Vulnerability

This section illustrates how the interplay between economic development and climate change will affect water futures and vulnerable ecosystems in the Siphandone/Stung Treng area.

3.1. Ecosystem components

Workshop participants identified the following ecosystems and habitats as critical and defining ecological aspects of the Siphandone/Stung Treng case study area.

Sand formations. Sandbars, sand beaches and sandy islands in the Siphandone/Stung Treng area shift according to seasons and flood patterns in the basin and provide important habitat for a variety of species (Bezuijen et al. 2008). In the dry season, the banks are also used by local communities for vegetable cultivation (IUCN 2008b).

Water channels. Permanently flooded areas in the Siphandone/Stung Treng area, such as the Hou Sahong channel, are critical for maintaining aquatic habitats and serving as a corridor for fish migration in the dry season (Warren et al. 1998). Water channels also provide water for local communities as well as avenues for transportation and sites for recreation.

Deep pools. Pockets of deep water within the Mekong riverbed provide important habitat and refugia for many migratory species in the basin, including dolphins and a

Table 2. Multilateral organizations in the Mekong basin pertaining to the Siphandone/Stung Treng area.

Country	Institution								
	ADB GMS	ASEAN–MB	MRC	FCDI	QEC	DTI	AEM–METI	ACMECS	Emerald Triangle
Vietnam	X	X	X	X		X		X	
Cambodia	X	X	X	X		X	X	X	X
Lao PDR	X	X	X	X	X	X	X	X	X
Thailand	X	X	X		X	X		X	X
Myanmar	X	X			X		X	x	
China	X	X			x				

Source: Hensengerth 2008.

6 For more information on the MRC see Browder and Ortolano (2000), Dinar et al. (2008), and Dore and Lazarus (2009).

variety of migratory fish, including the Mekong Giant Catfish. Estimates suggest that roughly 75% of fish caught downstream in Tonle Sap depend on migration to deep pools in the case study area for dry-season refuge (Poulson et al. 2002).

Flooded forest. Seasonally flooded forests in the Siphandone/Stung Treng area comprise various forest types whose vegetation ranges from small aquatic herbs to trees over 15 meters tall. These forests serve as important habitat, supporting a wide range of animal species (Baird 2007; Mollot 2005).

Gallery forest. Forests found above the high-water mark in the case study area comprising a mixture of mixed evergreen, seasonally deciduous, hardwood, and bamboo forest, and provide critical habitat for many species.

Rapids, rock outcrops, and waterfalls. The flow of water along steep and narrow channels in the Siphandone/Stung Treng area creates accelerated and turbulent flows. The rapids and waterfalls this creates are critical to the up- and downstream migration of fish in the basin, particularly during the dry season (Roberts 1993; Baird et al. 2004). These areas are also important for fish catch and tourism (IUCN 2008c).

All of the ecosystem components identified and discussed by conference participants experience substantial seasonal variation. As Table 3 illustrates, this natural variability is critical for maintaining ecological functions in the Mekong River basin. The ecosystem components defined above contain little in the way of climate refugia within themselves. This is not because of a lack of diversity of the region, but is instead a result of the way in which the components were defined. The ecosystem components are relatively small in scale (compared to the components in other case studies within this report) and are characterized by habitat features. Therefore they are not heterogeneous in microclimates. Microclimate variations and refugia often require variations in altitude, and the ecosystem components defined here do not contain a strong elevation gradient. However, within the study area, some ecosystem components serve as climate and spatial refugia from others. For example the deep pools provide refugia from the water channels when the channels get low during the dry season.

3.2. Drivers of risk and vulnerability

Population growth and economic development within the case study area and throughout the wider Mekong basin contribute to a variety of drivers affecting the vulnerability of ecosystem components in the Siphandone/Stung Treng area. Some of the major influential factors include:

- ***Land conversion.*** The expansion of settlements, agricultural production, and tourism infrastructure within the case study area contributes to the destabilization of river banks, alters the morphology of channels, disrupts the cycle of nutrients, and fragments ecosystems.
- ***Pollution.*** Pollutants generated by urban areas, rural settlements, and agricultural, mining, and industrial operations degrade ecosystems and disrupt connectivity.
- ***Resource extraction.*** Extraction of timber, sand, gravel, and peat from the case study area alter the composition and resilience of key ecosystems. Unsustainable and poorly regulated fishing practices affect the composition and resilience of the river's food webs. Illegal mechanisms for harvesting fish from the basin also alter the morphology of deep pools and the biodiversity of species in the basin.
- ***Water resource development.*** The construction of dams and levees upstream of the case study area impact ecosystem components through alterations to the flood pulse and sediment loads.

3.3. Development scenarios

Drawing on a range of basin-wide projections and site-specific studies, this analysis considers two broad development scenarios (Table 4). The low-development scenario reflects a continuation of the status and the minimum level of development required to keep pace with population growth through 2020 and the related rise in demand for food, water, and energy. The high-development scenario is defined by maximum levels of economic growth and water usage for the same projected population growth.

Both high-development and low-development scenarios are likely to have significant impacts on water resources in the Mekong River basin and the Siphandone/Stung Treng area. In terms of quantity, the continued construction of dams in China and the LMB will slightly decrease wet-season flows caused by rainy-season storage and increase dry-season flows in the basin caused by releases for hydropower generation. Dry-season flows are expected to increase under the high-development scenario due to the increase in the number of dams, but may be slightly offset by planned diversions upstream to support dry-season irrigation in Thailand. Overall, the collection of dams anticipated throughout the Mekong River basin under the high-development scenario is likely to contribute to a minor decrease in wet-season

mean monthly water flows, but is not expected to serve as substantial flood mitigation.

In terms of water *quality*, experts anticipate increases in water pollution throughout the basin due to demographic, industrial, and agricultural growth. As irrigated, plantation-style agriculture expands in and near the case study area, eutrophication and algal blooms may result if the use and discharge of fertilizers and pesticides is not appropriately controlled. Under high-development scenarios, bauxite and gold mining operations are expected to increase near the case study area and plans to construct a population center and additional tourist accommodations are under way. The discharge from each of these initiatives will affect water quality in the case study area. In addition, the operation of large dams in the basin is expected to contribute to localized changes in temperature and oxygen levels. While this is unlikely to affect the case study area under the low-development scenario (where mainstream dams are located a considerable distance upstream) it will have a substantial impact under high-development conditions if dams are constructed within and near the Siphandone/Stung Treng area. Finally, the construction and operation of tributary and mainstream dams in the basin is likely to change the levels and composition of sediment in the Mekong River with knock-on effects for habitats and existing vegetable production in the case study area (IUCN 2008b). In formulating future scenarios the Mekong River Commission (MRC) cautiously optimistic

Table 3. Assessment of vulnerable ecosystems against the four Flowing Forward criteria.

	Detrimental non-climatic impact	Natural variability	Refugia	Connectivity
Sand formations	Settlement, sand abstraction, land conversion, and upstream dams	High variability linked to seasonal flood patterns	limited	Mixed, with beaches more connected than sandbars and islands
Water channels	Land conversion, dam construction, gravel extraction, and transportation infrastructure	Vary depending on water levels and sediment load	moderate	Some fragmentation due to tributary dams and fishing traps, but relatively high connectivity facilitates fish migration
Deep pools	Pool morphology altered by explosive fishing methods and life in pools affected by abstraction and water quality	Thickness of bed floor, sediment composition, and depth change seasonally with flood patterns	limited	Linked by channels in the flood season but isolated in the dry season
Flooded forest	Land conversion and pollution disrupt nutrient cycles and alter sediment load	Vary with seasonal floods and temperature changes	moderate	High connectivity in the wet season with disruptions from high concentration of pollutants
Gallery forest	Affected by land conversion and timber extraction	Forest dynamics fluctuate with rainfall but is not dependent on flood/drought cycles	limited	Fragmented through development and abstraction
Rapids and waterfalls	Affected by changes in flow from upstream dams, settlement, and tourism infrastructure	Fluctuate with seasonal flows	moderate	High – falls block movement of some species but facilitate migration of many
Siphandone/ Stung Treng area	Impacted by land conversion, resource abstraction, dam construction, and pollution	Fluctuates with seasonal flows and flood patterns	moderate	High connectivity allows species to move up- and downstream and laterally through flood plains for foraging, spawning, and rearing – fragmented by national border

Table 4. Basic parameters of high-development and low-development scenarios for the Mekong River basin.

	Description
low-development scenario	~3,000 mcm in domestic and industrial usage in the LMB (~50% increase from baseline)
	~8,300,000 ha of irrigation in the LMB (an increase of ~1,000,000 ha from baseline) including expansion of wet-season irrigation and a small amount of dry-season irrigation to take advantage of dam discharge upstream
	~12,400 mcm in active storage/hydropower dams in the LMB
	~10,300 mcm in active storage/hydropower dams in China
	Increased market connectivity for the Siphandone/Stung Treng area
	Increased logging and land conversion in and near case study site
high-development scenario	~4,200 mcm in domestic and industrial usage in the LMB (250% increase from the baseline but still just 0.9% of the total Mekong flow)
	~11,300,000 ha of irrigation in the LMB with significant expansion of dry-season irrigation throughout the LMB and continued wet-season expansion in Cambodia
	~26,800 mcm in active storage/hydropower dams in the LMB
	4 major dams constructed and operational within or near the Siphandone/Stung Treng area
	~22,700 mcm in active storage/hydropower dams in China
	Increased market connectivity for the Siphandone/Stung Treng area
	Increased tourism and a new population center in the case study area
	Rise in bauxite and gold mining near the case study area
	Increased conversion of land from forest to irrigated rice production
	Potential for improved resource governance and pollution control

See World Bank (2004), available online at http://www.mrcmekong.org/programmes/bdp.htm.

that as riparian countries and communities in the basin continue to develop, more resources will become available and that efforts for the mitigation, control, and treatment of pollutants entering the river will improve.

Finally, both low-development and high-development scenarios are likely to alter the timing of flows in the basin. The filling of upstream dams in the basin will contribute to a delay in the onset of flood flows and may delay the first floods in the wet season between two weeks and one month. The onset of the flood season is an important trigger for species in the basin, including migratory fish. Additionally, the construction and operation of dams in the basin will contribute to daily fluctuations in flows based on releases. Such daily fluctuations will be most significant for the case study area if plans for the construction of the Don Sahong Dam, a 30-to-32-meter-high hydroelectric dam, move forward.[7] The planned construction of the Stung Treng and Sambor Dams in Cambodia will also impact the timing of flows in the case study area.[8]

3.4. Climate projections

The Greater Mekong Subregion is expected to become slightly warmer over the next century with warm periods extending in duration and covering much wider areas than present trends (TKK et al. 2009). While accurate information of the climate change situation at the national or subnational level is limited in the basin, both Lao PDR and Cambodia are expected to experience a significant increase in mean annual temperature over the next century (MRC 2009; TKK et al. 2009).

Rainfall patterns in the basin are expected to fluctuate in the first half of this century and increase over the latter half due to increases in the intensity of rainfall during the wet season (May–October) (TKK et al. 2009; Hoanh et al. 2004). Uncertainty remains regarding the effects of climate change on dry-season precipitation patterns. Recent analysis by TKK et al. (2009) suggests that dry-season precipitation will increase in northern catchments within the basin and decrease in southern catchments, while Nijssen (2001) and Hoanh et al. (2004) suggest that, throughout the basin, the driest months will become drier. Chinvanno (2008: 110) also notes the likelihood of a potential seasonal shift with the

7 The Don Sahong Dam is planned for a location one kilometer north of the Laos-Cambodian border in the Khone Falls area of Khong District, Champassak Province, in southern Laos, and is expected to produce between 240 and 360 MW of power for export.

8 The Stung Treng Dam is a proposed 22-meter-high hydroelectric dam in Stung Treng Province, Cambodia. Plans for the Sambor Dam in Kratie Province, Cambodia, include an option for a 54-meter-high hydroelectric dam or a 30-meter-high hydroelectric dam.

wet season beginning in June instead of May and lasting through November.

Anticipated precipitation changes are likely to contribute to variation in runoff and discharge within the Mekong basin and alter the current flow regime and flood pulse system in the LMB (TKK et al. 2009; Hoanh et al. 2004). Overall, the increase in precipitation and runoff is expected to maintain or improve annual water availability in various catchments, though pockets of dry-season water stress (particularly in northern Thailand and the Tonle Sap region of Cambodia) are expected to remain (TKK et al. 2009; Kiem et al. 2008). Additionally, in both Lao PDR and Cambodia, flooding and droughts are expected to increase in frequency, severity, and duration (MRC 2009; Eastham et al. 2008).

Recognizing that climatic changes constitute just some of the multiple changes driving water quantity, quality, and timing in the basin, climatic variation in the Mekong River basin is expected to affect water resources and ecosystems in numerous ways. Shifts in the onset of the wet season (from May to June) may delay the onset of flood flows in the basin. Additionally, increasing temperatures in the basin are expected to contribute to increased evaporation from the basin and a rise in water temperature, particularly in shallow ponds and wetland areas. Finally, increased intensity of wet-season rainfall is likely to drive bank erosion and contribute to increased seasonal sediment load while the anticipated increase in floods and droughts in the basin may lead to fluctuations in agricultural productivity, acceleration of forest degradation, inundation of coastal zones, and outbreaks of infectious disease.

3.5. Water futures

Overlaying projected climate and development futures for the Mekong River basin highlights the projected impact on water resources under various combined scenarios. As Table 5 illustrates, the combined effects of climate change and economic development will induce a range of hydrological changes that impact ecosystems and biodiversity and affect socioeconomic systems as well.

3.6. Implications for ecosystem components

Taking into account the description of the case study, analysis of vulnerable ecosystems, and consideration of the impact of development and climate changes on water resources, a few overarching conclusions can be drawn that may help inform management responses aimed at reducing vulnerability in the Siphandone/Stung Treng area.

Relative impacts of development and climate change. Analyzing water futures in the Mekong River basin highlighted the relative impact of development and climatic changes on the Siphandone/Stung Treng area. In doing so, it revealed that the impacts from economic development throughout the basin are likely to be far more influential in altering ecosystems and livelihoods in the case study area, particularly in the short to medium term.

Infrastructure impacts. The high-development scenario includes four major dams that have been proposed within or near the Siphandone/Stung Treng area: the Lat Sua and Don Sahong dams in Lao PDR and the Stung Treng and Sambor dams in Cambodia. Workshop participants identified several impacts from these proposed dams on ecosystem components within the case study area. Primary projected impacts include:

- ***Loss of connectivity.*** The placement of the proposed dams will significantly fragment the basin. The Hou Sahong Channel in which the proposed Don Sahong Dam would be situated has been shown to be the sole channel for year-round fish migration in the case study area and a critical corridor for dry-season migrations. As such, the current proposed placement of the dam is likely to have serious impacts on fish populations in the basin as well as knock-on effects for livelihoods within the case study area, as the population depends heavily on the fish catch as a source of both food and income (Baird 2009; Halls and Kshatriya, in press).
- ***Altered timing and water quality.*** In addition to fragmentation, theses dams will likely alter the timing and quality of water flows within the Siphandone/Stung Treng area. While the extent of these impacts will depend heavily on the design and operation of the infrastructure, changes in flow, temperature, and sediment load will affect the location and composition of sand formations, deep pools, and flooded forests. Such changes are likely to impact species migration and regeneration as well as vegetable cultivation in the area (Baird 2009; IUCN 2008b).
- ***Inundation of channels, islands, deep pools, and falls.*** Dam construction within the case study area may also lead to the inundation of several ecosystem components in the Siphandone/Stung Treng area. Depending on its size, the level and extent of inundation caused by the Sambor Dam proposed for Kratie Province in Cambodia may significantly diminish the falls located near the Laos-Cambodian border (Halls and Kshatriya, in press).

Significance of continued land conversion. The further expansion of agriculture and settlements in the case study area is also likely to have a significant impact on the ecosystem components.

- Continued encroachment and abstraction (of sand, gravel, peat, and timber) has the potential to further degrade existing forests and wetland areas. The degradation of these habitats through land conversion has the potential to decrease natural water storage in the area and make settlements more susceptible to damage from storms and floods.
- Further land use changes may also shift the nutrient cycles in the case study area, and the introduction of pollutants from agricultural runoff, sewage discharge, or mining runoff may contribute to further degradation and fragmentation.

4. Responses to Risk

Beyond the specific issues mentioned above, this case study provides some more general insights and lessons in terms of policy and infrastructure responses to the range of changing circumstances in the Mekong basin.

4.1. Policy responses

Workshop participants identified a number of policy responses aimed at protecting vulnerable ecosystems and livelihoods in the Siphandone/Stung Treng area and beyond.

Addressing uncertainty and filling information gaps. The knowledge base regarding the nature and effects of demographic, economic, and climatic changes in the Mekong River basin is rapidly increasing. Nevertheless,

Table 5. Description of water futures for the Siphandone/Stung Treng area.

		Climate Scenarios	
		Stationarity	**Climate Change**
Development Scenarios	**High-development**	Increase in dry-season flows due to upstream dam releases (partially offset by upstream diversions) Minor decrease in wet-season mean monthly water levels (not enough to serve as flood mitigation) Increase in pollution due to demographic, industrial, mining, and agricultural growth (potentially offset with better management, mitigation, and regulation) Localized change in temperature and oxygen levels due to dam operations Reduced sediment loads due to capture by dams Delay in the onset of flood flows due to dams filling Daily fluctuations in flow in the case study area based on dam operations Increased risk of bioaccumulation of methylmercury in the aquatic food web Increased risk of toxic filamentous algae developing in the reservoirs, affecting water quality and human and livestock health	Increase in dry-season flows due to upstream dam releases (partially offset by upstream diversions) Minor decrease in wet-season mean monthly water levels (not enough to serve as flood mitigation) Increase in intensity of wet-season rainfall Increase in the severity of floods and droughts Increase in pollution due to demographic, industrial, mining, and agricultural growth (partially offset with better management, mitigation, and regulation) Increase in pollution due to increases in the intensity of storms and the related runoff (partially offset for case study area by upstream dams) Increase in water temperature due to climate change Localized change in temperature and oxygen levels due to dam operations Uncertainty about sediment loads and the extent to which the increase in seasonal sediment loads due to climate change will be offset by increased sediment capture by dams Increased risk of bioaccumulation of methylmercury in the aquatic food web Increased risk of toxic filamentous algae developing in the reservoirs, affecting water quality and human and livestock health Delay in the onset of flood flows due to dams filling and climate change Daily fluctuations in flow in the case study area due to dam operations
	Low-development	Increase in dry-season flows due to upstream dam releases Increase in pollution due to demographic, industrial, and agricultural growth Reduced sediment loads due to capture by dams Delay in the onset of flood flows due to dams filling	Increase in dry-season flows due to upstream dam releases Increase in intensity of wet-season rainfall Increase in the severity of floods and droughts Increase in pollution due to demographic, industrial, mining, and agricultural growth Increase in pollution due to increases in the intensity of storms and the related runoff Increase in water temperature due to climate change Uncertainty about sediment loads and the extent to which the increase in seasonal sediment loads due to climate change will be offset by increased sediment capture by dams Delay in the onset of flood flows due to upstream dams being filled and climate change

there is still appreciable uncertainty surrounding our understanding of the magnitude of anticipated changes, the impact of these changes on water resources in the basin, and the secondary effects on ecosystems, agriculture, energy, and human health. Recognizing the inherent uncertainty in this complex field and seeking to fill knowledge gaps is important. Yet it is also critical that this acknowledgement of uncertainty not paralyze action, but rather encourage engagement in a more reflective and adaptive way. Noting the relative impacts of development and climate change discussed in Section 3.6, it is important to think strategically about the breadth of information gaps and the dedication of resources within the basin. For example, in addition to pursuing data about the causes and potential impacts and effects of climate change we must also seek to fill information gaps related to the "causes" of development patterns (i.e., political processes) and their impacts and effects.

Supporting multilayered adaptation. Given its position in the mainstream of a dynamic transboundary river, the Siphandone/Stung Treng area is vulnerable to changes occurring upstream and downstream in the Mekong basin. Consequently, successful adaptation at the local level will mean little if it is not reinforced by efforts for sound resource management at the national, multilateral, and basin-wide levels. However, despite the multiplicity of policies in place for resource management, implementation is lacking at all levels. Workshop participants noted that bolstering adaptive capacity and the implementation of existing resource management policies in the case study area could benefit from:

- ***Recognizing successful examples of adaptation at the community level.*** Adaptation is a way of life for communities in the case study area who are well accustomed to dealing with the seasonal fluctuations of the dynamic Mekong River. Policymakers may be able to capitalize on local knowledge from the Siphandone/Stung Treng area in supporting future adaptation to new challenges. As changes in the basin take place, increased investment in education, credit, and insurance for these rural communities may also enable the pursuit of alternative livelihoods.
- ***Bridging gaps in communication and coordination.*** Despite the interdependence of different government ministries, sectors, and user groups at various scales, existing governance arrangements within Lao PDR and Cambodia are ill equipped to facilitate dialogue, planning, implementation, and monitoring beyond these divides. Equipping organizations and decision makers with the tools for evaluating tradeoffs and implementing policies will require improved linkages across sectors and groups as well as increased communication of the benefits of cooperation. Improving the capacity of technical experts to collaborate and communicate across boundaries will contribute to this wider aim.
- ***Extending or re-shaping donor support.*** Workshop participants noted that currently within the region, adaptation is often viewed as a distinct initiative as opposed to an integrated and ongoing part of existing policy processes. Recognizing that adaptive management often requires longer planning horizons than typical government or institutional projects support, workshop participants further suggested that donor funding should be reviewed and adjusted to better match donor objectives.

Accounting for ecosystem services in decision-making. The broader integration and valuation of ecosystem services into the research and decision-making process will help policymakers engage in strategic planning with the capability of taking a more comprehensive view of the costs and benefits over the short and long term. Two major concerns regarding existing valuation and decision-making processes surfaced over the course of the workshop. First, several workshop participants were concerned that existing valuation techniques, which compared the monetary gain from the sale of electricity on the international market to the monetary value for the domestic consumption of fish, did not accurately reflect the tradeoffs facing the region (see also Friend et al. 2009). The second and related concern was that such cost-benefit considerations were not a central part of the often opaque decision-making procedures at the provincial and national levels in Lao PDR and Cambodia. As such, workshop participants suggested that for improved valuation, processes and efforts to increase transparency and strengthen the decision-making process may be beneficial for enhancing the overall adaptive capacity in the basin.

4.2. Infrastructure responses

In addition to policy responses, workshop participants identified several key considerations to take into account when developing projects and infrastructure affecting the Siphandone/Stung Treng area.

Infrastructure placement design and operation. According to workshop participants, most of the existing infrastructure in the case study area, including roads, houses, and bridges, are well equipped to deal with the seasonal fluctuations of the dynamic Mekong River.

Planners interested in constructing new infrastructure in the basin will likely take these examples into account in order to avoid damage. Given the vulnerability of the case study area's ecosystems of the case study area, additional consideration should be given to minimizing impact on vulnerable ecosystem components. Particular considerations for the implementation of new hydroelectric dam projects in the area include the placement of the project, the timing and temperature of releases, and sediment capture. Workshop participants emphasized the critical nature of infrastructure location in the Mekong River as a prime mechanism for avoiding serious disruption to fish migration through the case study area. Recognizing that a certain degree of mitigation is possible for some dams, participants expressed serious reservations that a fish pass could make a significant difference to the blocking effects of the proposed Don Sahong Dam.

Investment in natural infrastructure. Protecting the mosaic of ecosystems that comprise the Siphandone/Stung Treng area is critical for decreasing vulnerability and enabling adaptation. Yet too often discussions about infrastructure and adaptation focus only on new projects and artificial options and fail to take natural storage options, like wetlands, into consideration. Within the Siphandone/Stung Treng area, the protection and restoration of ecosystem components can serve as a strategic option for decreasing flood damage and bolstering overall resilience to changing circumstances in the case study area. Workshop participants emphasized that this option should be prioritized.

5. Reflections on Methodology

Overall, workshop participants found the Flowing Forward methodology to be a useful mechanism for thinking through the dynamics of complex systems. A few brief reflections are provided here to aid the application of this process in the future.

Workshop participants. The outputs generated by this workshop were greatly enhanced by the breadth of knowledge covered by the participants and the wealth of experience the majority of participants had within the specific case study area. A more diverse pool of participants might further enrich the discussion and insights of such analysis. Participants noted in particular that more representation from the governments of Lao PDR and Cambodia, as well as the business or finance sectors in these countries, could have provided an important perspective for the analysis.

Workshop agenda. Overall, the intense day-long format of the workshop worked well and provided just enough time to cover each section of the collective analysis. Given the busy schedules of the experts in attendance it might have been hard to ask participants to commit for more than one day. Nevertheless, an extra half-day session could have been useful to allow the group more time to collectively process and refine the generated outputs and reflect more on the strategic implications of the assessment of adaptive capacity.

6. References

Baird, I.G., M.S. Flaherty, and B. Phylavanh. 2004. Mekong River Pangasiidae catfish migrations and the Khone Falls wing trap fishery in southern Laos. *Natural History Bulletin of the Siam Society* 52(1): 81–109.

Baird, I.G. 2007. Fishes and forests: the importance of seasonally flooded riverine habitat for Mekong River fish species. *Natural History Bulletin of the Siam Society* 55(1): 121–148.

Baird, I. 2009. The Don Sahong Dam: Potential impacts on regional fish migrations, livelihoods and human health. POLIS Project on Ecological Governance, University of Victoria, Victoria, Canada.

Baran, E. 2006. Fish migration triggers in the Lower Mekong basin and other tropical freshwater systems. MRC Technical Paper No. 14, Mekong River Commission, Vientiane, 56 pp.

Browder, G. and Ortolano, L. 2000. The Evolution of International Water Resources Management in the Mekong. *Natural Resources Journal* 40: 499–531.

Bezuijen, M. R., R. Timmins and, T. Seng, editors. 2008. Biological surveys of the Mekong River between Kratie and Stung Treng Towns, northeast Cambodia, 2006–2007. WWF Greater Mekong – Cambodia Country Programme, Cambodia Fisheries Administration and Cambodia Forestry Administration, Phnom Penh.

Bush, S.R. 2004. Scales and Sales: Changing social and spatial fish trading networks in the Siphandone fishery, Lao PDR. *Singapore Journal of Tropical Geography* 25 (1):32–50.

Chinvanno, S. 2008. Information for Sustainable development in Light of Climate Change in the Mekong River basin, Paper presented at the Conference on Remote Sensing and Geographic Information Systems (GIS) Applications for Sustainable Development. http://203.159.5.16/digital_gms/Proceedings/A77_SUPPAKORN_CHINAVANNO.pdf.

Daconto, G, 2001. Siphandone wetlands: An overview, pages 7–19 in *Siphandone Wetlands. Environmental Projection and Community Development in Siphandone Wetland Project*, ed. G. Daconto, CESVI, Bergamo, Italy.

Dore, J. and Lazarus, K. 2009. De-marginalizing the Mekong River Commission, in *Contested Waterscapes in the Mekong*, ed. F. Molle, T. Foran, and M. Kakonen, London: Earthscan.

Dinar, A., Dinar, S., McCaffrey, S., McKinney, D. 2008.

Bridges over water: Understanding transboundary water conflict, negotiation and cooperation, New York: World Scientific Publishers.

Eastham, J., Mpelasoka, F., Mainuddin, M., Ticehurst, C., Dyce, P., Hodgson, G., Ali, R., and Kirby, M. 2008. Mekong River Basin Water Resources Assessment: Impacts of Climate Change, CSIRO Water for a Healthy country National Research Flagship Report, CSIRO.

Epprecht, M., Minot, N., Dewina, R., Messerli, P., Heiniman, A. 2008. The Geography of Poverty and Inequality in the Lao PDR. Washington, D.C.: IFPRI.

Friend, R., Arthur, R., Keskinen, M. Songs of the doomed: The continuing neglect of capture fisheries in hydropower development in the Mekong, in *Contested Waterscapes in the Mekong*, ed. F. Molle, T. Foran, and M. Kakonen, London: Earthscan.

Halls, A. and Kshatriya, M. in press. Modelling the cumulative effects of mainstream hydropower dams on migratory fish populations in the lower Mekong basin. MRC Technical Paper No. 25. Mekong River Commission, Vientiane.

Hesengerth, O. 2008. Vietnam's Security Objectives in Mekong basin Governance, Journal of Vietnamese Studies, 3(2), pp. 101–127.

Hoanh, C.T., Guttman, H., Dorrogers, P. and Aerts, J. 2004. Will we produce sufficient food under climate change? In *Climate change in contrasting river basins: Adaptation strategies for water, food and environment*, ed. J.C. Aerts, J.H. Aerts, and P. Droogers, CABI, Wallingford.

IUCN (International Union for Conservation of Nature). 2008a. An integrated assessment of the biodiversity, livelihood and economic implications of the proposed special management zones in the Stung Treng Ramsar Site, Cambodia. Vientiane: IUCN.

IUCN. 2008b. Fish, frogs and forest vegetables: Role of wild products in human nutrition and food security in Lao PDR. Vientiane: IUCN.

IUCN. 2008c. Siphandone Under Threat. Vientiane: IUCN.

IUCN. 2008d. The Ramsar Convention in Lao PDR. Vientiane: IUCN.

Kiem, A.S. Ishidaira, H., Hapuarachchi, H.P. Zhou, M.C. Hirabayashi, Y. and Takeuchi, K. 2008. Future hydro-climatology of the Mekong river basin simulated using the high-resolution Japan Meteorological agency (JMA) AGCM. *Hydrological Processes* 22(9): 1382–1394.

Mollot, R., Phothitay C., Kosy, S. 2005. Hydrology, habitat and livelihoods on the floodplains of southern Lao PDR. In Proceedings of the 6th Technical Symposium on Mekong Fisheries (6th Technical Symposium on Mekong Fisheries, Pakse, Lao PDR, 26th–28th November 2003) T.J. Burnhill and M.M. Hewitt, eds. Mekong River Commission, Vientiane, pp. 155–176.

MRC. 2003a. Biodiversity and fisheries in the Mekong river basin, Mekong Development Series No. 2. Vientiane: MRC.

MRC.2003b. State of the Basin Report. Phnom Penh: MRC.

MRC. 2007. Diagnostic study of water quality in the Lower Mekong basin, MRC Technical Paper, No. 15. Vientiane: MRC.

MRC. 2009. Climate Change Adaptation in the Lower Mekong Basin Countries – Regional Synthesis Report. Vientiane: MRC.

Nijssen, B., O'Donnell, G.M., Hamlet, A.F. and Lettenmaier, D.P. (2001) Hydrologic sensitivity of global rivers to climate change. *Climate Change* 50 (1–2): 143–175.

Poulsen, Anders, Ouch Poeu, Sintavong Viravong, Ubolratana Suntornratana and Nguyen Thanh Tung. 2002. Deep pools as dry season fish habitats in the Mekong basin. MRC Technical Paper No. 4, Mekong River Commission, Phnom Penh. 22 pp. ISSN: 1683–1489.

Roberts, T.R. 1993. Artisanal fisheries and fish ecology below the great waterfalls of the Mekong River in Southern Laos. *Natural History Bulletin of the Siam Society* 41: 31–62.

Rosenberg, D.M., F.Berkes, R.A. Bodaly, R.E. Hecky, C.A. Kelly, and J.W.M. Rud. 1997. Large-scale impacts of hydroelectric development. *Environmental Review* 5: 27–54.

Royal Government of Cambodia (RGC). 2008. 2008 Census, Available online at http://www.stat.go.jp/english/info/meetings/cambodia/pdf/pre_rep1.pdf. Accessed on 28 September 2009.

Suchindah, A. and Mueller, P.P. 2009. ASEAN is at the forefront of the climate change challenge. *The Nation*, Bangkok, Thailand.

TKK and SEA START RC. 2009. Water and climate change in the Lower Mekong basin: Diagnosis and recommendations for adaptation. Espoo, Finland: Helsinki University of Technology. Available online at: http://users.tkk.fi/u/mkummu/water&cc.

Try, T. and Chambers, M. 2006. Situation Analysis: Stung Treng Province, Cambodia. Vientiane: Mekong Wetlands Biodiversity Conservation and Sustainable Use Program.

Vientiane Times. 2009. Vietnamese firm plans new town in southern Laos. 29 August.

Warren, T.J., G.C. Chapman, and D. Singhanouvong 1998. The upstream dry-season migrations of some important fish species in the lower Mekong River in Laos. *Asian Fisheries Science* 11: 239–251.

World Bank. 2004. Modelled Observations on Development scenarios in the Lower Mekong basin. http://www.mrcmekong.org/programmes/bdp.htm.

World Wildlife Fund. 2010. Flowing Forward: Freshwater ecosystem adaptation to climate change in water resources management and biodiversity conservation decision making.

Addendum A: Workshop Agenda

Date: 7 September 2009Venue: Holiday Inn
Silom, Bangkok

Time	Activity	Core Questions/Objectives
8:30–9:00	Welcome/Workshop Overview	What are we doing today and why? How does the Siphandone/Stung Treng case study fit into the wider "Flowing Forward" study? What outputs will we generate by the end of the day?
9:00–10:30	Identify and describe ecosystem components and drivers of vulnerability	What are the key ecosystem components in the case study area? What are the nonclimatic pressure, and aspects of natural variability, refugia, and connectivity that characterize each of these key ecosystem components? What key drivers of vulnerability affect these ecosystem components?
10:45–12:30	Identify water futures using development and climate scenarios	What are the impacts on water quantity, water quality, and water timing (i.e., water futures) if we overlay climate change predictions on the development scenarios?
13:30–15:30	Identify the impacts of the specified water futures	How might the water futures identified in the previous session influence the key ecosystem components in the Siphandone/Stung Treng area? What are the socioeconomic implications of these water futures for the Siphandone/Stung-Treng area? What are the implications of these water futures for infrastructure in the case study area and beyond?
15:45–17:00	Analyze adaptive capacity and responses to risk	Given the changing circumstances and identified vulnerabilities affecting the Siphandone/Stung Treng area, what are the opportunities for adaptation? Are effective policy, legislative, and planning frameworks in place for water resource management at the local, national, and transboundary levels? Do they account for changing circumstances? What are some opportunities/barriers for enhancing the content and implementation of these frameworks? Is there sufficient financial, institutional, and human capacity at the local, national and transboundary levels? What are the opportunities and obstacles to enhancing the level and utilization of such capacity? What is the status of infrastructure development in the area (for storage, hydropower, development, and water services provision)? How is the infrastructure operated and maintained in practice? What are the opportunities and obstacles to enhancing the construction, operation, and maintenance of infrastructure in the basin?
17:00–17:30	Summary/ Conclusions	

Addendum B: Workshop Participants

Name	Area of expertise	Association	E-mail
Dirk Lamberts	Ecologist	The Flood Pulse Co. Ltd	dirklamberts@yahoo.com
Tri P.D. Van	Hydraulics	University of Southampton	P.D.T.Van@soton.ac.uk
Colin McQuistan	Socioeconomic (livelihoods)	WWF GMPO	colin.mcquistan@wwfgreatermekong.org
Peter McCornick	Facilitator	Duke University	pm60@duke.edu
Suppakorn Chinvanno	Socioeconomic (region)	START SEA	suppakorn@start.or.th
Elizabeth Kistin	Facilitator	Duke University	elizabeth.kistin@duke.edu
Geoffrey Blate	Facilitator	WWF GMPO	gblate@wwfgreatermekong.org
Milena Gongora	Organizer	WWF Thailand	mGongora@wwfgreatermekong.org
Robert Mather	Ecologist	IUCN	robert@iucnlao.org
Manuel Cocco	Environmental Specialist	World Bank	manuel.cocco@gmail.com
Kien Tran Mai	Climate Change Coordinator	MRC	kien@mrcmekong.org
Marc Goichot	Infrastructure	WWF GMPO	Marc.Goichot@wwfgreatermekong.org
Chu Thai Hoanh	Hydrologist	IWMI	c.t.hoanh@cgiar.org
Nikolai Sindorf	Hydrologist	WWF US	nikolai.sindorf@wwfus.org
Roger Mollot	Aquatic Ecologist	WWF Laos	Roger.Mollot@wwfgreatermekong.org
Gordon Congdon	Aquatic Ecologist	WWF Cambodia	Gordon.Congdon@wwfgreatermekong.org
Soviet Lim	Rural development	Cambodia	soviet@online.com.kh
Sun Mao	Rural development	CRDT, Cambodia	sun_mao@crdt.org.kh
Peter John Meynell	Infrastructure	Consultant	peterjohn.meynell@gmail.com

the Nicholas Institute

The Nicholas Institute for Environmental Policy Solutions at Duke University is a nonpartisan institute founded in 2005 to help decision makers in government, the private sector, and the nonprofit community address critical environmental challenges. The Institute responds to the demand for high-quality and timely data and acts as an "honest broker" in policy debates by convening and fostering open, ongoing dialogue between stakeholders on all sides of the issues and providing policy-relevant analysis based on academic research. The Institute's leadership and staff leverage the broad expertise of Duke University as well as public and private partners worldwide. Since its inception, the Institute has earned a distinguished reputation for its innovative approach to developing multilateral, nonpartisan, and economically viable solutions to pressing environmental challenges.

for more information please contact:

Nicholas Institute for Environmental Policy Solutions
Duke University
Box 90335
Durham, North Carolina 27708
919.613.8709
919.613.8712 fax
nicholasinstitute@duke.edu
nicholasinstitute.duke.edu

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