

# Draft



**Mekong River Commission**  
Basin Development Plan Programme, Phase 2

## **Assessment of basin-wide development scenarios**

### **Technical Note 4**

# **Environment assessment**

**(Work in Progress)**

**February 2010**

**Note to the reader**

This series of technical notes is prepared to serve facilitation and discussion on the assessment of basin-wide development scenarios of the Mekong Basin by stakeholders in the basin countries. The assessment process is continuing and feedback on the initial findings is requested.



**Mekong River Commission**  
Basin Development Plan Programme, Phase 2

**Assessment of basin-wide development scenarios**

**List of Technical Notes**

**Technical Note 1: *Synthesis of initial findings from assessments***

**Technical Note 2: *Hydrological assessment***

**Technical Note 3: *Geomorphological assessment***

**Technical Note 4: *Environmental assessment: Impact on valuable wetland ecosystem/  
Habitats and biodiversity***

**Technical Note 5: *Social assessment***

**Technical Note 6: *Economic assessment***

**Technical Note 7: *Power benefits assessment***

**Technical Note 8: *Agriculture impacts assessments***

**Note:** Technical note on Fisheries Assessment is being prepared. Only power point presentation is available

**Part 1: Impacts on valuable (wetland)  
ecosystems/habitats and biodiversity**

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# 1 Introduction

In this report, results of the assessment of the impacts of the hydrological changes brought about by the Definite Future and 20 Year Plan scenarios on the valuable ecosystems /habitats and the associated species diversity are given.

A description of the valuable ecosystems and their species composition, with an emphasis on rare and endangered species, is given in Chapter 2. Expected impacts of the above mentioned scenarios are described in Chapter 3. The described impacts on the habitats in the river channel, deep pools, rapids and small islands and riverine sandbars, are based on the expert judgment provided by the BDP river morphologist, Paul Carling, as also described in a separate report on morphological impacts of the scenarios (Carling, 2010).

Impacts on the other valuable ecosystems/habitats, notably flooded forests, marshes/seasonal wetlands and inundated grasslands, pertain mainly to changes in areas flooded by the average yearly floods. This information has been derived by overlaying an ecosystem/habitat map with flood extension, flood depth and flood duration maps for the various scenarios. The ecosystem/habitat map is a simplification of the MRC (2005) wetland map (level-5).

Impacts on the ecosystems/habitats as a result of changes in other environmental conditions, e.g. possible changes in water quality, are not discussed here.

In Chapter 4 impacts on a number of identified 'Environmental Hotspots' are discussed, whereas in Chapter 5 the impacts on the Mekong 'Flagship species' are presented.



## 2 Valuable ecosystems/habitats and biodiversity in the LMB

### 2.1 Introduction

River channel and wetland habitats are of crucial importance for the ecological functioning of the Mekong river system. Wetlands are complex systems with a variety of physical, hydrological and vegetative characteristics. Simple categorization of these systems is difficult. In the Lower Mekong Basin the structure and functioning of wetlands is narrowly linked to the seasonal flow pattern of the Mekong River, involving a wet season flow up to 10 meters higher than the dry season. Changes in river flow and the consequent changes in characteristics of the floodplain flooding may change the floodplain wetlands. Not only changes in flood regime are threatening the wetland biodiversity of the Lower Mekong Basin, the destruction of natural habitats (logging, drainage, conversion to agricultural land) and illegal hunting for the wildlife trade are other critical factors that have brought a number of species on the brink of extinction.

Knowledge of the status of the biodiversity of the Lower Mekong Basin is patchy. Recent efforts of both national and international agencies have often focused on the larger and more exotic groups, e.g. mammals and birds, while ignoring smaller less obvious groups. For example, estimates of the total number of fish species in the Lower Mekong Basin range between 436 to 1,300 species. Also, while there is some information available on turtles, almost no information exists on groups such as frogs. Invertebrates remain largely undescribed.

### 2.2 Important ecosystems/habitats in the Lower Mekong Basin

Important habitats for conservation within the Lower Mekong Basin are described by Birdlife International in Indochina (Annual report on IBA management and conservation in Cambodia, July 2004 – August 2005) and by mekongwetlands.org on their website. Descriptions of the habitats and associated biodiversity as presented by these sources is reproduced here with slight adaptations.

#### 2.2.1 *Main river channels*

Water height in the main river channels varies by up to 10 meters between the wet and dry season. These channels are vitally important for the seasonal longitudinal migration of white fish species (see the section on fish). Although the main channels support a large variety of aquatic species, they exhibit little endemism. There are at least 17 fish species on the IUCN Red List of Threatened and Endangered species, 6 of which are highly migratory. The most well known is the Mekong Giant Catfish *Pangasianodon gigas*.

Closely related to the main river channels are the seasonally inundated riverine forests. A unique example is found along the Mekong River in the Stung Treng Ramsar site (between Stung Treng town and the Lao border) on sandy islands and on isolated rocky outcrops. It comprises tree species identified tentatively as *Barringtonia* sp., *Eugenia* sp., and *Acacia* sp. The trunks of the trees are often bent almost horizontal in the direction of the river flow and there are many epiphytes or parasites particularly of the fig *Ficus* sp.

The inundated forest is important for fish breeding and shelter during peak flow, and some fish species are known to feed on the fruit of the trees. The forest may be important for monkeys and gibbons.

Mammals depending on the river channels are the Critically Endangered Irrawaddy Dolphin *Orcaella brevirostris*, the Globally Vulnerable Smooth-coated Otter *Lutra perspicillata* and Fishing Cat *Felis viverrina*.

In the riverbed itself, river weed or 'Kai' *Cladophora glomerata* (a branched filamentous algae) is of importance, it is collected for consumption.

### 2.2.2

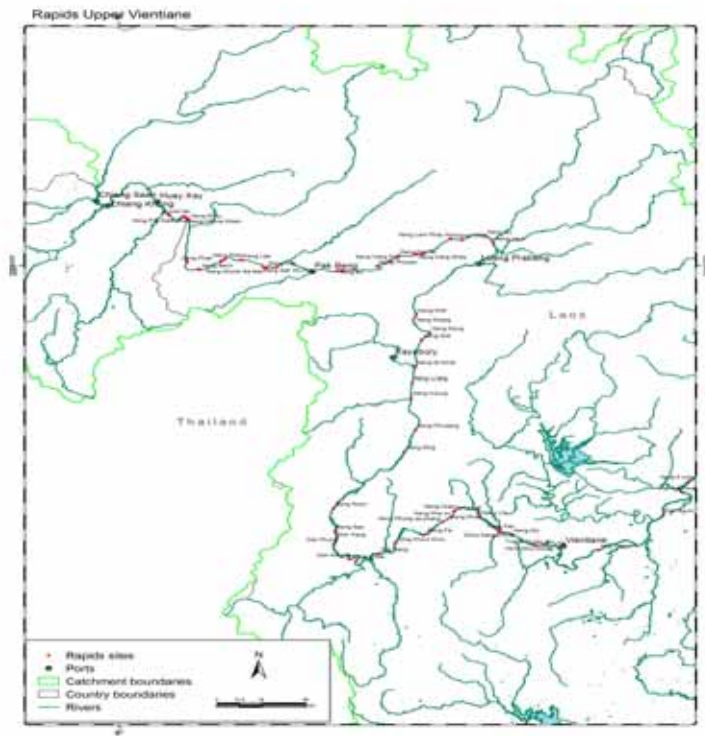
### **Rapids**

Large complex rapids occur frequently on the main Mekong River and its tributaries. These support a diverse assemblage of fish (and invertebrate) species. Specialists to this habitat have a number of diverse adaptations to avoid being swept away including suckers, flattened bodies and expanded fins. The diversity of fish species from these rapids is known from only a few survey sites. Due to the comparatively small area of rapids in the Lower Mekong Basin, fish biodiversity experts recommend that every species permanently associated with rapids be classified as critically endangered.

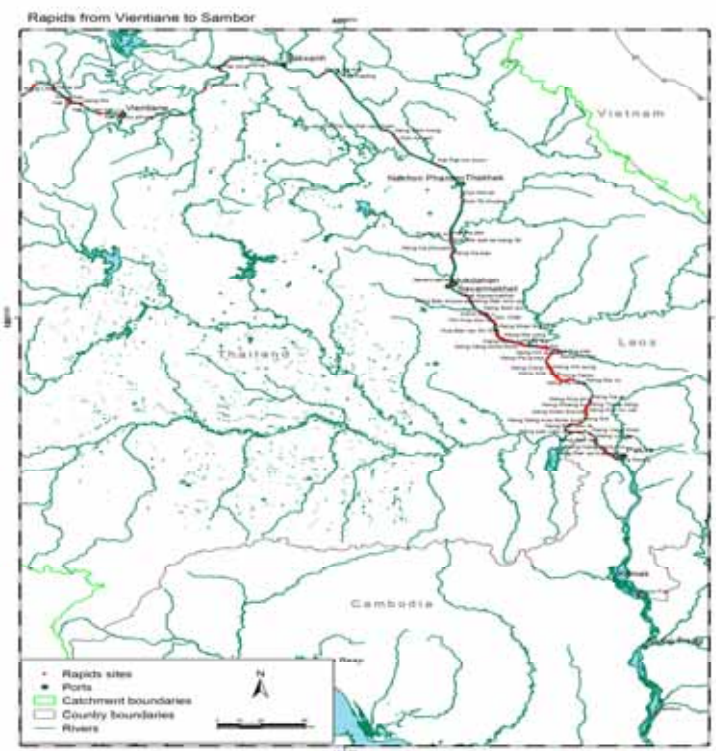
Rapids form an important habitat for the shrub *Homonoia riparia* and the following bird species: Blyth's Kingfisher *Alcedo Hercules* (NT, Nearly Threatened), Great Thick-knee *Esacus recurvirostris* (NT), River Lapwing *Vanellus duvaucelii*, Black-bellied Tern *Sterna acuticauda*, Great Cormorant *Phalacrocorax carbo*, Jerdon's Bushchat *Saxicola jerdoni*, River Tern *Sterna aurantia*, Small Pratincole *Glareola lacteal*; Spot billed Duck *Anas poecilorhyncha*, Wire-tailed Swallow *Hirundo smithii*, Yellow-eyed Babbler *Chrysomma sinense*, Chestnut-capped Babbler *Timalia pileata* and a number of both resident and migrant warblers.

The most well known rapids are the Khone Phapheng Falls at Siphadone and the rapids in the river reach between Stung Treng and Kratie. Figure 1 and 2 show the location of the rapids along the main stream channel.

**Figure 1: Location of rapids in the Mekong River, upstream of Vientiane**



**Figure 2: Location of rapids in the Mekong River between Vientiane and Kratie**



### 2.2.3 *Deep pools*

Deep pools have formed in fast flowing channels of the main stream and the larger tributaries. These pools are maintained by the scouring of the high river flows during the wet season. In the dry season,

these areas are connected by shallower stretches. They are very common on the Mekong in southern Laos and northern Cambodia, and on some major tributaries including the Se San, Srepok and Xe Kong.

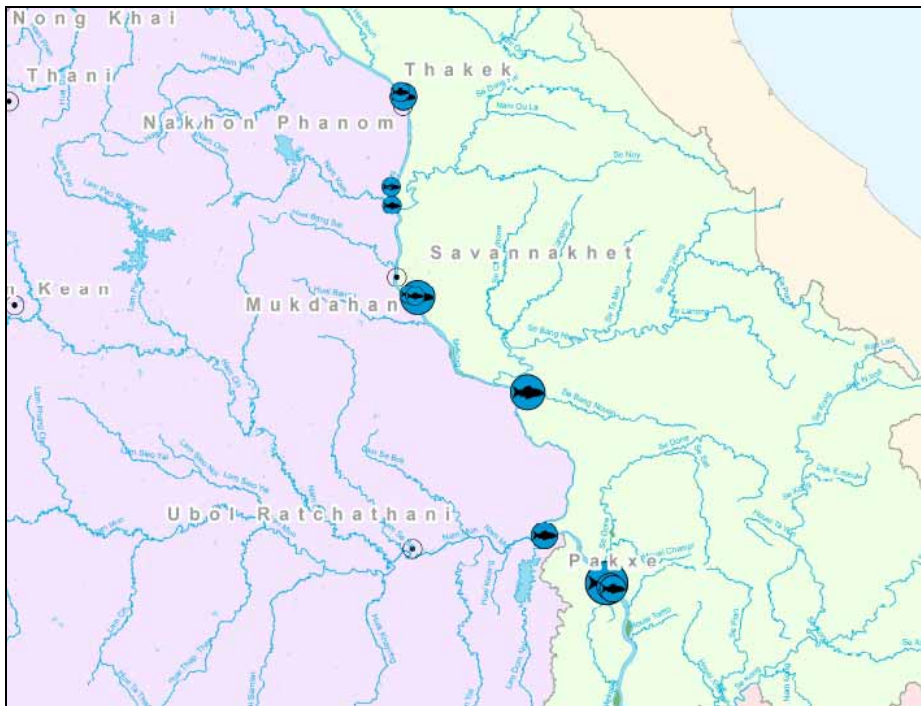
Deep pools are a vital dry season refuge for both resident and migratory fish species and undoubtedly contain a diverse assemblage of undescribed invertebrates. The Globally Critically Endangered Mekong Giant Catfish *Pangasianodon gigas* is one of the established 56 fish species that reside in the pools during part of their life cycle. Of the remaining 55 species, at least 5 are Globally Threatened: Jullien's Carp *Probarbus jullieni* (GT-EN), Thick-lib barb *Probarbus labeamajor* (DD), Royal Featherback *Chitala blanchi* (GT-NT), Trey po pruy *Pangasius sanitwongsei* (DD) and Endemic freshwater herring *Tenualosa thibeaudeaui* (GT-EN).

These habitats are also vital dry season refuge for the Globally Critically Endangered Irrawaddy Dolphin *Orcaella brevirostris*, which prefers areas with a water depth greater than 8 meters. Figures 3, 4 and 5 show the locations of the most important deep pools.

**Figure 3: Deep pools in the main river, upstream of Thakek**



**Figure 4: Deep pools in the main river between Thakek and Pakse**



**Figure 5: Deep pools in the main river between Pakse and Phnom Penh**



#### 2.2.4 *Small islands and riverine sand-bars*

Small islands and riverine sand-bars are common on stretches of the Mekong and its tributaries. They are formed by deposition during seasonal high river flow. The plant *Anogeissus rivularis* dominates the pioneer community of low-lying vegetated sandbars. The older, larger sand-bars, built up into islands over many years, have more substantial vegetation similar to the neighboring gallery forest.

The smaller sandbars and islands provide safe breeding sites for many species of water birds, some of which are globally rare and endangered. The only recent confirmation in Indochina for the breeding of

the Globally Vulnerable Black-bellied Tern was recorded on such islands. They also support the largest numbers of Great Thick-knee, River Lapwing, and Small Pratincole in South East Asia.

IUCN, during surveys for Biodiversity Assessment of the Mekong River in Northern Lao PDR in 2003 to 2005, identified in total 21 bird species that are dependent on the sandbars often in combination with dependency on the riverbanks or mudflats or a combination of these habitats (IUCN, 2006). They are listed in Table 1.

**Table 1: Habitat dependence and relative abundance of birds observed during the IUCN surveys**

Family	Common & Scientific Name	Habitat*)			Abundance**)		
		RB	SB	MF	C	UC	R
Anatidae	Ruddy Shelduck – <i>Tadorna ferruginea</i>		X	X			X
	Spot-billed Duck – <i>Anas poecilorhyncha</i>		X	X			X
Scolopacidae	Common Sandpiper – <i>Actitis hypoleucos</i>		X	X	X		
Burhinidae	Great Thick-knee – <i>Esacus recurvirostris</i>		X	X			X
Charadriidae	Little-ringed Plover – <i>Charadrius dubius</i>	X	X	X	X		
	Long-billed Plover – <i>Charadrius placidus</i>		X	X			X
	Kentish Plover – <i>Charadrius alexandrianus</i>		X	X		X	
	River Lapwing – <i>Vanellus duvaucelii</i>	X	X	X		X	
	Grey-headed Lapwing – <i>Vanellus cinereus</i>	X	X	X		X	
	Red-wattled Lapwing – <i>Vanellus indicus</i>	X	X	X		X	
	Temminck's Stint – <i>Calidris temminckii</i>		X	X		X	
Glareolidae	Small Pratincole – <i>Glareola lactea</i>	X	X	X	X		
Ardeidae	Little Egret – <i>Egretta garzetta</i>	X	X	X	X		
	Intermediate Egret – <i>Mesophoyx intermedia</i>	X	X	X		X	
	Great Egret – <i>Casmerodius albus</i>		X	X			X
	Chinese Pond Heron – <i>Ardeola bacchus</i>	X	X	X	X		
	Grey Heron – <i>Ardea cinerea</i>		X	X		X	
	Little Heron – <i>Butorides striatus</i>	X					X
Alcedinidae	Common Kingfisher – <i>Alcedo atthis</i>	X				X	
	Blyth's Kingfisher – <i>Alcedo hercules</i>	X					X
Halcyonidae	White-throated Kingfisher – <i>Halcyon smyrnensis</i>	X			X		
Motacillidae	White Wagtail – <i>Motacilla alba</i>	X	X	X	X		
	Grey Wagtail – <i>Motacilla cinerea</i>	X		X			X
	Paddyfield Pipit – <i>Anthus rufulus</i>			X		X	
Hirundinidae	Barn Swallow – <i>Hirundo rustica</i>		X		X		
	Red-rumped Swallow – <i>Hirundo daurica</i>		X		X		
	Wire-tailed Swallow – <i>Hirundo smithii</i>	X					X
	Plain Martin – <i>Riparia paludicola</i>	X	X			X	
Apodidae	Asian Palm Swift – <i>Cypsiurus balasiensis</i>	X			X		
<b>Total</b>		<b>17</b>	<b>21</b>	<b>20</b>	<b>10</b>	<b>10</b>	<b>9</b>

\*) RB = Riverbank, SB = Sand bar, MF = Mudflat

\*\*) C = Common, UC = Uncommon, R = Rare. Note: Relative abundance is given, as observed during a limited field survey of IUCN in 2005

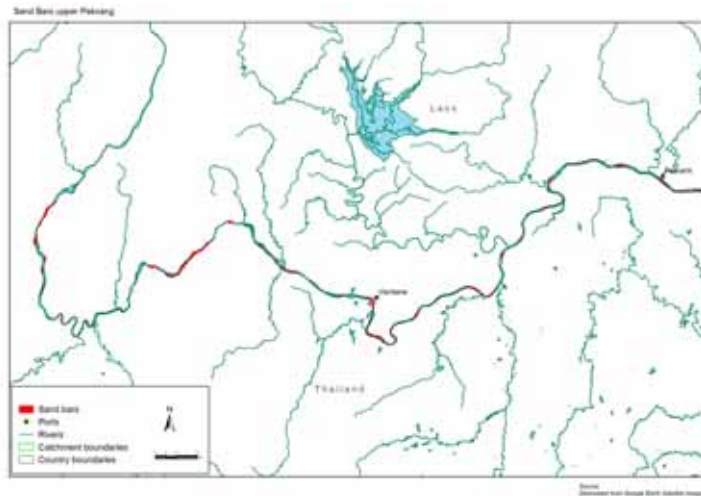
The location of the most important sandbank complexes has been mapped by using Google Earth, see Figure 6 to 9. The total area of sandbars in a number of river reaches is given in Table 2.

**Table 2: Area of sandbars (in ha) for a number of Mekong River reaches**

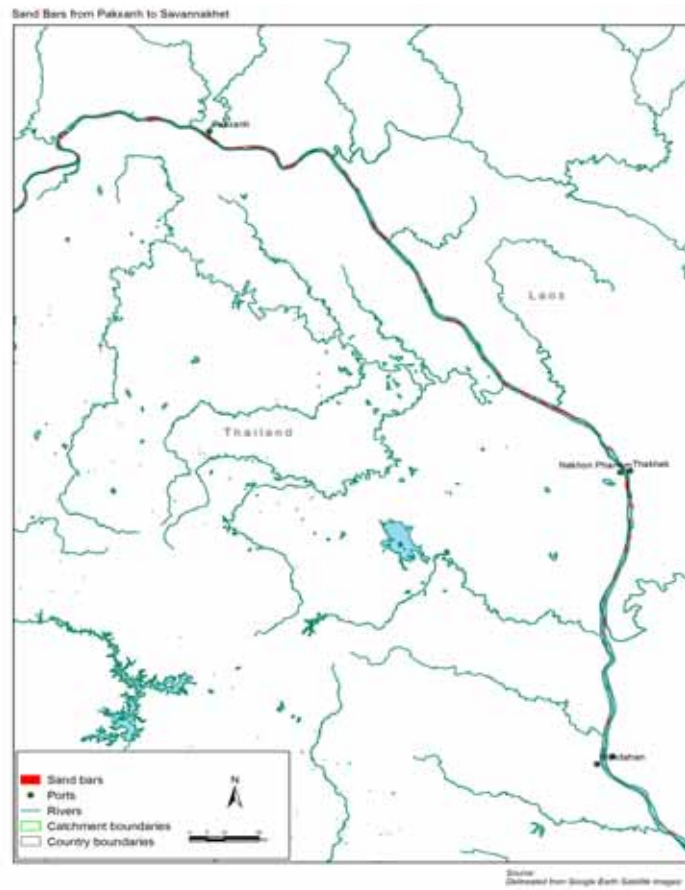
River reach	Area (ha)
Upstream of Vientiane	2,903
Vientiane - Pakse	4,966
Pakse - Kratie	6,094
Downstream Kratie	4,856
<b>Total</b>	<b>18,820</b>



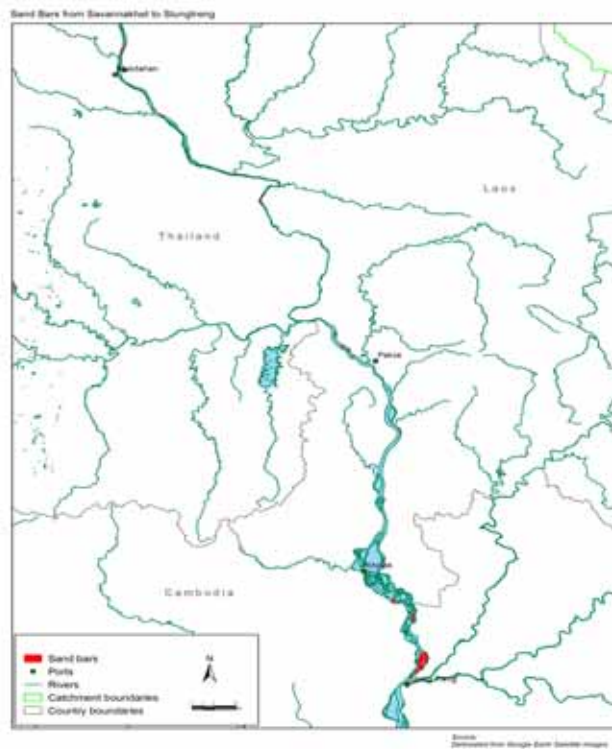
**Figure 6: Locations of sandbars in the river stretch upstream of Pakxan**



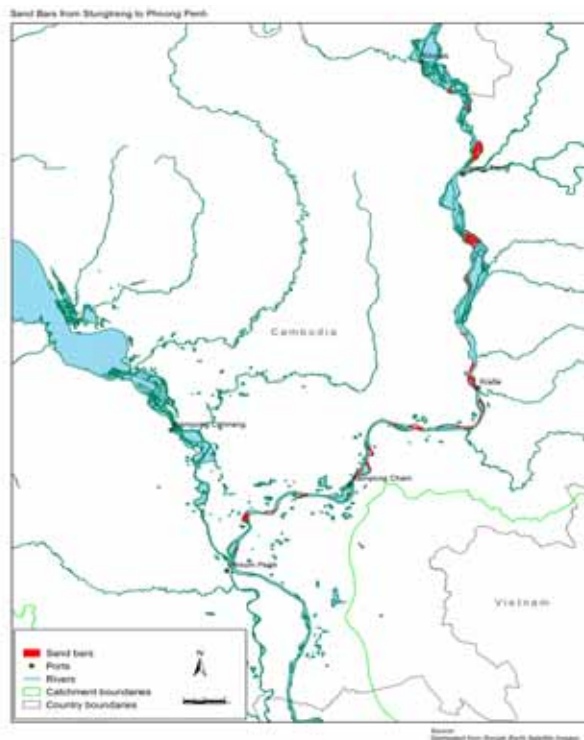
**Figure 7: Location of the sandbars in the river stretch between Pakxanh and Savanakheth**



**Figure 8: Location of the sandbars in the river stretch between Savannakhet and Stung Treng**



**Figure 9: Location of the sandbars in the river stretch downstream of Stung Treng**





A number of permanent and seasonal wetlands are found in the Lower Mekong Basin. The high wet season water levels of the Mekong inundate many of these wetlands seasonally; groundwater and seasonal monsoonal rains maintain others. These provide some of the most productive habitats in the Lower Mekong Basin and include reed and sedge beds, swamps, lotus ponds, inundated grasslands and inundated forest.

The seasonal changes in water level of the Mekong inundated plain drive a seasonal migration of large water birds between wetlands. In the dry season, many species move to permanent wetlands and grassy plains around Lake Tonle Sap and the Delta, while in the wet season they retreat to higher seasonal wetlands in northern Cambodia and southern Lao.

(a) Seasonally inundated forest

One of the most important wetland habitats of the Lower Mekong Basin is the seasonally inundated forest found on the gently sloping plains adjacent to lakes, rivers and tributaries and submerged by the seasonal 8-10 meter flood levels of the wet season.

The composition of this forest type is quite different from swamp forests and mangrove systems. Over 200 species of plants have been found in these inundated forests. Major communities include *Barringtonia acutangula*, *Elaeocarpus madopetalus* and *Diospyros cambodiana*; floating and emergent herbs including *Brachiaria mutica*, *Eichornia crassipes*, *Polygonium barbatum*, *P. tomentosum* and *Sesbania javanica*, and a diverse mixed scrubland containing over 60 species. The woody species of this forest are often laden with fruits and seeds at the time of inundation, providing food for the 34 species of fruit-eating fish of the Lower Mekong Basin. Over 200 species of fish use this habitat as a feeding, breeding, and nursery ground and it is vitally important for breeding colonies of large water birds.

The seasonally inundated forest of Lake Tonle Sap is of high ecological value. Acting as part of the Mekong floodplain, the flood pulse from the Mekong River reverses the flow of the Tonle Sap River to inundate the forest surrounding the Lake which expands in area from around 300,000 hectares to 1.2 million hectares at peak flood height, inundating some 450,000 hectares of forest. As the water level of the Mekong River drops, the Tonle Sap River resumes its normal direction of flow and discharges the lake into the Mekong Delta.

Over 170 species of plants have been identified from the shores around Lake Tonle Sap. Many species are deciduous, shedding leaves with the rising water. Over 140 species of fish have been recorded in the Lake. The lake's productivity is very high and makes a substantial contribution to the annual fish production in Cambodia.

Lake Tonle Sap's inundated forest is one of the most important breeding sites for large waterbirds in Asia. Species breeding in the forest include the Globally Endangered Greater Adjutant *Leptoptilos dubius* and White-winged Duck *Cairina scutulata*; Globally Vulnerable Spot-billed Pelican *Pelecanus philippensis*, Milky Stork *Mycteria cinerea*, Lesser Adjutant *Leptoptilos javanicus*; and Globally Near-threatened Oriental Darter *Anhinga melanogaster* and Painted Stork *Mycteria leucocephala*. These species are believed to migrate to other wetlands in the Lower Mekong Basin during periods of high water level on Lake Tonle Sap. A more detailed description of the Tonle Sap area is given in a separate background paper.

According to the MRC wetland map (2009) the total area of seasonally inundated forests in the LMB is around 500,000 ha, most of it in Cambodia (450,000 ha). The remainder is mainly located in Vietnam. Areas of flooded forests in Lao PDR and Thailand have been included in the marshes and seasonally flooded wetland mapping unit. Note that these figures refer to areas of flooded forest which are affected by the mainstream flooding, i.e. that are within the ranges of the maximum recorded flood of 2000. Location of the flooded forests is presented in Figures 10 and 11 and 12.

(b) Marshes, small pools and seasonal wetlands

Extensive seasonal and permanent marshes, small lakes, and other palustrine wetlands occur throughout the Lower Mekong Basin. They are usually shallow, filled by seasonal rainfall and typically are

connected to river systems which in the wet season form the inundated plain of the Lower Mekong Basin. They contain a mosaic of wetland habitats including reeds, sedge, lotus beds and open water. Submerged communities are dominated by *Ceratophyllum demersum* and *Utricularia aurea*.

In the dry season, these wetlands are vital in maintaining breeding stocks of floodplain fish, including air-breathing species (e.g. gouramies, walking catfish), while in the wet season they function as breeding and nursery grounds for many fish species, the black fish. These wetlands are important for almost all water birds in the Lower Mekong Basin, particularly cormorants, Oriental Darter, Spot-billed Pelican, Greater and Lesser Adjutants, Milky Stork, Woolly-necked Stork *Ciconia episcopus*, Black-necked Stork *Ephippiorhynchus asiaticus*, Painted Stork, the Globally Endangered White-shouldered Ibis *Plegadis davisoni*, Glossy Ibis *P. falcinellus*, Black-headed Ibis *Threskiornis melanocephalus*, White-winged Duck, Pallas's Fish Eagle *Haliaeetus leucoryphus*, Grey-headed Fish Eagle, the Globally Vulnerable Masked Finfoot *Heliopais personata*, and the Globally Near-threatened Sarus Crane *Grus antigone*.

The total area of seasonal and permanent marshes and small lakes, as given on the MRC Wetlands map (2009) amounts to 525,000 ha, 507,000 of which are located in Cambodia, 12,000 in Thailand and 8,000 in Lao PDR. Again, these figures only refer to areas which are affected by the mainstream flooding. For the locations of the seasonal and permanent marshes see Figures 10 and 11.

#### (c) Inundated grasslands

Seasonally inundated grasslands are common on the floodplains of the Lower Mekong Basin. Close to the water edge, floating or emergent vegetation forms dense mats or stands up to 3 meters tall. As water levels rise, dense mats may dislodge and float, propelled by currents or the wind. The main species include *Achyranthes aquatica*, *Brachiaria mutica*, *Eichornia crassipes*, *Polygonum barbatum* and *Sesbania javanica*. Other plant species found on the upper reaches of the inundated plain include several grasses, including *Echinochloa stagnina*, sedges including *Cyperus pilosis*, *Rhynchospora* sp., and dicotyledons such as *Aeschynomene indica*, *Impatiens* sp., *Ludwigia hyssopifolia* and *Nelumbo nucifera* (lotus).

These areas support Sarus Crane, White-shouldered Ibis and Greater and Lesser Adjutants. Although, in the Lower Mekong Basin, these areas are greatly disturbed, they do hold more substantial grasslands than other parts of S.E. Asia and thus are a priority for conservation. They are of crucial importance for the Globally Endangered Bengal Florican *Houbaropsis bengalensis*.

The total area of inundated grasslands in the LMB, as given on the MRC Wetlands map (2009) is 428,000 ha, 315,000 of which are located in Cambodia, 49,000 in Thailand, 9,000 in Lao PDR and 55,000 in Vietnam. Again, these figures only refer to areas which are affected by the mainstream flooding. For the locations of the inundated grasslands see Figures 10, 11 and 12.

### 2.2.6 ***Permanent and Seasonally-inundated Floodplain Wetlands in the Vietnamese Delta***

Although there is evidence from tree stump remains that the Vietnamese Delta was once heavily forested, the character of the Delta has changed to such an extent during its long occupation by humans that little is known of the original vegetation. However, the vegetation communities existing today have been extensively studied.

Natural and semi-natural vegetation communities reflect the climatic, soil and hydrological conditions found in the area, and can be divided into freshwater and saline communities. Freshwater communities can be further divided into swamp-forest vegetation, herbaceous vegetation, riverbank vegetation, and aquatic vegetation in waterways and waterbodies. Saline communities consist largely of mangrove forest.

The dominant tree species in the Vietnamese Mekong Delta swamp-forest is *Melaleuca cajuputi*. This species forms semi-natural forest in some small remaining areas, though the majority is plantation. Species forming the ground layer in swamp-forests vary according to local conditions, but usually include *Phragmites vallatoria* and *Eleocharis* spp. grasslands.

*Melaleuca* forests are encountered particularly in areas with acid sulphate soils. A high proportion is of relatively recent origin and many are within wood production reserves. In Lang Sen, Plain of Reeds, there are patches of the former riverine delta forest comprising *Melaleuca leucodendron* associated with *Syngium* sp., *Elaeocarpus hygrophilus*, *Ficus microcarpa* and *Cassia grandis*. Peat swamps are associated with *Melaleuca* forest in U Minh. The remaining, scattered patches of forest are an impoverished relic of a once more extensive and variable forest cover.

Although today's *Melaleuca* forests are low in plant biodiversity, they form an important habitat for fish, amphibians, reptiles and birds. These *Melaleuca* forests are of prime importance for breeding colonies of large water birds and are one of the few refuges in the Delta for freshwater species such as turtles.

Formerly, extensive grasslands occurred throughout the Vietnamese Mekong Delta, today, much of this habitat is under rice cultivation. Herbaceous vegetation includes areas of seasonally inundated grassland which can be sub-divided into four main groups:

- Grassland in areas of deep and prolonged freshwater inundation that are dominated by *Eleocharis dulcis*, *Oryza rufipogon* and *Phragmites vallatoria*, occurring on potential or light active acid sulphate soils;
- Grassland on active acid sulphate soils that are dominated by *E. dulcis*, *E. ochrostachys*, *Ischaemum rugosum* and *Lepironia articulata*, and inundated with freshwater to a moderate depth and for a moderate duration;
- Grassland on sandy and old alluvial soils that are dominated by *Eragrostis atrovirens*, *Setaria viridis*, *Mnesithea laevis* and *Panicum repens*, and inundated only to a shallow depth and for a short time; and
- Grasslands affected by brackish water that are dominated by *Paspalum vaginatum*, *Scirpus littoralis*, *Zoysia matrella*, *Eleocharis dulcis* and *E. spiralis*. They are affected by brackish water and can be inundated on a daily basis by the tide.

In the Mekong Delta seasonally inundated grasslands provide habitat for globally threatened birds, including Bengal Florican *Houbaropsis bengalensis* and White-shouldered Ibis *Pseudibis davisoni*. The habitat also supports at least 60% of the population of the eastern sub-species of Sarus Crane *Grus antigone sharpii* in the dry season. These grasslands also contain unique vegetation communities, some of which are not likely to be found elsewhere in Indochina. The saline influence and predominance of acid sulphate soils in the Delta have a strong influence on the species composition of plant communities found here. Seasonally inundated grassland in the Mekong Delta are now mainly confined to the Ha Tien plain and the Plain of Reeds. In the Ha Tien plain, substantial areas still exist, but none has any form of protection and all are in imminent danger of being lost to rice cultivation. Almost all the grassland of the Plain of Reeds has been converted to rice agriculture, with only 2 small fragments under conservation protection in Tram Chim National Park and the Lang Sen Wetland Reserve.

Intertidal mangrove forests cover large areas of the coastal portion of the Vietnamese Mekong Delta. Some 40 species of mangroves are found. Successive communities are dominated by *Avicennia*, *Brugiera*, *Rhizophora*, *Sonneratia caseolaris* and *Nypa fruticans*. This is an ecologically important area as a breeding ground for many species of fish, crabs and shrimps. Over 300 species of fish have been recorded in the Delta.

There are no reports of vertebrates endemic to the mangrove areas, but the wildlife is diverse with mammals such as fishing cats, otters and crab-eating macaques. Salt-water crocodiles are still reported in the Delta. Many fish and shrimp species depend upon the estuaries of the delta for their breeding and nursery areas. Some marine species of fish of the families Polynemidae (threadfins) and Tachysuridae ascend the rivers to spawn in the gradient or freshwater zone of the estuaries, while the larvae of many economically important shrimp species, spawned in the shallow coastal areas, are moved by tides into the brackish water zone where they stay as juveniles for 2-4 months amongst abundant food and safe from predators.

For the location of the major wetland types encountered in Vietnam see Figure 13.

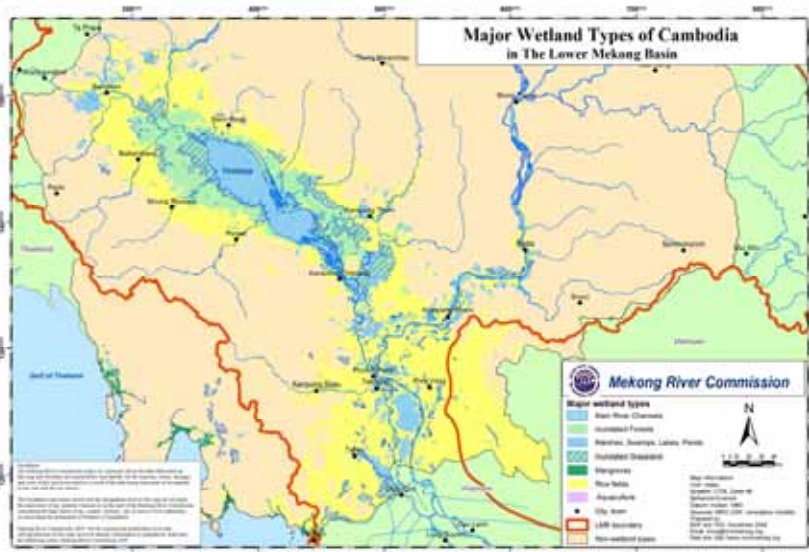
#### **Figure 10: Wetlands in the Lao PDR**



Figure 11: Wetlands in NE Thailand



Figure 12: Wetlands in Cambodia



**Figure 13: Wetlands in Vietnam**



### 2.2.7 Tributaries and reservoirs

Above description concentrated on the ecosystems/habitats encountered in the main stream/larger tributaries and the areas affected by the yearly mainstream flooding. However construction of hydropower dams in upper watersheds and the creation of reservoirs will have impacts on habitats and species distribution as well. Hence a short description of the affected/created habitats is given here.

Tributaries on the east side of the Mekong flow from high in the Annamite Mountains and the northern Plateau of Lao PDR. The Korat Plateau of Thailand on the west side of the Mekong forms the southerly catchment of the middle reaches of the lower basin. These areas have a high level of fish endemism and are vitally important for wetland associated mammal species.

The headwaters of the higher mountains are found on the eastern side of the Mekong River. These areas are characterised by the steepest gradients, higher altitude and rocky substrates. Smaller streams flow through a closed canopy forest, which opens as the streams widen. Most fish species of the headwaters appear to be permanent residents, but, with few surveys to date, little is known of the overall fish diversity.

The Globally Near-Threatened Grey-headed Fish Eagle *Ichthyophaga ichthyaetus* inhabits the larger rivers, while the Brown Fish Owl *Ketupa zeylonensis* and Buffy Fish Owl *Ketupa ketupu* associate with smaller rivers.

The middle reaches of the medium-sized and smaller tributaries of the Mekong River contain diverse geological features that form a number of different habitats including deep-water pools, rapids, waterfalls and gorges. There is limited flooding in the wet season, and usually there is no floodplain.

The fish biodiversity of the middle reaches of most of the larger tributaries of the Mekong is not well known. However, the fish diversity of Nam Theun, a relatively large Mekong tributary in central Lao PDR, has been studied in more detail than many other systems and will be used to demonstrate the fish diversity of these larger tributaries. In Nam Theun, there is an endemic fish, *Luciocyprinus striolatus*, which can grow to 60 kg, and according to local people is known to eat monkeys. Although found in other tributaries, it is not known from mainstream channels. A herbivorous carp of the genus *Poropuntius* (*Poropuntius* cf. *deauratus*) is the most abundant medium-sized fish species in the Nam Theun Basin and is possibly endemic. Two new endemic species, *Onychostoma* sp. nov. and *Scaphognathops* sp. nov., both occur in the middle reaches of the river. Of the three species of *Tor* spp. in the Mekong, two are endemic and one is known only from the Nam Theun basin. The eel *Anguilla marmorata* migrates from the Nam Thun to breed in the sea over 1,500 km away. In total, of the 87 species of fish identified from the middle and upper reaches of this river, 33 (38%) were previously undescribed, and possibly endemic, species.

It is anticipated that surveys of other Mekong tributaries will yield similar levels of fish diversity. Many fish species of the middle reaches are not found in the headwaters of tributaries or mainstream channels of the Mekong or its larger tributaries. Of the 456 species identified in taxonomic studies of the Lower Mekong Basin by Kotellat (Kotellat, 2001) 53 species (11%) are known from only single sub-basins.

Man made impoundments usually have limited seasonal variation in water height and possess a uniform underwater landscape. In terms of freshwater biodiversity, reservoirs force a shift from a riverine system to a standing water community in which only a few species are able to adapt. The fish fauna of these reservoirs is usually stocked, often with exotic species.

Mitigation programs for dams often propose surrounding catchments as conservation areas. However, this does little to protect aquatic biodiversity and concerns for catchment biodiversity conservation typically focus on large mammals, birds and forests.

## 2.3 Environmental services of wetlands

Ecosystems, and particularly wetlands, provide a wide range of goods and services for human production and consumption. Examples are fish, timber, fuel, food, medicines, crops and fodder. Natural ecosystems such as forests and wetlands generate important economic services which maintain the quantity and quality of water supplies. Furthermore, they help to mitigate or avert water-related disasters such as flooding and drought. Often ecosystems provide a more effective, cost-efficient, equitable and affordable means of supplying these goods and services than engineered alternatives. The ecosystem services of importance in the Lower Mekong Basin are given in Table 3.

**Table 3: Wetland ecosystem services of importance in the Lower Mekong basin**



Ecosystem service	Description
Regulation of flows	By storing large amounts of water, that are gradually released, wetlands delay and even out peak flows and so attenuate downstream flooding.
Regulation of water quality	For example wastewater purification and control of sedimentation and siltation. Wetlands absorb, filter, process and dilute nutrients, pollutants and wastes. They usually have a high nutrient retention capacity and are effective in removing bacteria and microbes and in some cases, removing toxic chemicals. Nutrient retention in wetlands makes them among the most productive recorded, rivaling even intensive agricultural systems.
Conservation of biodiversity	Wetlands are usually very diverse and productive ecosystems. Freshwater wetlands hold more than 40 percent of the world's species and 12 percent of all animal species. The Mekong wetlands support over 1,200 recorded fish species and a diverse fauna of other aquatic animals such as shrimps, crabs, molluscs, reptiles and insects as well as waterfowl and other birds and animals. The diversity of the flora is also extremely high.
Source of fish and other food	<p>Wetlands are a main source of food - rice, fish and other aquatic animals. They are the basis for people's strategies to cope with rice deficit and the major source of protein for much of the population. Non-fish aquatic animals harvested from wetlands include several species of frogs, water birds, molluscs, turtles, crabs etc. A variety of aquatic plants is also consumed. Recent studies on the availability and use of aquatic biodiversity from rice-based ecosystems in Cambodia, China, Lao PDR and Viet Nam recorded a large number of species, including 145 fish, 11 crustacean, 15 mollusc, 13 reptile, 11 amphibian, 11 insect and 37 plant species directly caught or collected from wetlands and used by rural people during one season.</p> <p>Roughly 2 million tonnes fish are caught each year in the Lower Basin. Another 0.5 M ton are produced by aquaculture and reservoir fisheries. The direct economic value of this fish production is about 2 B US\$, 2/3 of the population of the basin is involved in fisheries one way or another.</p>
Provision of goods	Collection of craft materials, fuels, construction material, medicines and raw materials
Cultural value	Wetlands are frequently of religious, historical, archaeological or other cultural significance at the local or national level.
Recreation and (eco)tourism	Many wetlands are prime locations for tourism; some of the finest are protected as National Parks, World Heritage Sites, Ramsar sites, or Biosphere Reserves. Many wetland sites generate considerable income from tourism locally and nationally.
Water supply	Most types of wetlands store, regulate and recharge both surface and sub-surface water supplies, as well as groundwater. Water from wetlands is extracted for domestic, agricultural and industrial use. Some wetlands are used as a water supply for villages.
Riverbank stabilization and shoreline protection	Coastal wetlands play a critical role in protecting the land from storm surges and other weather events; they reduce wind, wave and current action, and coastal vegetation helps to hold sediment in place.

## 2.4 Biodiversity, rare and endangered species

The wetlands of the Lower Mekong Basin support almost 100 species classified as Globally Threatened (Critically Endangered, Endangered, Vulnerable, Near-Threatened and Data Deficient). This reflects the vital contribution of the Lower Mekong Basin to global wetland biodiversity. Comprehensive information on all the biodiversity of the Lower Mekong Basin is not available. Large mammals and birds are quite well documented, while other groups are less so. Thus of necessity, this review will focus on documented taxa, e.g. mammals and birds, and will consider those groups whose information base is increasing, e.g. fish and reptiles. Little information exists for groups such as amphibians and invertebrates.

### 2.4.1

#### *Mammals*

The wetlands of the Lower Mekong Basin are vitally important for many mammals. These mammal species fall into two groups: permanent wetland residents and seasonally wetlands residents, particularly reliant on wetlands with permanent water in the dry season.

Almost all mammals that permanently associate with wetlands are severely threatened. Species of particular concern are:

- The Critically Endangered Irrawaddy Dolphin *Orcaella brevirostris*. The Irrawaddy Dolphin inhabits coastal and larger river systems in the Indo-Malayan realm. It is believed to be Critically Endangered locally. The former range of the Mekong population of the Irrawaddy Dolphin was from Vietnam to the Khone Falls, including Lake Tonle Sap and the Xe Kong in Attepeu Province. Today, the population is estimated to be less than 100 individuals, which are mainly confined to Kratie and Stung Treng Provinces in Cambodia with occasional wet season reports from the Xe Kong. The dry season is critical for this species when the dolphins retreat to pools with a depth greater than 8 meters;
- The Endangered Wild Water Buffalo *Bubalus arnee* was reported in southern Laos earlier this century. It is now believed to be close to extinction in the Mekong River Basin as the result of disturbance and hunting;
- The Endangered Lowe's Otter *Civet Cynogale lowei* is endemic to the region. It is reported to be found in Vietnam, Yunnan and North-eastern Thailand and may still be present in Lao PDR or Cambodia;
- The Hairy-nosed Otter *Lutra sumatrana* and Smooth-coated Otter *Lutrogale perspicillata* are both classified as Globally Vulnerable. Reported from smaller rivers and relatively undisturbed habitats, both species are believed to be in serious decline due to hunting. However, there are reports of viable populations in some localities in the Lower Mekong Basin;
- The Near-threatened Oriental Small-Clawed Otter *Aonyx cinerea* is found in rivers and streams in forests and in adjacent degraded areas;
- The Near-threatened Fishing Cat *Prionailurus viverrinus* is found in lowland riverine and deciduous forest; and
- The Eurasian Otter *Lutra lutra* is still believed to occur in a number of different wetland habitats.

All of these species are under heavy hunting pressure. In addition, the conversion of wetland areas to agricultural land has severely reduced available habitat, e.g. in north-east Thailand and the Mekong Delta.

A list of endangered and threatened mammals with dry season associations to wetlands is given in Table 4. It is uncertain whether all of these species still occur in the Lower Mekong Basin.

**Table 4: Globally-threatened mammals associated with wetlands during the dry season**

Common name	Scientific name	Conservation status	Habitat
Fishing cat	<i>Prionailurus viverrinus</i>	G-NT	Evergreen forest, adjacent to river courses
Long tailed macaque	<i>Macca fascicularis</i>	G-NT	Riverine forests
Pileated gibbon	<i>Hylobates pileatus</i>	G-NT	Evergreen forest, adjacent to river courses
Rhesus macaque	<i>Macaca mulatta</i>	G-NT	Adjacent to water courses
Silvered langur	<i>Semnopithecus cristatus</i>	G-NT	Evergreen forest, adjacent to river courses

GT: Globally Threatened; CR: Critically Threatened, EN: Endangered, VU: Vulnerable, NT: Near Threatened, DD: Data Deficient

## 2.4.2

### Birds

The Lower Mekong Basin wetlands are critically important for a number of globally-threatened waterbird species. These wetlands are believed to support one Globally Critically Endangered species, 4 Globally Endangered species and 10 species classified as Vulnerable.



### 2.4.3

### *Globally important endangered species*

The Critically Endangered Giant Ibis *Pseudibis gigantea*, long thought to be extinct, was re-discovered in 1993 along the Xe Kong floodplain in southern Lao PDR. Small waterbodies along the Xe Kong in Attepeu Province in southern Laos and near the Se San and Srepok Rivers in Stung Treng, are vitally important for this species. The total world population of this species may be less than 100 individuals.

The population of the Globally Endangered White-winged Duck *Cairina scutulata* in southern Lao and northern Cambodia is one of the largest remaining in the world.

The Globally Endangered Greater Adjutant *Leptoptilos dubius* and White-shouldered Ibis *Pseudibis davisoni* occur in the dipterocarp forest and wetland mosaic of northern Cambodian and southern Lao PDR. These areas are also vital for the Globally Vulnerable Green Peafowl *Pavo muticus*.

The Globally Endangered Bengal Florican *Houbaropsis bengalensis* is found in Tram Chim on the Plain of Reeds and in the seasonally flooded grasslands of Lake Tonle Sap. Similar habitats are important for Globally Threatened -Vulnerable Sarus Crane *Grus antigone*, which in the wet season migrates to northern Cambodia and southern Lao PDR to seek out non-flooded grasslands.

Globally Vulnerable species relying on the riverine habitats of the Mekong and its larger tributaries include the Indian Skimmer *Rynchops albicollis* and Black-bellied Tern *Sterna acuticauda*.

Other Globally Vulnerable species depending on a variety of wetland habitats in the Lower Mekong Basin include the Masked Finfoot *Heliopais personata*, Pallas's Fish-Eagle *Haliaeetus leucoryphus*, Greater Spotted Eagle *Aquila clanga*, Spot-billed Pelican *Pelecanus philippensis*, Milky Stork *Mycteria cinerea* and the Lesser Adjutant *Leptoptilos javanicus*.

A list of endangered, threatened bird and protected bird species reliant on wetlands is provided below in Table 5.

The number of bird species found in Cambodia is 435 (Ministry of Environment, Wetland biodiversity of Cambodia, Workshop on National Wetlands Planning, October 2000). Of these 106 species are water birds.

**Table 5: Birds dependant upon wetlands in the Lower Mekong Basin and their conservation status**

Common name	Scientific name	Conservation status
Giant Ibis	<i>Pseudibis gigantea</i>	GT-CR
Greater Adjutant	<i>Leptoptilos dubius</i>	GT-EN
White-shouldered Ibis	<i>Pseudibis papillosa davisoni</i>	GT-EN
White-winged Duck	<i>Cairina scutulata</i>	GT-EN
Bengal Florican	<i>Houbaropsis bengalensis</i>	GT-EN
Nordmann's Greenshank	<i>Tringa guttifer</i>	GT- EN
Spot-billed Pelican	<i>Pelecanus philippensis</i>	GT-VU
Milky Stork	<i>Mycteria cinerea</i>	GT-VU
Lesser Adjutant	<i>Leptoptilos javanicus</i>	GT-VU
Greater Spotted Eagle	<i>Aquila clanga</i>	GT-VU
Green Peafowl	<i>Pavo muticus</i>	GT-VU
Masked Finfoot	<i>Heliopais personata</i>	GT-VU
Black-bellied Tern	<i>Sterna acuticauda</i>	GT-VU
Indian Skimmer	<i>Rynchops albicollis</i>	GT-VU
Sarus Crane	<i>Grus antigone</i>	G-VU
Oriental Darter	<i>Anhinga melanogaster</i>	G-NT
Great-billed Heron	<i>Ardea sumatrana</i>	G-NT
Painted Stork	<i>Mycteria leucocephala</i>	G-NT

Asian Openbill	<i>Anastomus oscitans</i>	G-NT
Black-headed Ibis	<i>Threskiornis melanocephalus</i>	G-NT
Grey-headed Fish-Eagle	<i>Ichthyophaga ichthyaetus</i>	G-NT
Grey-headed Lapwing	<i>Vanellus cinereus</i>	G-NT
Asian Dowitcher	<i>Limnodromus semipalmatus</i>	G-NT
Malaysian Plover	<i>Charadrius peronii</i>	G-NT
Asian Golden Weaver	<i>Ploceus hypoxanthus</i>	G-NT
Comb Duck	<i>Sarkidiornis melanotos</i>	LC
Brahminy Kite	<i>Haliastur indus</i>	LC
Greater Flamingo	<i>Phoenicopterus ruber</i>	LC
Osprey	<i>Pandion haliaetus</i>	LC
Black Kite	<i>Milvus migrans lineatus</i>	LC
White-bellied Sea-Eagle	<i>Haliaeetus leucogaster</i>	LC
Black-shouldered Kite	<i>Elanus caeruleus</i>	LC
Western Marsh Harrier	<i>Circus aeruginosus</i>	LC
Pied Harrier	<i>Circus melanoleucos</i>	LC
Brown Fish Owl	<i>Ketupa zeylonensis</i>	LC
Buffy Fish Owl	<i>Ketupa ketupu</i>	LC

GT: Globally Threatened; CR: Critically Endangered, EN: Endangered, VU: Vulnerable, NT: Near Threatened, DD: Data Deficient, LC: Least Concern

#### 2.4.4 Reptiles

The Siamese Crocodile *Crocodylus siamensis* is Critically Endangered. It was formerly widespread throughout the Lower Mekong Basin, but has declined drastically due to excessive hunting and habitat destruction. This species is now very rare and believed to be extinct in the wild in Vietnam and Thailand. The small numbers confined to the south of Lao PDR and Cambodia are of extreme global importance as the last wild populations but they still face a number of threats. These include hunting, habitat destruction and harvesting of the young for crocodile farms. The natural genetic stock is also under threat from cross-breeding with both the Cuban Crocodile *Crocodylus rhombifer* and the Saltwater Crocodile *Crocodylus porosus* encouraged by crocodile farms in the region.

Local, but unconfirmed reports from the Stung Treng area in northern Cambodia mention the presence of the False Gharial *Tomistoma schlegelii*, listed as Data Deficient, but probably Globally Critically Endangered.

**Table 6: Globally threatened crocodiles from the Lower Mekong Basin**

Specific name	Common name	Global Status	Comment
<i>Crocodylus siamensis</i>	Siamese crocodile	GT-CR	
<i>Gavialis gangeticus</i>	Gharial	GT-EN	Unconfirmed
<i>Tomistoma schlegelii</i>	False gharial	DD	Unconfirmed
<i>Crocodylus porosus</i>	Salt water crocodile	-	

Over 20 species of turtles and terrapins occur in the Lower Mekong Basin, ten of which are listed in the Red Data Book. The Chinese three-striped box turtle *Cuora trifasciata* and River Terrapin *Batagur baska* are Critically Endangered. Seven other species are listed as Globally Threatened - Vulnerable.

The populations of all species of turtle and terrapin in the Lower Mekong Basin are thought to be in rapid decline. Many hundreds of tonnes of turtles, i.e. millions of individuals, are exported from the countries of the Lower Mekong Basin annually, many destined for the food markets of East Asia and for use in traditional medicines.

**Table 7: Globally threatened turtles from the Lower Mekong Basin**

Scientific name	Common name	Conservation Status
<i>Batagur baska</i>	River terrapin	GT -EN
<i>Cuora trifasciata</i>	Chinese-three striped box turtle	GT - EN
<i>Indotetudo elongata</i>	Elongated tortoise	GT - VU
<i>Manouria impressa</i>	Impressed tortoise	GT - VU
<i>Manouria emys</i>	Asian giant tortoise	GT - VU
<i>Pelochelys bibroni (cantori)</i>	Asian giant softshell turtle	GT - VU
<i>Hieremys annandalii</i>	Yellow-headed temple turtle	GT - VU
<i>Sacalia quadriocellata</i>	Four-eyed turtle	GT - VU
<i>Amyda cartilaginea</i>	Asiatic softshell turtle	GT - VU
<i>Cuora amboinensis</i>	Malayan box turtle	G - NT
<i>Cuora galbinifrons</i>	Indochinese box turtle	G - NT
<i>Hoesemys grandis</i>	Giant asian pond turtle	G - NT
<i>Platysternon megacephalum</i>	Big-headed turtle	DD
<i>Malayemys subtrijuga</i>	Malayan snail eating turtle	VU
<i>Pyxidea mouhotii</i>	Keeled box turtle	GT-EN
<i>Siebenrockiella crassicollos</i>	Black marsh turtle	DD
<i>Cyclemys dentata</i>	Asian leaf turtle	G-NT
<i>Cyclemys tcheponensis</i>	Striped necked turtle	DD

Two species of monitor are found associated with the wetlands of the Lower Mekong Basin. These are the Bengal monitor *Varanus bengalensis*, and the water monitor *Varanus salvator*. Both are subjected to heavy hunting pressure.

#### 2.4.5 **Amphibians**

There have been few systematic studies of the amphibians of the Lower Mekong Basin. Over 100 species of frogs are reported from Lao PDR.

#### 2.4.6 **Fish**

The information presented in this section has been derived for a large part from Baran (2005), Cambodian inland fisheries, Facts, Figures, Context.

The Mekong hosts over 1,000 species of fish, one of the highest species counts of any river system in the world. When including estuarine and deltaic species above figure may rise to over 1,300. The continuing variation in hydrology and the variety of habitats allow the persistence of many species, which all require different conditions. Some species are most abundant on the floodplain and its wetlands, some favor lowland rivers and some are found mainly in tributaries, but nearly all migrate within or between habitats to complete their life cycles. Above figures are a little controversial, since not all species have been taxonomically verified. In comparison, Kotellat's (Kotellat, 2001) taxonomic studies have recorded 456 species of freshwater fish species in the Lower Mekong Basin, of these 179 (40%) are known to be endemic and 53 species (11%) are known from only a single sub-basin, illustrating the high level of local endemism.

On the other hand, for Cambodia 477 fresh water fish species are recorded (FishBase 2004) of which 40% is endemic.

The fish fauna of the Mekong River is dominated by species of carp (Cyprinidae; 54%), catfish (Siluridae, Clariidae, Schilbeidae, Bagridae, Sisoridae and Akysidae; 19%) and murrels (Chanidae and Ophicephalidae; 8%). The remaining 19% consist of featherbacks (Notopteridae), herring (Clupeidae), climbing perch and gouramis (Anabantidae) and other miscellaneous groups.

Some 85-95% of the freshwater fish populations in the Mekong basin follow the inundation-spawning pattern, undertaking lateral migrations from the mainstream and tributaries into the inundation zones to spawn and rear young between July and September.

Basically two groups of fish are distinguished: white-fish and black-fish. When floodplains drain at the end of the wet season, water remains in lakes and scattered depressions, which continue to shrink in size and number during the dry season. Floodplain water bodies become hot, oxygen is depleted and food and shelter diminish, with many ponds drying-out completely. So the fish which feed and grow on flooded areas must either return to the river as the waters recede, or remain and endure the poor conditions on the floodplain.

Species, which leave flooded areas and return to rivers are referred to as 'white fish', as they spend most of their lives in turbid (white) river water. Most white-fish species migrate into flooded areas during the monsoon season and migrate over long distances to dry-season refuges at the end of the flood season. Representatives of this group are some of the cyprinids, such as *Cyclocheilichthys enoplos* (Soldier river barb or Chhkok) and *Cirrhinus microlepis* (Small mud carp or Prul/Kralang), as well as the river catfishes of the family Pangasiidae.

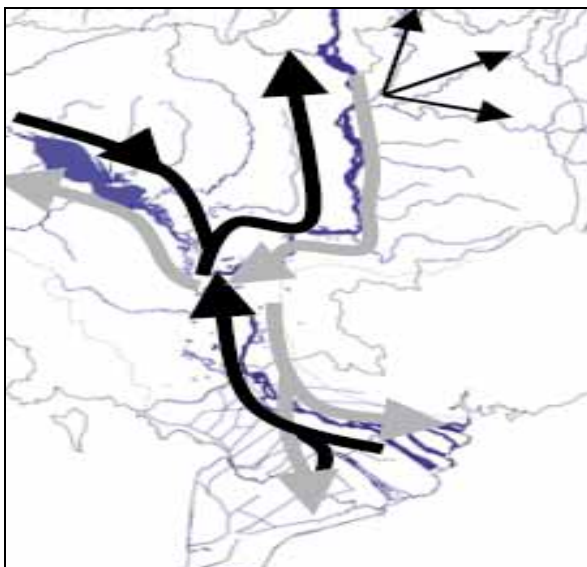
The species of fish which remain in lakes and swamps on the floodplain are known as 'black fish', as they spend their lives in relatively clear water that is tea-colored by chemicals dissolved from floodplain vegetation. Decomposition of vegetation causes floodplain water to be acidic and depleted in oxygen, stresses which black fish can tolerate. Most black fish can breathe air, while many species can survive out of the water for long periods, and most can move overland in search of new water bodies. A few species can bury themselves deep in the mud and wait until the next flood. Many black fish are used in aquaculture and are transported alive to markets.

They are normally referred to as non-migratory, although they perform short seasonal movements between permanent and seasonal water bodies. Examples of black-fish species in the Mekong are the climbing perch (*Anabas testudineus*), the clarias catfishes (e.g. *Clarias batrachus*) and the striped snakehead (*Channa striata*).

Welcomme, 2002, distinguished an additional group, intermediate between black fish and white-fish: the so-called grey-fish. Species of this group undertake only short migrations between floodplains and adjacent rivers and/or between permanent and seasonal water bodies within the floodplain.

The main migration routes in the Lower Mekong Basin are displayed in Figure 14.

**Figure 14: Main fish migration routes in the Lower Mekong Basin**



Source: Poulsen et al., 2002

In the Lower Mekong Basin a number of migratory diadromous fish species, i.e. fish that migrate between marine/estuarine and freshwater or visa-versa) are found. Those species include:

- The catfish *Pangasius krempfi* which is believed to spend its life in the coastal waters of the South China Sea, but returns to the Mekong River to spawn (Khone Falls). Also *Arius caelatus* is reported to undertake diadromous migrations;
- The eel *Anguilla marmorata* is known to migrate from the ocean to upland tributaries for spawning;
- Threadfins: *Eleutheronema tetradactylum*, *Polynemus borneensis*;
- Perch: *Lates calcarifer*; and
- Herrings: *Coila* sp., *Setipinna* sp.

Migration patterns of species in the upper tributaries are not well understood.

#### 2.4.7 *Threatened and endangered species of fish in the Lower Mekong Basin*

Table 8 provides a list of fish species from the Lower Mekong Basin listed in the IUCN Red List of Threatened and Endangered species (after Baran, 2005 (Baran, E, 2005, Cambodia inland fisheries: facts, figures and context. WorldFish Center and Inland Fisheries Research and Development Institute) and Poulsen et al. 2004 (Distribution and ecology of some important riverine fish species of the Mekong River Basin, MRC Technical Paper No. 10, May 2004) .

Three are regarded as Globally Critically Endangered in the Lower Mekong Basin: Leaping Barb *Chela caeruleostigmata*, Dwarf Botia *Botia sidthimunki* and the Mekong Giant Catfish *Pangasianodon gigas*, that is probably the best known. There are two discrete populations of Giant Catfish. One is believed to migrate many hundreds of kilometers each year from the mainstream Mekong north of the Khone Falls, to stretches of the Mekong upstream of Vientiane where it is believed to spawn. The second population is below Khone Falls in Cambodia and Viet Nam. Although this population is also known to undergo seasonal migrations, the location of the breeding sites is not known.

**Table 8: Globally threatened fish species from the Lower Mekong Basin**

Scientific name	Common name	Status	Comment
<i>Chela caeruleostigmata</i>	Leaping Barb	GT-CR	
<i>Botia sidthimunki</i>	Dwarf Botia	GT-CR	
<i>Pangasianodon gigas</i>	Mekong Giant Catfish	GT-CR	Highly migratory
<i>Scleropages formosus</i>	Golden Arowana	GT-EN	Heavily traded
<i>Tenualosa thibaudeaui</i>	Endemic freshwater Herring	GT-EN	Highly migratory
<i>Probarbus jullieni</i>	Jullien's Barb	GT-EN	Highly migratory
<i>Dasyatis laosensis</i>	Mekong Freshwater Stingray	GT-EN	
<i>Himantura oxyrhynchus</i>	Marbled Mekong Stingray	GT-EN	
<i>Pristis Zijsron</i>	Green Sawfish	GT-EN	
<i>Balantiocheilos melanopterus</i>	Silver Shark	GT-EN	
<i>Chitala blanci</i>	Royal Featherback	GT-NT	
<i>Carcharhinus leucas</i>	Bull Shark	LC	
<i>Redigobius bikolanus</i>	Goby	LC	
<i>Aptosyax grypus</i>	Giant Predatory Carp	DD	
<i>Probarbus labeamajor</i>	Thick-Lip Barb	DD	Highly migratory
<i>Probarbus labeaminor</i>	Thin-lip Barb	DD	Highly migratory
<i>Pangasius sanitwongsei</i>	Giant Catfish	DD	Highly migratory

It is certain that a number of species should be added to this list. However, due to the lack of a broad-based understanding of fish diversity, fish life histories, and an evaluation of threats to species, only a superficial analysis can be made. There is currently insufficient information to make useful and comprehensive assessments related to fish biodiversity conservation in the Lower Mekong Basin.

In the last decades there has been a dramatic increase in fishing effort, combined with an increase in the use of modern gears and destructive fishing practices. This has placed severe pressure on some fish species. Of grave concern is the use of illegal fishing methods, i.e. electro-fishing and use of explosives in sensitive habitats such as small ponds and deeper pools, which act as dry season refuges for many species. Although the use of explosives is decreasing, electro-fishing is still occurring in a number of wetlands.

#### 2.4.8 *Invertebrates*

The wetlands of the Lower Mekong Basin also contain a wealth of diversity of invertebrate groups. However, there have been only very limited surveys of these taxa:

- Insects: there have been few detailed studies of the insects of the Lower Mekong Basin.
- Crustacea: the giant fresh water prawn *Macrobrachium rosenbergi* undertakes an impressive migration. Adults live in the freshwater areas of the Mekong including tributaries, natural lakes, rice fields and ditches. On maturing the prawns migrate towards the estuary to spawn in saline water. After 2-6 months in the estuary, juveniles migrate back into freshwater areas. Adults can be found up to 200 km from the estuary.
- Molluscs: an example of invertebrate diversity can be seen from the limited surveys for molluscs. A survey of only 500 km of the Mekong River in Thailand and Laos identified 160 mollusc species. Of these, 116 (72%) species were endemic.

#### 2.4.9 *Additional information on the Vietnamese Delta*

Much of the fauna of the Mekong Delta remains little studied and delta-wide descriptions are largely lacking. Most information presented here has been taken from a publication by Le Dien Duc (1989, Socialist Republic of Vietnam. pp. 749-793 in D. A. Scott, ed. *A directory of Asian wetlands*. Gland, Switzerland: IUCN). More recent information was compiled during a survey of BirdLife International in 1999 (The conservation of key wetland sites in the Mekong Delta, Conservation Report Number 12, 1999).

The mammal fauna of the Mekong Delta is poorly documented, and it is likely that it has been severely depleted as a result of conversion of land to agriculture and expansion of the human population.

Le Dien Duc (1989) listed 23 species of mammal as occurring in the Delta, including five species of dolphin, Crab-eating Macaque *Macaca fascicularis*, Smooth-coated Otter *Lutragale perspicillata* and Fishing Cat *Prionailurus viverrina*. Recently evidence has been provided for the continuing occurrence of the latter three species, as well as Sunda Pangolin *Manis javanica*, Cambodian Striped Squirrel *Tamiops rodolphii*, an unidentified *Callosciurus* squirrel, an unidentified otter *Lutra* sp., Common Palm Civet *Paradoxurus hermaphroditus*, Small Asian Mongoose *Herpestes javanicus*, Leopard Cat *Prionailurus bengalensis*, Wild Boar *Sus scrofa* and Sambar *Cervus unicolor* in the U Minh wetlands. It is likely that other otter species once occurred in the Delta, and some may remain, including Hairy-nosed Otter *Lutra sumatrana* and Oriental Small-clawed Otter *Aonyx cinerea*.

Le Dien Duc (1989) listed 92 species of waterfowl in the Delta, and noted important colonies of cormorants, herons, egrets, storks and ibises. In the grasslands of Ha Tien 74 species have been recorded, including the Globally Endangered Bengal Florican *Houbaropsis bengalensis*.

BirdLife International, during their survey work in 1999, recorded a total of 194 species of birds. Of these, 73 were 'waterfowl' under the definition given by the Ramsar Convention, and a further 27 species could be described as wetland-dependent (including several kingfisher species and wetland-dependent passerines such as reed warblers *Acrocephalus* spp.). Thus, over half (100 species) were strongly associated with wetlands. Almost one third (61 species) were strictly migrants to the Delta, including most of the shorebirds recorded. Most of these were non-breeding visitors that breed outside of Vietnam. Fourteen globally threatened or near-threatened species were recorded during the survey work, of which three are classed as endangered, two as vulnerable and nine as near-threatened.

The Mekong Delta provides habitat for a significant proportion of the regional or global population of several species. Most notably, over 10% of the South-East Asian populations of Glossy Ibis *legadis*



*falcinellus*, Little Egret *Egretta garzetta* and Cattle Egret *Bubulcus ibis*, 3% of the world population of Indian Cormorant *Phalacrocorax fuscicollis*, and 6% of the South-East Asian population of Purple Heron *Ardea purpurea* were recorded. At Bai Boi and Dat Mui up to 0.8% of the world population of endangered Chinese Egret and up to 1.1% of the near-threatened Asian Dowitcher were recorded. Likely these are underestimates and probably the sites support >1% of the global population of both species.

For several widespread species it is likely that the Mekong Delta provides important habitat for significant proportions of their regional populations. For example, the minimum estimates of the South-East Asian populations of Spot-billed Duck *Anas poecilorhyncha* (sub-species *poecilorhyncha*), Chinese Pond Heron *Ardeola bacchus*, Black Bittern *Dupetor flavicollis* and Oriental Pratincole *Glareola maldivarum* are each less than 70,000, and each species is common outside the natural and semi-natural sites in the area. The Mekong Delta populations of each species is therefore likely to constitute >1% of its South-East Asian regional population.

The passerine avifauna of the Delta is species poor. Most species recorded are common and widespread throughout much of Asia, and only two species of conservation interest occur, the Globally Near-Threatened Asian Golden Weaver, and Large-billed Crow *Corvus macrorhynchos*, which is believed to be vulnerable to human pressure and is very rare in the Mekong Delta. Particularly common and widespread resident species include Golden-bellied Gerygone *Gerygone sulphurea*, Pied Fantail *Rhipidura javanica*, Common Iora *Aegithina tiphia*, Oriental Magpie Robin *Copsychus saularis*, Oriental White-eye *Zosterops palpebrosus* and Olive-backed Sunbird *Nectarinia jugularis*. Several winter visitors use the area, the commonest being Brown Shrike *Lanius cristatus*, Black Drongo *Dicrurus macrocercus* and Oriental Reed Warbler *Acrocephalus orientalis*. Wetland dependent passerines include Oriental Reed Warbler, Black-browed Reed Warbler *Acrocephalus bistrigiceps*, Rusty-rumped Warbler *Locustella certhiola* and Zitting Cisticola *Cisticola juncidis*. Very few species typical of terrestrial forest are found: those recorded (e.g. Scarlet Minivet *Pericrocotus flammeus* and Indochinese Cuckoo-shrike *Coracina polioptera*) are restricted to mature *Melaleuca* forest.

The number of species recorded in each of the four main habitat categories gives an indication of the relative importance of each to biodiversity conservation. Bird species richness was highest in seasonally inundated grassland and swamps (100 species), while anthropogenic habitats (including paddy fields, aquaculture ponds and villages) had the lowest richness (83 species). *Melaleuca* forest also held a large number of species, almost as many as grassland and swamp (97 species).

Of the 14 globally threatened or near-threatened species recorded, nine were recorded in seasonally inundated grasslands and swamps, and only three were recorded in anthropogenic habitats (Grey-headed Lapwing, Spot-billed Pelican and Painted Stork). The high number of threatened species recorded in mangroves and mudflats emphasizes the importance of these sites for migratory water birds.

**Table 9: Number of species associated with each of four habitats from surveys carried out in the Mekong Delta, by BirdLife International, 1999**

	Agricultural and urban	Mangrove and mudflats	Seasonally inundated grassland and swamp	<i>Melaleuca</i> forest
Number of species recorded	83	92	100	97
Number of GT species	3	7	9	4

Mammals, reptiles and amphibians were infrequently recorded during the survey of Birdlife International. No evidence was found of the continuing existence of dolphins or crocodiles in the waterways of the Mekong Delta. Although no specific effort was made to search for these, there was no anecdotal evidence to suggest otherwise. Anecdotal reports did suggest, however, that otters *Lutra*, *Lutragale*, *Aonyx* spp. remain at a few sites.

Historical information is available on some species known to exist in the past. Most notable amongst reptiles are Estuarine Crocodile *Crocodylus porosus*, Batagur Terrapin *Batagur baska*, four species of water snake *Enhydryis* spp., Water Monitor *Varanus salvator* and Reticulated Python *Python reticulatus*.

### 3 Impacts on ecosystems/habitats and biodiversity

#### 3.1 Introduction

The Lower Mekong River Basin harbors a number of unique ecosystems, exceptionally rich in biodiversity. They form habitats for a wide range of globally threatened and endemic species, by providing water and primary productivity upon which people and numerous species of plants and animals depend for survival and completion of their life cycle. Wetland ecosystems support high concentrations of birds, mammals, reptiles, amphibians, fish and invertebrate species. Many of these species can only live in wetlands and loss of wetlands will eliminate part of the wetland-dependent species.

In Table 10 a rough indication of the number of species depending on the wetland types in the LMB is given. The table is based on sketchy available information from various sources.

**Table 10: Wetland types and number of species dependent on them**

Wetland ecosystem	Plants	Birds	Fish	OAAs	Mammals	Amphibians	Reptiles	Insects
Main river channels	>1		>1,200	>160 mollusks >5 crustaceans	>3			>15
Rapids		>8	>201		>1			
Deep pools			>162		>1			
Sandbars/riverbanks		>23	>19		>2			>17
Inundated forests	>200	>87	>183	>30	>8	>7	>11	>3
Marshes, swamps,	>75	>74	>215		>2	>6	>10	
Flooded grasslands								
Ricefields	>69 trees >41 aquatic	>33 - 107	>37					

Impacts of the development scenarios on ecosystems/habitats are related to one or more of the following aspects:

- Changes in the spatial extent (quantity) of important ecosystems described in Chapter 2;
- Changes in the availability and quality of important habitats (nesting, roosting, feeding, breeding, spawning grounds) for wetland-dependent species;
- Changes in ecosystem processes, functions and services (groundwater recharge, flood attenuation, sediment/nutrient/toxicant retention/water purification, recreation/ tourism, provision of products on which local subsistence/livelihoods depend, etc);
- Habitat fragmentation effects or reduction of habitat connectivity; and
- Barrier effects that interrupt or block migratory routes of certain species;

Above changes may be classified as direct or indirect, permanent or temporary, having an impact on the long term or on the short term and as ‘stand alone’ or cumulative. Besides a distinction can be made between positive and negative impacts.

The magnitude of the impact depends on the extent of the impact and the significance and can be categorized as:

- High (major): substantial change in the integrity of the ecosystem and, in the long term, its ecological features, structure, functions and services. The change is irreversible and beyond the ecosystem’s ability to recover. The impact area is large.
- Medium (moderate): the change is likely to be significant in the short to medium term to some, not all, of the ecosystem’s features, structures, functions and services. The impact area is considerable; and
- Low (Minor): some minor change of limited extent.



Of special importance are changes in the spatial extent and quality of environmental ‘Hotspots’ and changes in ability of countries and the Mekong Region to meet international obligations with regard to conservation of wetlands and related biodiversity.

At the species level, changes in ecosystem/habitat may affect mortality rate and so result in changes in species richness, diversity, composition and distribution. At the same time the risk of invasion by alien species may be enhanced. This may change the number of species at risk and ultimately cause species extinction. Of special importance are changes in population and status of flagship species, globally threatened species, species of international importance, or species identified as priority species in global/regional/national biodiversity conservation plans and efforts.

Impacts on the species level may also be classified as direct or indirect, permanent or temporary, having an impact on the long term or on the short term, as positive or negative and as ‘stand alone’ or cumulative.

The magnitude of impacts on a species is:

- High (major) if there is a substantial change in the existence, abundance and distribution of the entire population of the species, beyond the ability of the species to recover by natural recruitment;
- Medium (moderate) if the change is likely to be significant in the short to medium term to some individuals, but not the entire population; and
- Low (minor) if there are some minor changes of limited extent.

### 3.2 River channels

The area of river channels is not expected of change under the Definite Future and 20 Year Plan scenarios. However, construction of dams in tributaries and mainstream dams will affect the continuity of the habitat: flowing water will transform to near standing water bodies. The Inception Report, Vol II, Mainstream Project Profile Summaries of the MRC SEA for Hydropower on the Main Stream (ICEM, 2009) gives the characteristics of the proposed projects. Lengths of impoundment areas are given as well. These are summarized in Table 11.

**Table 11: Area and length of impoundments of proposed mainstream dams**

Name of the dam	Location	Impoundment	
		Area (km <sup>2</sup> )	Length (km)
1- Pak Beng	Lao PDR	87	130 - 145
2- Luang Prabang	Lao PDR	90	170
3- Xayabouly	Lao PDR	49	90
4- Pak Lay	Lao PDR	108	110 - 120
5- Sanakham	Lao PDR	81	80
6- Pak Chom	Lao PDR	74	> 80
7- Ban Koum	Lao PDR	160	200 *
8- Lat Sua	Lao PDR	87	10 - 100 **
9- Don Sahong	Lao PDR	3	0
10- Stung Treng	Cambodia	211	50
11- Sambor	Cambodia	620	70

\* Impoundment length calculated from given area of flooded channel, assuming an average channel width of 700 m, as derived from Google Earth

\*\* Two sites are given and 2 impoundment areas. Depending on the site the calculated length of the impoundment is 10 to 100 km

Analysis using Google Earth and above given lengths of impoundments reveals that the Northern Lao dams will completely flood the river stretch between Pak Chom (km 1651) and Houei Xai (at about km 2300), with the exception of a stretch of about 30 km directly downstream of the Luang Prabang dam. In other words, about 600 km of the river in this area will totally change in character from a flowing river to a cascade of more or less stagnant ponds.

In south Lao PDR the Ban Kum and Lat Sua dams will convert the river stretch between km 855 and about km 1100 from a flowing water environment to a near stagnant water environment. In northern Cambodia a river stretch of 120 km between Sambor at km 575 and the Cambodia – Lao PDR border will face the same fate.

In total the river will be heavily modified in character over a length of nearly 1000 km between Sambor (km 575) and Houei Xai (km 2300). This is nearly 60% of its length over this stretch. Consequences for biota will be very significant.

Besides the dams themselves form barriers for migrating fish. Of the at least 17 fish species on the IUCN Red List of Threatened and Endangered species the 6 highly migratory species, including the Mekong Giant Catfish are likely to become extinct under the 20 Year Plan scenario (see also the chapter on Flagship species). A number of the other endangered species may neither be able to adapt to the changing conditions in the channel.

Of the channel dependent birds the most important are the Globally Vulnerable Indian Skimmer *Rynchops albicollis*, Black-bellied Tern *Sterna acuticauda*, Little Tern *Sterna albifrons*; Globally Near-Threatened Grey-headed Fish Eagle and Great Thick-knee *Esacus recurvirostris*, River Lapwing *Vanellus duvaucelii*, and Small Pratincole *Glareola lacteal*, and the Endemic Mekong Wagtail *Motacilla samveasna*. Above described changes in the channel will heavily affect their populations, most probably they will not be able to adapt to the new situation.

Of the mammals the Critically Endangered Irrawaddy Dolphin *Orcaella brevirostris*, will become extinct under the 20 Year Plan scenario (see Chapter on Flagship species). The same is probably valid for Globally Vulnerable Smooth-coated Otter *Lutra perspicillata* and Fishing Cat *Felis viverrina*.

Analysis of expected increases in nutrient inflow into the main river (see Technical Note on Water Quality) indicate that overall impacts are probably limited. However, locally inflow of nutrient laden discharges from agricultural or urban areas into the impoundments could result in concentrations of N and P and levels of BOD which are above the threshold values applied in the basin. Eutrophication could be the result, having a negative impact on the channel ecosystem.

### 3.3 Deep pools

Impacts of tributary and mainstream dam construction on the morphology of the river channel, and so on the deep pools (and also on the rapids and sandbars, as discussed in the following paragraphs) has been described by Carling (2010).

Geomorphologically the Mekong River can be divided in a number of 'geomorphological regions': the bedrock confined channel upstream of Vientiane, the alluvial channel from Vientiane to Pakxahn, the mixed alluvial channel between Pakxahn and Pakse, the bedrock confined channel between Pakse and Kratie and the completely alluvial channel downstream of Kratie. Where appropriate this distinction is applied here.

According to Carling impacts on deep pools of changes in river flows will be very limited, actually no noticeable changes are expected. By definition deep pools are flushed out of sediment. With decreasing sediment loads, resulting from the trapping of sediments by the China dams, the pools will even become more flushed out. Increased dry season flows will not result in higher rates of infilling. Since the pools are generally very deep, impacts on light penetration are negligible.

The impacts of mainstream dam construction can be substantial. Deep pools located within the impoundment area will start to fill in with sediment, whereas flow condition will change from flowing to near stagnant. During the construction phase of the dams downstream pools may be affected by pollution, noise and filling-in with construction debris and sediments brought into suspension as a result of the construction activities.

When comparing the maps displaying the location of important deep pools (Figures 3, 4 and 5) with the data on impoundments presented in Chapter 3.2, it becomes clear that nearly all important deep pool areas are located in the impoundment areas of the proposed mainstream dams: the deep pools between Kratie and Stung Treng, those between Lat Sua (Pakxe) and Savannakhet, as well as all deep pool complexes in Northern Lao with the possible exception of the deep pools near Houei Xai, that may be located just upstream of the impoundment area of the Pak Beng dam. Consequences for river ecology will be considerably because of the loss of dry season refuge for both resident and migratory fish species. Most of the 56 fish species that reside in the pools during part of their life cycle will be heavily impacted, the already Globally Critically Endangered Mekong Giant Catfish and the Globally Threatened Jullien's Carp, Thick-lib barb, Royal Featherback, Trey po and the Endemic freshwater herring will not be able to maintain populations.

The deep pools are also a vital dry season refuge for the Globally Critically Endangered Irrawaddy Dolphin *Orcaella brevirostris*. The loss of the deep pool will mean the end of this species in the Mekong (See also the Chapter on Flagship species).

### 3.4 Rapids

Rapids form a habitat for specific guilds of fish and water birds. Since rapids only cover a very small area in the Lower Mekong Basin, fish biodiversity experts recommend that every species permanently associated with rapids be classified as Critically Endangered. Of the birds commonly associated with rapids two are NT, the Great Thick-knee and Blyth's Kingfisher.

Changes in wet season flow will not have an impact on the rapids. In the dry season water levels will become substantially higher than in the present situation. Although the rapids will not submerge, there will be increased water depths (the more shallow, gradual rapids) or higher flow velocities (the steep rapids) or a combination of the two. Light penetration may decrease as a result of greater depth, but this will be counteracted by lower sediment concentrations. Changes in water depth are probably less than 5%, changes in maximum flow velocities are probably comparable with the changes reported for the gauging stations, possibly somewhat higher.

In the stretch upstream of Vientiane, the rapids will loose sand and water turbidity and the abrasive power of the stream will decrease.

It has to be remarked that the variation of depths and flow velocities over the rapids is extremely high in 'natural conditions'. It is therefore expected that habitat suitability will not really change and that impacts on species will be very limited.

Construction of mainstream dams will heavily affect the rapids in the basin. All rapids in the stretches that become impounded (See Chapter 3.2) will drown and completely change their character. As such the majority of the rapids in the basins will disappear as will the specific fish and bird guilds associated with them

### 3.5 Small islands and riverine sandbars

#### 3.5.1 *Upstream of Vientiane:*

Increases in low water levels will drown (part of) the sandbars, but this is a temporary effect; after some time the sandbars would start to grow again, provided there was sufficient sediment available in the system. However, this part of the channel is bedrock confined and as a result of the decreasing sediment inflow from China, the river will become deprived of sediment and the existing sandbars will gradually be flushed out. There will be a noticeable reduction in sandbar area within the 20 year timeframe, at a time horizon of 50 years all sandbars will be gone. Another change will be that, as the sand is gradually

removed from the system, gravel shoals may developed, however over a much lower total area than the existing sandbanks.

Construction of mainstream dams in this stretch would result in trapping of sediments moving down the river. At the inflow of the reservoir impoundment areas sandbanks would develop.

The existing total area of sandbars upstream Vientiane is 2,900 ha (MRC database).

#### *3.5.2 Vientiane – Pakxahn:*

The river will pick up sediments in this alluvial part of the channel by eroding its bed. As a result a loss of sandbars in the first 20 to 30 km downstream of Vientiane is to be expected within the next 20 years. Further downstream the sandbars will be sustained for longer. The area with bed erosion will gradually progress in the downstream direction over the years. After 50 years sandbars in the stretch of up to 50 km downstream of Vientiane may have disappeared.

#### *3.5.3 Pakxahn – Pakse:*

Within 20 years there will be no noticeable impact on the sandbanks in this mixed alluvial-bedrock stretch of the river channel. On a time horizon of 50 years, there may be some visible decreases in sandbar area.

The existing total area of sandbars between Vientiane and Pakse is 4,970 ha (MRC database).

#### *3.5.4 Pakse – Kratie;*

In this river reach the channel consists of solid bedrock. In the reach between Pakse and Strung Treng, there will be no visible impacts on the sandbars within 20 years, and probably not within 50 years. Near Stung Treng the 3 Se rivers are thought to deliver large amounts of sediments to the main river (40 % of the total (main river) load is mentioned by various authors, although this is not substantiated by monitoring data). Due to dam construction in the 3 Se rivers, sediment inflow into the main river will decrease, an overall trapping efficiency of 37% is mentioned in various reports. Consequently, the sandbars downstream of the confluence will be impacted noticeable in the next 20 years. In a 50 year period the losses may be significant.

The existing total area of sandbars between Pakse and Kratie is 6,090 ha (MRC database)

#### *3.5.5 Kratie – Delta:*

This reach is completely alluvial, and the situation downstream of Kratie is comparable with the situation as described for Vientiane. Within the 20 year period the river bed in the first 20 to 30 km downstream of Kratie will start to erode and sandbars will be noticeable affected. In the period 20 to 50 years from now, the channel erosion will progressively extend in downstream direction. Downstream of Phnom Penh there are no sandbars and the channel will start to incise.

Coastal erosion as a result of changes in sediment supply is not to be expected in the next 20 years, within 50 years some local effects may become visible.

Impacts of mainstream dams in the lower Mekong are comparable to those of the dams upstream of Vientiane. Sandbars may form where flow velocities reduce at the inflow of the impoundments.

Downstream of the dam sites (alluvial beds) will degrade and sandbars, if present, will progressively disappear.

The existing total area of sandbars downstream of Kratie is 4,856 ha (MRC database).

### 3.5.6 Impacts on species

As described in Chapter 2 at least 21 birds in the upper reaches of the Mekong River species depend on sandbanks as either a feeding, resting or a nesting habitat. Disappearance of the sandbanks in the stretch upstream of Vientiane as foreseen under the 20 year plan scenario will lead to disappearance of these species from the area. Nine of these species are already rare in the area, at least one, the Grey-headed Lapwing is Globally Near Threatened, whereas the only recent confirmation in Indochina for the breeding of the Globally Vulnerable Black-bellied Tern was recorded from small islands in the main stream.

**Table 12: Abundance of sandbank dependent species in northern Lao PDR (IUCN, 2006)**

Family	Common & Scientific Name	Abundance**)		
		C	UC	R
Anatidae	Ruddy Shelduck – <i>Tadorna ferruginea</i>			X
	Spot-billed Duck – <i>Anas poecilorhyncha</i>			X
Scolopacidae	Common Sandpiper – <i>Actitis hypoleucos</i>	X		
Burhinidae	Great Thick-knee – <i>Esacus recurvirostris</i>			X
Charadriidae	Little-ringed Plover – <i>Charadrius dubius</i>	X		
	Long-billed Plover – <i>Charadrius placidus</i>			X
	Kentish Plover – <i>Charadrius alexandrianus</i>		X	
	River Lapwing – <i>Vanellus duvaucelii</i>		X	
	Grey-headed Lapwing – <i>Vanellus cinereus</i>		X	
	Red-wattled Lapwing – <i>Vanellus indicus</i>		X	
	Temminck's Stint – <i>Calidris temminckii</i>		X	
Glareolidae	Small Pratincole – <i>Glareola lactea</i>	X		
Ardeidae	Little Egret – <i>Egretta garzetta</i>	X		
	Intermediate Egret – <i>Mesophoyx intermedia</i>		X	
	Great Egret – <i>Casmerodius albus</i>			X
	Chinese Pond Heron – <i>Ardeola bacchus</i>	X		
	Grey Heron – <i>Ardea cinerea</i>		X	
Motacillidae	White Wagtail – <i>Motacilla alba</i>	X		
Hirundinidae	Barn Swallow – <i>Hirundo rustica</i>	X		
	Red-rumped Swallow – <i>Hirundo daurica</i>	X		
	Plain Martin – <i>Riparia paludicola</i>		X	
<b>Total</b>		<b>10</b>	<b>10</b>	<b>9</b>

\*) RB = Riverbank, SB = Sand bar, MF = Mudflat, \*\*) C = Common, UC = Uncommon, R = Rare. Note: Relative abundance is given, as observed during a limited field survey of IUCN in 2005

Construction of main stream dams in the river stretch upstream of Vientiane will fasten the process of sandbar loss: nearly all the sandbars will drown in the impoundments of the dams. This will also be the case for the sandbars in the reach between Kratie and Stung Treng.

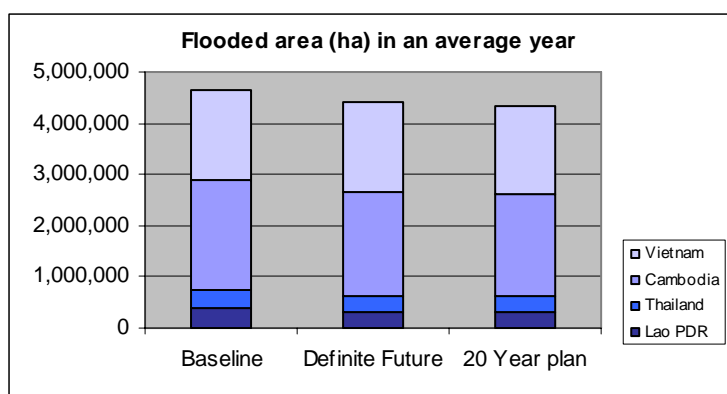
## 3.6 Flooded area

The total area inundated by the mainstream flooding in an average hydrological year reduces from 4.7 million ha to 4.4 million ha (-7%) going from the Baseline to the 20 Year Plan scenario. Changes are biggest in Thailand (-21%) and Lao (-17%), moderate in Cambodia (-7%) and small in Vietnam (-1.5%). In a dry year changes in Lao PDR and Thailand are smaller, only about 3%, in Cambodia bigger: 9%.

**Table 13: Inundated areas in the 4 LMB countries in an average hydrological year**

Inundated area	Lao PDR	Thailand	Cambodia	Vietnam	LMB
Baseline	395,035	362,781	2,132,686	1,773,495	4,663,997
Definite Future	331,792	296,012	2,029,312	1,755,508	4,412,623
Change from baseline (ha)	-63,243	-66,769	-103,374	-17,987	-251,374
<i>Change from baseline (%)</i>	<i>-16.0</i>	<i>-18.4</i>	<i>-4.8</i>	<i>-1.0</i>	<i>-5.4</i>
20 Year plan	328,696	286,808	1,990,988	1,748,251	4,354,743
Change from Definite Future (ha)	-3,096	-9,204	-38,324	-7,257	-57,880
<i>Change from Definite Future (%)</i>	<i>-0.9</i>	<i>-3.1</i>	<i>-1.9</i>	<i>-0.4</i>	<i>-1.3</i>
Change from baseline (ha)	-66,339	-75,973	-141,698	-25,244	-309,254
<i>Change from baseline (%)</i>	<i>-16.8</i>	<i>-20.9</i>	<i>-6.6</i>	<i>-1.4</i>	<i>-6.6</i>

**Figure 15: Total flooded area in the Lower Mekong basin under the 3 scenarios**



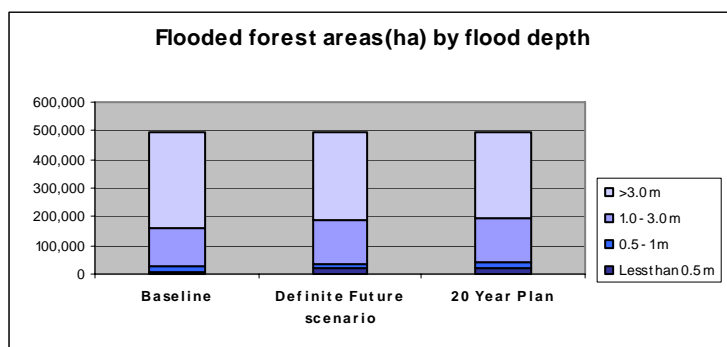
### 3.7 Inundated forests

Inundated forest comprise both seasonally inundated riverine forests and seasonally inundated floodplain forests, a distinction could not be made on the MRC Wetland map. Note that areas of inundated forest refer to areas flooded by the mainstream Mekong. Small pockets of floodplain forest in Lao PDR and Thailand are comprised in the wetland category marshes/seasonal wetlands. Table 14 gives the changes in forest areas that are flooded by the average annual flood under the Definite Future and 20 Year Plan scenarios. Changes in areas are very limited: in Cambodia just over 1% of the presently flooded area will not flood anymore under the 20 Year Plan scenario. However, flood depth and flood duration change as well: areas of shallow flooding increase at the expense of deep flooded areas. Average flood depth decreases with 0.4 to 0.6 m. Average flood duration may decrease with up to one month in a limited area.

**Table 14: Changes in forest area, inundated in an average year (ha)**

Inundated forest	Lao PDR	Thailand	Cambodia	Vietnam	LMB
Baseline	0	0	451,799	45,770	497,569
Definite Future	0	0	449,062	45,551	494,613
Change from baseline (ha)	0	0	-2,737	-219	-2,956
Change from baseline (%)	0.0	0.0	-0.6	-0.5	-0.6
20 Year plan	0	0	446,794	45,362	492,155
Change from Definite Future (ha)	0	0	-2,269	-189	-2,458
Change from Definite Future (%)	0.0	0.0	-0.5	-0.4	-0.5
Change from baseline (ha)	0	0	-5,006	-408	-5,414
Change from baseline (%)	0.0	0.0	-1.1	-0.9	-1.1

**Figure 16: Flooded forest areas by flood depth**



### 3.7.1 Cambodia

Nearly all the flooded forest in Cambodia is located in the Tonle Sap basin. Impacts on this basin will be discussed in a separate Technical Note.

### 3.7.2 Vietnam

In the Vietnamese Delta flooded *Melaleuca cajuputi* forests are mainly semi-natural wood production reserves that are low in plant biodiversity, nevertheless they form an important habitat for fish, amphibians, reptiles and birds. They are of prime important for breeding colonies of large water birds. Under the scenarios the areas flooded will only reduce with less than 1%, most of it already as a result of the Definite Future scenario. Analysis of the flood maps indicates that flood depth in an average year will reduce with 30 to 50 cm, between baseline and 20 year Plan. The difference between Definite Future scenario and 20 Year Plan is generally less than 10 cm. Changes in a dry and wet year are in the same order of magnitude. The duration of flooding decreases in most of the area with less than 0.5 month between the Baseline and the 20 Year Plan scenario. Locally changes are more, up to 1 month. Again differences between an average, a dry and a wet year are limited.

Overall impacts on the *Melaleuca* forests are expected to be limited: the reduction in flooded area is very small as are reductions in flood depth and duration. As a consequence also the impacts on species diversity are expected to be low.

### 3.8 Marshes/seasonal wetlands

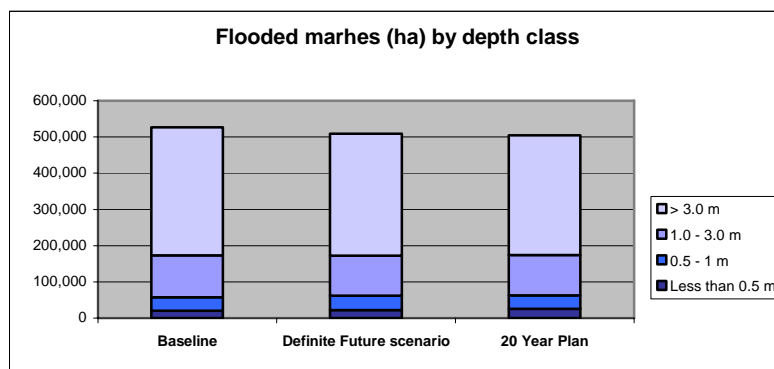
Changes in are of marshes/seasonal wetlands flooded in an average year under the 3 scenarios are summarized for the four LMB countries in Table 15. The table shows that under the 20 Year Plan scenario the area of wetlands flooded in an average year decreases with about 18% in Lao PDR and Thailand as compared with the baseline. Most of these changes can already be attributed to the Definite Future scenario. In fact, in Lao PDR marshland/seasonal wetland areas (including open waters) increase under the 20 Year Plan scenario as compared to the Definite Future scenario because of the increase in reservoir area. In Cambodia and Vietnam marsh areas flooded by the average flood decrease with about 4% under the 20 Year Plan Scenario as compared to the Baseline scenario.

Not only the flooded areas decrease, also flood depth and duration will decrease. Figure 17 shows the changes in flood depth for each of the scenarios.

**Table 15: Changes in marsh/seasonal wetland area, flooded in an average year (ha)**

Inundated marshes	Lao PDR	Thailand	Cambodia	Vietnam	LMB
Baseline	7,944	11,771	506,580	0	526,295
Definite Future	6,286	9,882	493,062	0	509,230
Change from baseline (ha)	-1,658	-1,889	-13,518	0	-17,065
<i>Change from baseline (%)</i>	-20.9	-16.0	-2.7	0.0	-3.2
20 Year plan	6,475	9,623	488,499	0	504,597
Change from Definite Future (ha)	189	-259	-4,563	0	-4,633
<i>Change from Definite Future (%)</i>	3.0	-2.6	-0.9	0.0	-0.9
Change from baseline (ha)	-1,469	-2,148	-18,081	0	-21,698
<i>Change from baseline (%)</i>	-18.5	-18.2	-3.6	0.0	-4.1

**Figure 17: Flooded marshes/seasonal wetlands by depth class**



#### 3.8.1

#### Lao PDR

Under the Definite Future scenario Lao PDR loses 21% of its present nearly 8,000 ha of marshes/seasonal wetlands. Under the 30 Year Plan scenario, the area of wetlands increases again, as a result of the creation of storage reservoirs. Not only the area of wetlands reduces considerably, also the depth and duration of the flooding will decrease. Impacts on the species level are hard to assess. As a very rough estimated it could be assumed that a reduction of area by 20% and a decrease in habitat quality, due to reduced flood depth and duration, could easily lead to a 25% reduction in species diversity. As described in Chapter 2 the number of wetland dependent Globally Threatened species in the LMB is quite large: at least 7 mammals that permanently associate with wetlands and 5 Globally Threatened mammals that associate with wetlands in the dry season. These latter will be extremely vulnerable for decreases in flood depth and duration, since this may affect the recharge of the wetland



systems. Besides, some 35 Globally Threatened birds depend on wetlands in the region, as well as 4 species of Globally Threatened crocodiles and some 18 Globally Threatened turtles. More common species that may be affected are the fish species *Boraras micros* (the world's third smallest fish), *Clarias batrachus*, *Betta splendens*, *Badis badis*, *Albulichthys albuloides*, *Osteochilus schlegeli*, *Ceratoglanis scleronema*. Common birds that will probably be affected are: *Aythya baer*; Purple Heron *Ardea purpurea*, Ferruginous Pochard *Aythya nyroca*, Lesser Whistling Duck *Dendrocygna javanica*, Intermediate Egret *Egretta intermedia*, Little Egret *Egretta garzetta*, Pheasant-tailed Jacana *Hydrophasianus chirurgus*, Garganey *Anas querquedula* and Black Stork *Ciconia nigra*.

### 3.8.2 NE Thailand

In NE Thailand 2,100 (18%) of the present 12,000 ha wetland area will not flood anymore under the 20 Year Plan scenario. Again, already 16% of the reduction will take place under the Definite Future scenario. Impacts will be comparable with those described for Lao PDR in Chapter 3.7.1, to which reference is made.

### 3.8.3 Cambodia

Cambodia has by far the largest wetland area of the 4 LMB counties: in total more than 500,000 ha. The bigger part of this wetland area is located in the Tonle Sap basin: some 310,000 ha. The remainder are wetlands scattered over the Cambodian delta floodplains. Losses of wetland area resulting from the implementation of the 30 Year Plan scenario will be 3.6% (18,000 ha), three quarters of this will already disappear under the Definite Future scenario. Impacts of changes in the Tonle Sap area will be presented in a separate Technical Note, here impacts on the delta floodplain wetlands will be discussed.

In the delta floodplains the flooded marshes area will reduce with some 13,000 ha, or about 7%. In an average year the depth of flooding reduces considerably, with 20 to 80 cm going from the Baseline to the Definite Future scenario. Under the 20 Year Plan scenario an additional reduction of about 10 cm is observed. Changes are biggest in the upstream part, directly downstream of Kratie, where present flood depths are 3 to 4 m, and become smaller in the direction of the border with Vietnam where the changes are between 20 and 30 cm (present flood depth 1 to 3 m). In a wet year the changes are very limited, actually water levels may even go up a bit between Definite Future and 20 Year Plan scenario. In a dry year, changes increase to as much as 1 m in the upstream part to 20 to 40 cm near the Vietnamese border, again going from the Baseline to the 20 Year Plan scenario.

Flood duration is not very much affected by the scenarios: in an average year the flood duration reduces with less than 2 weeks in most of the area (baseline to 20 Year Plan), a change which is slightly bigger in a dry year and even less in a wet year. Present flood duration ranges between 3 to 5 months in most of the area.

Overall the changes are considered to be significant: a loss of 7% of the area, combined with a considerable loss of flood depth and a small change in flood duration will certainly have an impact on the wetland productivity and the species diversity. For the Tonle Sap area a linear relationship between fish catch and flood depth has been demonstrated (see Technical Note on Tonle Sap). Most likely such a relationship is also valid for the floodplains in the Cambodian delta and the loss of 7% wetland area and the reduced flooding could probably lead to a 10 to 20% reduction in overall productivity. This would also significantly affect the wetland dependent species in the area (See Chapter 3.7.1).

## 3.9 Inundated grasslands

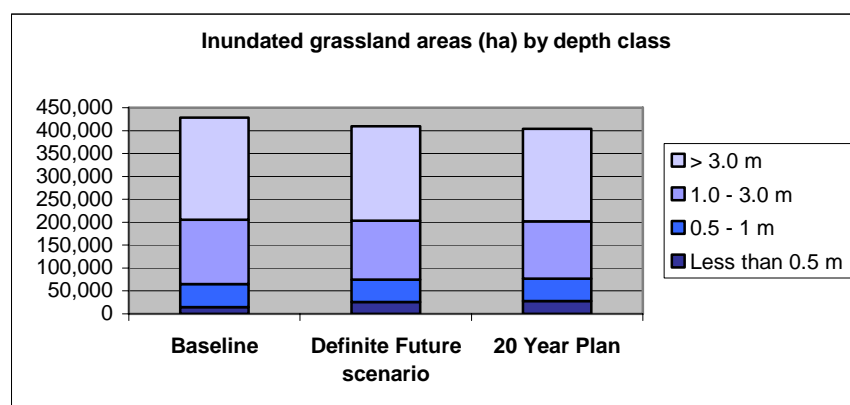
Grassland area flooded with the average flood decreases considerably in Lao PDR and Thailand under the 20 Year Plan scenario as compared with the Baseline scenario: with nearly 50% (Lao PDR) and nearly 18% (Thailand). Changes in flooded grassland areas in Cambodia and Vietnam are less big: in

Cambodia the decrease in nearly 4%, in Vietnam only 0.2%, see Table 16. Again, not only the flooded area decreases, also the flood depth and duration will decrease under the Definite Future and 20 Year Plan scenarios. Figure 18 gives the inundated grassland areas by depth class for each of the 3 scenarios.

**Table 16: Changes in grassland area, inundated in an average year (ha)**

Inundated grassland	Lao PDR	Thailand	Cambodia	Vietnam	LMB
Baseline	8,989	49,315	315,057	54,775	428,136
Definite Future	5,297	41,816	307,691	54,715	409,519
Change from baseline (ha)	-3,692	-7,499	-7,366	-60	-18,617
Change from baseline (%)	-41.1	-15.2	-2.3	-0.1	-4.3
20 Year plan	4,664	40,659	303,731	54,691	403,745
Change from Definite Future (ha)	-633	-1,157	-3,960	-24	-5,774
Change from Definite Future (%)	-12.0	-2.8	-1.3	0.0	-1.4
Change from baseline (ha)	-4,325	-8,656	-11,326	-84	-24,391
Change from baseline (%)	-48.1	-17.6	-3.6	-0.2	-5.7

**Figure 18: Flooded grasslands by depth class**



### 3.9.1

#### *Lao PDR*

Under the 20 Year Plan scenario Lao PDR will lose nearly half its inundated grassland area since 4,300 of the nearly 9,000 ha inundated grasslands will not be inundated anymore by the mainstream flooding. Besides, flood depth and flood duration will reduce. Although the loss represent only 1% of the inundated grassland area available in the LMB, the loss is of more than Lao national importance since the Mekong Basin holds more substantial grasslands than any other part of S.E. Asia. As such inundated grasslands are a priority for conservation and of crucial importance for the Globally Critically Endangered White-shouldered Ibis, the Globally Endangered Bengal Florican *Houbaropsis bengalensis*, the Endangered Greater Adjutant and the Vulnerable Lesser Adjutant and Sarus Crane.

### 3.9.2

#### *NE Thailand*

Under the 20 Year Plan scenario NE Thailand will lose nearly 18% (9,000 ha) of its 50,000 ha inundated grassland. As in Lao PDR, flood depth and flood duration will reduce. Consequences of these changes are comparable to those described for Lao PDR, see Chapter 3.8.1.

### 3.9.3

#### *Cambodia*

Most of Cambodia's 315,000 ha inundated grasslands are located in the Tonle sap basin and will be described in a separate Technical Note on Tonle Sap. The only substantial area of inundated grassland

outside the Tonle Sap Basin is located in the deep flooded area, close to the border with Vietnam. This area, the 'Boeung Prek Lapouv Sarus Crane and Various Other Birds Management and Conservation Area' (8,305 ha) is an important dry season refuge for fish and birds and is inundated for about four months each year, during which some 30 species of aquatic vegetation can be found. The area provides critical wetland habitat to 25% of the world's population of Endangered, Non-breeding Eastern Sarus Cranes (*Grus antigone sharpii*).

Surveys conducted in the area have recorded 58 bird species including 34 water bird species. In addition to bird diversity, the site also supports other wildlife and plants including species of reptiles, amphibians, mollusks, fish, aquatic vegetation, and inundated forest vegetation. Of the 58 bird species present, 6 are globally threatened: Sarus Crane (*Grus antigone*), Bengal Florican (*Houbaropsis bengalensis*), Spot-billed Pelican (*Pelecanus philippensis*), Painted Stork (*Mycteria leucocephala*), Darter (*Anhinga elanogaster*) and Black-headed Ibis (*Threskiornis melanocephalus*).

In an average year food depth will decrease with less than 20 cm (Baseline compared to 20 Year Plan), in a wet year even less. Present flood depth is 2 to 3 m. In a dry year the reduction may be 20 to 30 cm. In a wet year flood duration will not change, in a dry year the maximum reduction in flood duration is about 1 month, compared to the present flood duration of 4 to 5 months. Overall, the changes in flood characteristics will somewhat reduce the habitat quality. Impacts on species diversity are thought to be limited.

### 3.9.4

### **Vietnam**

Inundated grasslands in Vietnam are mainly located in the Tram Chim National Park and the Lang Sen Wetland Reserve in the Plain of Reeds. Losses in inundated grassland area in Vietnam are negligible: about 0.2 % of the total area of 55,000 ha. As in Prek Lapouv changes in flood depth and flood duration are expected to be limited. Flood depth will reduce less than 10 cm in a wet year, 10 to 20 cm in an average year and about 30 cm in a dry year, compared to a flood depth at present of 2 to 3 m in an average year. Most of these changes already take place under the Definite Future scenario. Flood duration in a wet and average year is hardly affected, in a dry year the reduction in the flood duration under the 20 year Plan scenario is about 0.5 to 1 month. At present the area is flooded for 4 to 5 months in a dry year.

Overall impacts on the inundated grasslands are expected to be limited: the reduction in flooded area is very small as are reductions in flood depth and duration. As a consequence also the impacts on species diversity are expected to be low.

## 4 Impacts on environmental hotspots

### 4.1 Introduction

In total 32 environmental ‘Hotspots’ that are likely to be directly affected by the hydrological changes under different scenarios have been identified within the LMB. Selected as hotspots were: protected/sensitive areas with local/national/regional/global conservation management status, containing a rich biodiversity, a large number of important species at risk (threatened or endemic species), as well as areas important for migrating species, or supporting key ecological processes. Included are designated Ramsar Sites, Biosphere Reserves, protected Areas, Important Bird Areas (IBA’s) and Greater Mekong Subregion (GMS) Hotspots.

Table 17 gives the location and status of the identified Hotspots. Figure 19 provides the locations of the Hotspots.

**Table 17: Location and status of the 32 identified environmental Hotspots**

Country	Number	Status				
		RS	BR	PA	IBA	GMS
Shared by >1 country	4			1	2	1
Lao PDR	5			1	4	
Thailand	4	2		2	2	
Cambodia	13	2	1	5	13	3
Vietnam	6			1	6	
<b>TOTAL</b>	<b>32</b>	<b>4</b>	<b>1</b>	<b>10</b>	<b>27</b>	<b>4</b>

RS = Ramsar Site, BR = Biosphere Reserve, PA = Protected Area, IBA = Important Bird Area, GMS = GMS Hotspot

### 4.2 Description of the Hotspots

The following table provides short descriptions of the 32 identified hotspots. The Tonle Sap area (No. 19), discussed here briefly as well, is described in more detail in a separate Technical Note.

**Table 18: Characteristics of the 32 identified environmental hotspots**

Name and characteristics of environmental Hotspot	
1	<p>Nong Bong Kai Non-Hunting Area (Thailand)            Area: 434 ha; Elevation: 350 m; Depth = 0 – 4.5 m (average = 2 m)            Description: Permanent freshwater lake, surrounded by seasonal floodplain, mountains, low hills, ricefields, marshes and swamps, within the Chiang Saen Basin, the extreme north of Thailand adjacent to the Lao and Burmese borders. Water from the lake flows into the Lua River before entering the Mekong River at San Thai village, about 6 km to the west of the lake.            Biodiversity: &gt;46 fish species, &gt;225 bird species, &gt;121 species of both local and migratory birds, 5 species recognized as of International Importance including Globally Vulnerable Baer’s Pochard <i>Aythya baeri</i>, White-eyed Pochard <i>Aythya nyroca</i>, Grey-headed Lapwing <i>Vanellus cinereus</i>, Schrenck’s Bittern <i>Ixobrychus eurhythmus</i>, and Painted Stork <i>Mycteria leucocephala</i>. Besides Baer’s Pochard <i>Aythya baeri</i>, on the basis of occurrence of Spotted Redshank <i>Tringa erythropus</i> and Small Pratincole <i>Glareola lacteal</i>, the site is considered an IBA.            Status: Ramsar site, Protected Area &amp; Important Bird Area</p>
2	<p>Golden Quadrangle (China, Myanmar, Thailand, Lao PDR)            Area: GMS Hotspot area 52,910 (1,852 km<sup>2</sup> wetlands; 3,684 km<sup>2</sup> protected areas)            Description: The site covers parts of southern Yunnan (China), Chiang Rai (Thailand), Shan State (Myanmar), Bokeo and Luangnamtha (Lao PDR). Two large tributaries (Kok and Ing Rivers in Thailand) join the Mekong near the southern edge of this Hotspot. The nearest mainstream dam is Manwan Dam in China (completed in 1996).            Biodiversity: The site supports the Critically Endangered Mekong Giant Catfish <i>Pangasianodon gigas</i>.            Status: GMS HOTSPOT &amp; Protected Area</p>

**Figure 19: Location of the environmental Hotspots**



3	<p>Mekong Channel from Chiang Saen to Chiang Khong (Thailand, Lao PDR)</p> <p>Description: a complex riverine ecosystem, including evergreen riverine forests, tall grass reed beds (nesting sites for birds and small mammals), rapids (including Khon Pi Luang), deep pools, long pools, whirlpools, seasonally inundated mud/pebble flats, sandbars (water level &lt; 5 m in dry season) and emerged sandbars with herbaceous shrub (feeding, nesting and resting sites for waders, ducks and prinias), islands, vertical riverbanks (nesting habitats for birds).</p> <p>Biodiversity: The site is feeding, spawning and refuge habitats for fish and supports the Critically Endangered Mekong Giant Catfish <i>Pangasianodon gigas</i>. Birds: Endangered Swan Goose <i>Anser cygnoides</i>, Near-threatened Black-bellied Tern <i>Sterna acuticauda</i>, River Lapwing <i>Vanellus duvaucelii</i>,</p> <p>Status: Ecosystems / Habitats of Biodiversity Conservation Importance</p>
4	<p>Mekong Channel upstream of Luang Prabang (Lao PDR)</p> <p>Description: Major site of clusters of alternating shallow rapids &amp; deep pools</p> <p>Status:</p>
5	<p>Mekong Channel from Luang Prabang to Vientiane (Lao PDR, Thailand)</p> <p>Description: 4 Minor sites of clusters of alternating shallow rapids &amp; deep pools (including Ban Done Kao, Luang Prabang)</p> <p>Status: Important Bird Area (18,230 ha)</p>
6	<p>Mekong Channel from Vientiane to the Mun River Confluence (Lao PDR, Thailand)</p> <p>Description: 6 Minor sites of clusters of alternating shallow rapids &amp; deep pools; with dry-season riverbanks, beaches, sandbars, islands, rapids</p> <p>Biodiversity: habitats and breeding sites for <i>Glareola lactea</i>, <i>Esacus recurvirostri</i>, <i>Vanellus duvaucelii</i>, <i>Hirundo smithii</i>, <i>Saxicola jerdoni</i>. 5 Globally Endangered fish depend on this site: <i>Dasyatis laosensis</i>, <i>Himantura xhaophraya</i>, <i>Pangasianodon gigas</i>, <i>Probarbus jullieni</i>, <i>Tenualosa thibaudeaui</i>.</p> <p>Status: Important Bird Area (18,890 ha)</p>
7	<p>Bung Khong Long Non-Hunting Area (Thailand)</p> <p>Area: 2,214 ha; Elevation: 160 – 170 m</p> <p>Description: Permanent freshwater lake surrounded by seasonal floodplain. Water from the lake flows down to Songkhram River and eventually to the Mekong River.</p> <p>Biodiversity: supporting high diversity of wetland wildlife, especially migratory birds including a Globally Near-Threatened <i>Aythya nyroca</i>, &gt;75 aquatic plant species, &gt;66 fish species including 9 Mekong endemic fish. &gt;67 bird species. &gt;6 amphibian species. &gt;10 reptile species. Globally Vulnerable Baer's Pochard <i>Aythya baeri</i> depends on this site.</p>

	Status: Ramsar site, Protected Area & Important Bird Area
8	<p>Kut Ting Marshland (Thailand)  Area: 2,200 ha; 180 m. amsl.  Description: An oxbow lake in “H” shape; an extensive water storage of 2 – 5 m depth on the site of a marsh which connects draining north (ca. 5 km) into the Mekong. Dry season water supply source for the locals. Traps natural fertile sediment from the Mekong and provide arable land to the locals annually.  Biodiversity: &gt;59 plant species, &gt;113 fish species including 9 Mekong endemic fish. This wetland supports the world’s 3<sup>rd</sup> smallest freshwater fish <i>Boraras micros</i> (Thai endemic), the Globally Endangered carp <i>Probarbus jullieni</i>, and Globally Vulnerable Baer’s Pochard <i>Aythya baeri</i>.  Status: The site is being considered by Thailand to be nominated as a Ramsar Site.</p>
9	<p>Songkhram River’s lower reaches, seasonally inundated forests, and floodplains (Thailand)  Area: 3,000 km<sup>2</sup>; 145 – 160 m msl.  Description: catchment area 12,700 km<sup>2</sup>; total length of 420 km; along most of its lower reaches, the river meanders over an extensive floodplain at an altitude of 145 – 160 m. msl.; the site comprises many different wetland types e.g. main river channel, pools, riverine sandbars, streams, seasonally inundated forests (26,593 ha), swamps, ponds, depressions, channels, oxbow lakes, seasonally inundated grasslands; Songkhram River enters the Mekong River in Tha Utaen District, Nakhon Phanom; several tributaries join the Songkhram River, forming an extensive lowland floodplain system; in-basin precipitation and reverse flow from the Mekong cause extensive flooding for 2 – 4 months a year, forming one massive shallow lake covering an area of about 96,000 ha (or over 30% of the entire lower Songkhram River basin). River levels vary 10 – 12 m in height difference between the dry and wet season. One of the last remaining extensive areas of freshwater seasonally inundated forests in Thailand.  Biodiversity: &gt;139 food/edible plants; &gt;61 local income-earning plants; &gt;80 medicinal plants; &gt;153 aquatic organisms, including &gt;11 reptiles, &gt;6 turtle species, &gt;4 shrimp species, &gt;12 mollusk species, &gt;4 crab species, &gt;7 amphibians, &gt;8 mammals, &gt;87 birds, &gt;183 fish species (&gt;58 fish species migrating between the Mekong and Songkhram Rivers; &gt;58 are short distance migratory species). At least 6 fish species known to be present are listed in the IUCN <i>Red List of Threatened and Endangered Species</i>. Critically Endangered Mekong Giant Catfish <i>Pangasianodon gigas</i> was formerly caught regularly, but now extremely rare. Other Globally Endangered species include <i>Tenuulosa thibaudeaui</i>, <i>Probarbus jullieni</i>. &gt;8 alien invasive species.  Status: The site is being considered by Thailand to be nominated as a Ramsar Site.</p>
10	<p>Xe Khampho / Xe Pian (Lao PDR)  Area of IBA: 197,280 ha  Description:  Biodiversity: The site supports Globally Endangered White-winged Duck <i>Cairina scutulata</i> and Globally Vulnerable Masked Finfoot <i>Heliopais personata</i>  Status: Important Bird Area &amp; Protected Area</p>
11	<p>Xe Kong Plains (Lao PDR)  Area of IBA: 37,150 ha  Description:  Biodiversity: The site supports Critically Endangered White-shouldered Ibis <i>Pseudibis davisoni</i> and Giant Ibis <i>Thaumatibis gigantean</i> ; Globally Vulnerable Lesser Adjutant <i>Leptoptilos javanicus</i>, Sarus Crane <i>Grus antigone</i>, and Masked Finfoot <i>Heliopais personata</i>  Status: Important Bird Area</p>
12	<p>Mekong Channel from Savannakhet to Khone Falls / Siphandon (Lao PDR)  Description: Minor site of clusters of alternating shallow rapids &amp; deep pools – Ban Khanh Gneir (Champasak), Ban Seine Tay (Khong Island)  Status: Important Bird Area (34,200 ha)</p>
13	<p>Khone Falls – Siphandon (Lao PDR)  Area: 150 km<sup>2</sup> ; Area of IBA: 37,320 ha  Description: Major site of clusters of alternating shallow rapids &amp; deep pools; 7 important deep pools: Boong Pha Gooawng, Boong Pha Jook, Boong Hin Sang, Boong Ken, Boong Pha Leum, deep pools below Tam Ee Daeng and Gawng Nyai, Hin Dta Moon – near the mouth of Hoo Sahong;  in-channel wetlands; bedrock anastomosed channel from Muang Khong – Khone Falls on the Lao-Cambodian border; a zone of wide slow-flowing water dotted with countless islets; the Mekong River drops 20 – 30 m at this site; the river forms a complex network of narrow, braided channels.  Biodiversity: supporting &gt; 201 fish species, including endemic or endangered species <i>Mekongina erythrospila</i> (Pa Sa Ee) and <i>Probarbus jullieni</i>. The area below the falls is the most important fish production ground in Lao PDR, significant fishing activity takes place almost all year round in and around the falls; the area supports one of the few remaining concentrations of freshwater dolphins <i>Orcaella brevirostris</i> in the Mekong; the 3<sup>rd</sup> largest group of Irrawaddy dolphins in the Mekong River; this group of 10 individuals represents 14% of the Mekong population and this group is the only population of Irrawaddy dolphins in Lao PDR. The site also support the Critically Endangered Mekong Giant Catfish <i>Pangasianodon gigas</i>. Birds: Critically endangered Giant Ibis <i>Thaumatibis gigantean</i>, White-shouldered Ibis <i>Pseudibis davisoni</i>, White-rumped vulture <i>Gyps bengalensis</i>. Reptiles: Critically Endangered Siamese Crocodile <i>Crocodylus siamensis</i>; Globally Endangered Asian Giant Soft-shelled Turtle <i>Pelochelys cantorii</i> and Big-headed Turtle <i>Platysternon megacephalum</i>, Globally Vulnerable Asiatic Soft-shelled Turtle <i>Amyda cartilaginea</i>,  Status: Important Bird Area, Fish Conservation Zones of 59 villages</p>

14	<p>Mekong Channel from Lao Border – Kratie (Cambodia)</p> <p>Description: The most important deep pool area in the LMB; Major site and 3 Minor sites of clusters of alternating shallow rapids &amp; deep pools; dry season refuge habitats (58 deep pools identified; name list with length, width, depth is available in Poulsen et al., 2002)</p> <p>Biodiversity: The site supports Critically Endangered White-shouldered Ibis <i>Pseudibis davisoni</i>; Globally Endangered Greater Adjutant; Globally Vulnerable Lesser Adjutant; Woolly-necked Stork; the rare and Endangered Asian Giant Soft-shelled Turtle; and Mekong River Dolphin, Critically Endangered Irrawaddy Dolphin <i>Orcaella brevirostris</i>; Sambor (Kratie Province); extremely important for recruitment for the entire LMB, including floodplains in southern Cambodia and the Vietnam Delta.</p> <p>Status: Important Bird Area (83,501 ha), including 14,600 ha of Middle Stretches of Mekong River North of Stung Treng which is a Ramsar site</p>
15	<p>Middle Stretches of Mekong River North of Stung Treng (Cambodia)</p> <p>Area: 14,600 ha Distance: 37 km; Elevation: 50 m</p> <p>Description: very important site for biodiversity conservation; the stretch of the Mekong mainstream from 6 km north of Stung Treng Town to 3 km south of the Lao border; a distance of 37 km; riparian ecology of the Stung Treng Ramsar Site is very unique and rare, including mainstream Mekong, many sandy/rocky islands, gravel bars, braided channels, seasonally flooded forests, 25 important deep pools within this Ramsar Site along the Mekong in Sambor District, Stung Treng Province; strong turbulent flow with numerous whirlpools, areas of upwelling, and channels between rocky and sandy islands which are completely inundated during the high water (10 m or more) and high alluvial islands remain dry (for half a year). Leaves of forest trees provide fish habitats and food especially for young fish during inundated period. &gt;40 tributary creeks and streams are important fish habitats, spawning, nursery grounds. Biodiversity: unique wetland type and habitats for flora and fauna at critical stage of their biological cycle, including Critically Endangered Mekong River Dolphin or Irrawaddy Dolphin <i>Orcaella brevirostris</i>. &gt;167 fish species. &gt;231 bird species (17 globally threatened). &gt;26 mammal species. &gt;43 reptile species. &gt;18 turtle species. All 4 flagship species are found at this Ramsar Site.</p> <p>Status: Ramsar site, Important Bird Area &amp; Protected Area</p>
16	<p>Sekong River (Cambodia)</p> <p>Area of IBA: 14,116 ha</p> <p>Description:</p> <p>Biodiversity: The site supports Critically Endangered Giant Ibis <i>Thaumatibis gigantea</i></p> <p>Status: GMS Hotspot, Important Bird Area</p>
17	<p>Sesan River (Cambodia)</p> <p>Area of IBA: 20,504 ha</p> <p>Description: the most important tributary of the lower Mekong River basin, supplying 20.5% of annual flow</p> <p>Biodiversity: &gt;149 fish species; large fish species, including rare and endangered species, migrate from the lower mainstream Mekong up into the Se San to spawn; the only river in the GMS outside Myanmar that still supports an extensive variety of riverine sandbank dependent birds; the site supports Globally Vulnerable Lesser Adjutant <i>Leptoptilos javanicus</i></p> <p>Status: GMS Hotspot, Important Bird Area</p>
18	<p>Boeng Chhmar and Associated River System and Floodplain (Cambodia)</p> <p>Area of Ramsar Site: 28,000 ha ; Area of IBA (Boeung Chhmar / Moat Khla): 39,405 ha;</p> <p>Elevation: 10 m</p> <p>Description: Permanent freshwater lake, surrounded by creek systems and inundated forest in the northeast fringe of Tonle Sap Lake; part of Tonle Sap floodplain</p> <p>Biodiversity: supports high diversity of flora and fauna. The site supports Globally Endangered Greater Adjutant <i>Leptoptilos dubius</i> ; Globally Vulnerable Spot-billed Pelican <i>Pelecanus philippensis</i>, Lesser Adjutant <i>Leptoptilos javanicus</i>, Masked Finfoot <i>Heliopais personata</i></p> <p>Status: Ramsar site, Important Bird Area &amp; Protected Area</p>
19	<p>Tonle Sap Lake, Tonle Sap River, Prek Toal, and adjacent floodplain (Cambodia)</p> <p>GMS Hotspot area: 13,593 km<sup>2</sup> (239 km<sup>2</sup> forest; 12,649 km<sup>2</sup> wetlands; 5,418 km<sup>2</sup> Protected Area); Area of Prek Toal Biosphere Reserve: 39,873 ha ; Protected Area = 316,250 ha ; IBAs = 2,357 ha (Chhnuk Tru), 53,543 ha (Stung / Chi Kreng / Kampong Svay), 5,873 ha (Veal Srongae)</p> <p>Description: Tonle Sap Lake is the largest freshwater lake in Southeast Asia. Dry season area = 2,500 km<sup>2</sup>; Depth = 0.2 – 1.5 m. Wet season area = 15,800 km<sup>2</sup>; Depth = 10 – 14 m. The site covers permanent water, seasonally inundated forests (201.6 km<sup>2</sup>: 1.7% of the total floodplain), seasonally inundated grasslands, receding &amp; floating ricefields, seasonally flooded crop fields, swamps. Different water level between the lake and the Mekong mainstream; during wet season, water flows from the Mekong mainstream up to Tonle Sap; during dry season, water flows from Tonle Sap back into the mainstream. Natural floodplain vegetation provides a wide variety of timber and non-timber forest products.</p> <p>Biodiversity: Tonle Sap ecosystems are exceptionally important for global biodiversity at genetic, species, habitats, and ecosystem processes levels. &gt;885 species of floodplain plants and animals. &gt;170 plant species on the shores around Tonle Sap Lake. Dominant species within floodplain include <i>Barringtonia acutangula</i>, <i>Diospyros cambodiana</i>, <i>Terminalia cambodiana</i>, <i>Gmelina asiatica</i>, <i>Ficus heterophylla</i>, <i>Vitex holoadenon</i>. &gt;228 fish species. &gt;29 mollusks. &gt;5 crustaceans. &gt;8 oligochaete worms. &gt;15 insects.</p> <p>The site supports Critically Endangered Mekong Giant Catfish <i>Pangasianodon gigas</i> and Irrawaddy Dolphin <i>Orcaella brevirostris</i>. &gt;104 waterbird species. Tonle Sap Lake's inundated forest is one of the most</p>

	<p>important breeding sites for large waterbirds in Asia. Species breeding in the forest include the Globally Endangered Greater Adjutant <i>Leptoptilos dubius</i> and White-winged Duck <i>Cairina scutulata</i>; Globally Vulnerable Spot-billed Pelican <i>Pelecanus philippensis</i>; Milky Stork <i>Mycteria cinerea</i>, Lesser Adjutant <i>Leptoptilos javanicus</i>, and Globally Near-threatened Oriental Darter <i>Anhinga melanogaster</i>, Painted Stork <i>Mycteria leucocephala</i>. The site supports Critically Endangered White-shouldered Ibis <i>Pseudibis davisoni</i>; Globally Endangered Bengal Florican <i>Houbaropsis bengalensis</i> (in the seasonally flooded grassland); Globally Vulnerable Greater Spotted Eagle <i>Aquila heliaca</i>, Sarus Crane <i>Grus antigone</i>, Manchurian Reed-warbler <i>Acrocephalus tangorum</i>, Masked Finfoot <i>Heliopais personata</i>; Critically Endangered Siamese Crocodile <i>Crocodylus siamensis</i>; Hairy-nosed Otter. &gt;215 species of fish in Tonle Sap. &gt;5 commercial species of water snakes (caught &amp; trade), endemic Tonle Sap watersnake <i>Enhydryis longicauda</i>; around the lake, commercial rearing of captive crocodiles is practiced</p> <p>Status: Protected Area (including Chhnuk Tru), UNESCO BIOSPHERE RESERVE, GMS HOTSPOT, Important Bird Areas (including Preah Net Preah, Kra Lanh, Pourk, Dei Roneat, Chhnuk Tru, Stung / Chi Kreng / Kampong Svay, Veal Strongae)</p>
20	<p>Ang Tropeang Thmor Sarus Crane Reserve (Cambodia) Area of IBA: 12,659 ha Description: Inland wetland, northwest of Tonle Sap Lake Biodiversity: The site supports Critically Endangered White-shouldered Ibis <i>Pseudibis davisoni</i>; Globally Endangered Greater Adjutant <i>Leptoptilos dubius</i>, Bengal Florican <i>Houbaropsis bengalensis</i>; Globally Vulnerable Spot-billed Pelican <i>Pelecanus philippensis</i>, Milky Stork <i>Mycteria cinerea</i>, Lesser Adjutant <i>Leptoptilos javanicus</i>, Greater Spotted Eagle <i>Aquila heliaca</i>, Imperial Eagle <i>Aquila heliaca</i>, Sarus Crane <i>Grus antigone</i> Status: Important Bird Area &amp; Protected Area</p>
21	<p>Stung / Prasat Balang (Cambodia) Area of IBA: 100,675 ha Description: Biodiversity: The site supports Globally Endangered Bengal Florican <i>Houbaropsis bengalensis</i>; Globally Vulnerable Lesser Adjutant <i>Leptoptilos javanicus</i> Status: Important Bird Area</p>
22	<p>Stung Sen / Lower Stung Sen / Santuk / Northern Santuk / Baray (Cambodia) Area of IBA: 12,390 ha (Lower Stung Sen), 109,081 ha (Stung Sen / Santuk / Baray), and 24,312 ha (Northern Santuk) Description: Biodiversity: The site supports Critically Endangered White-shouldered Ibis <i>Pseudibis davisoni</i>; Globally Endangered Greater Adjutant <i>Leptoptilos dubius</i>, Bengal Florican <i>Houbaropsis bengalensis</i>; Globally Vulnerable Spot-billed Pelican <i>Pelecanus philippensis</i>, Milky Stork <i>Mycteria cinerea</i>, Lesser Adjutant <i>Leptoptilos javanicus</i>, Greater Spotted Eagle <i>Aquila heliaca</i>, Sarus Crane <i>Grus antigone</i>, Manchurian Reed-warbler <i>Acrocephalus tangorum</i> Status: Important Bird Area &amp; Protected Area</p>
23	<p>Basset Marsh (Cambodia) Area of IBA: 2,770 ha Description: Biodiversity: The site supports Globally Vulnerable Spot-billed Pelican <i>Pelecanus philippensis</i> Status: Important Bird Area</p>
24	<p>Boeung Veal Samnap (Cambodia) Area of IBA: 11,286 ha Description: The site supports Globally Vulnerable Spot-billed Pelican <i>Pelecanus philippensis</i> Status: Important Bird Area</p>
25	<p>Bassac Marsh (Cambodia) Area of IBA: 52,316 ha Description: Biodiversity: The site supports Globally Vulnerable Spot-billed Pelican <i>Pelecanus philippensis</i> Status: Important Bird Area</p>
26	<p>Boeung Prek Lapouv (Cambodia) Area of IBA: 9,276 ha Description: Biodiversity: The site supports Globally Endangered Bengal Florican <i>Houbaropsis bengalensis</i>; Globally Vulnerable Spot-billed Pelican <i>Pelecanus philippensis</i>, Sarus Crane <i>Grus antigone</i> Status: Important Bird Area</p>
27	<p>Tram Chim National Park (Vietnam) Area of IBA: 7,588 ha Description: the last remnants of wetland ecosystem of the Plain of Reeds, including seasonally inundated grassland and <i>Melaleuca</i> forest. A freshwater wetland with regulated water levels (peak flood – late October) and a high abundance of fish, amphibian, reptile and waterbird species. Biodiversity: The site supports Globally Endangered Bengal Florican <i>Houbaropsis bengalensis</i>; Globally Vulnerable Lesser Adjutant <i>Leptoptilos javanicus</i>, Sarus Crane <i>Grus antigone</i>.</p>



	Status: Important Bird Area & Protected Area
28	Lang Sen Wetland Reserve (Vietnam) Area: 3,280 ha Description: 23 km northeast of Tram Chim; the only area in the former Plain of Reeds where remnant natural <i>Melaleuca</i> forest occurs on a river channel and has an important biodiversity value. Biodiversity: Birds: > 61 species. The site supports Globally Vulnerable Sarus Crane <i>Grus antigone</i> . Status: Important Bird Area
29	Ha Tien Plain and Phu My Grassland (Vietnam) Area of IBA at Ha Tien: 6,981 ha Description: mixture of grassland (e.g. <i>Eleocharis dulcis</i> , <i>Lepironia articulata</i> ) and naturally regenerating <i>Melaleuca</i> scrub on acid sulphate soil and old alluvial sediments. Timing of peak flood (early October) is an important parameter. <i>Lepironia articulata</i> at Phu My requires 3-4 month flood, 2-3 m deep. In the Mekong Delta, <i>Eleocharis dulcis</i> and wild rice <i>Oryza rufipogon</i> require 5 month flood, 3-4 m deep. <i>Ischaemum rugosum</i> requires at least 3 month flood, 2 m deep. Biodiversity: The site supports Globally Endangered Bengal Florican <i>Houbaropsis bengalensis</i> . At Phu My, Sarus Crane <i>Grus antigone</i> numbers in 2007 have peaked at 94 individuals. Status: Important Bird Area
30	Kien Luong (Vietnam) Area: 7,624 ha Description: Biodiversity: The site supports Critically Endangered White-shouldered Ibis <i>Pseudibis davisoni</i> ; Globally Vulnerable Spot-billed Pelican <i>Pelecanus philippensis</i> , Sarus Crane <i>Grus antigone</i> (the site has been lost to development and was used intermittently by up to 40 cranes in 2004 – 2005). Status: Important Bird Area
31	Tra Su (Vietnam) Description: <i>Melaleuca</i> forests plantation + inundated grassland. Biodiversity: Birds: Painted Stork, Oriental Darter, Asian Golden Weaver,
32	Tinh Doi (Vietnam) Area: 10,000 ha Description: <i>Melaleuca</i> forests plantation + inundated grassland Biodiversity: The site supports Globally Endangered Spotted Greenshank <i>Tringa guttifer</i> , Globally Vulnerable Chinese Egret <i>Egretta eulophotes</i> , Lesser Adjutant <i>Leptoptilos javanicus</i> Status: Important Bird Area

### 4.3 Assessment of impacts on the environmental Hotspots

Impacts of the Basin Development scenarios on the environmental Hotspots have been made by expert judgment, taking into account detailed information available on changes in flooding patterns (extent, depth, duration) to be expected as resulting from the Definite Future and 20 Year Plan scenario. Impacts categories and criteria applied are as follows:

- High (Major): the area has a global/regional conservation management status; substantial changes (both short term and long term) expected in the integrity of the ecosystems present within the site, that are beyond the ecosystem's ability to recover, and/or substantial changes expected in the existence, abundance and distribution of the entire population or species beyond the ability of species to recover;
- Medium (Moderate): the area has a national conservation management status; expected changes are likely to be significant in the short to medium term and to affect the integrity to some, not all, of the ecosystems present within the site, and/or expected changes are likely to be significant in the short to medium term to some, not all the populations or species; and
- Low (Minor): areas being under local conservation management status; some minor changes expected of the integrity of the ecosystems present within the site and/or limited impacts on the species depending on the site.

Table 19 summarizes the outcome of the assessment. For a number of the more important sites, information on the expected changes is given in the flowing paragraphs.

**Table 19: Summary of expected impacts on environmental hotspots**

No	Name of 'Hotspots'	Status	Species at risk	Impacts/Type of change	DF	20Y
1	Nong Bong Kai Non-Hunting Area	PA, RS, IBA	Bird: 5 (VU)	Indirect, cumulative, long term	L	L

2	Golden Quadrangle China / Myanmar / Thailand/Lao PDR	GMS Hotspot, PA	Fish: 1 (CR)	Direct, long term, permanent, immediate	M	H
3	Mekong Channel from Chiang Saen to Chiang Khong		Fish: 1 (CR); Bird: 1 (EN), 1 (NT)	Direct, long term, permanent, immediate	M	H
4	Mekong Channel upstream of Luang Prabang			Direct, long term, permanent, immediate	M	H
5	Mekong Channel from Luang Prabang to Vientiane	IBA	Fish: 1 (CR), 4 (EN)	Direct, long term, permanent, immediate	M	H
6	Mekong Channel from Vientiane to the Mun River Confluence	IBA	Fish: 1 (CR), 5 (EN)	Direct, long term, permanent, immediate	M	H
7	Bung Khong Long Non-Hunting Area	PA, RS, IBA	Bird: 1 (VU), 1 NT; Fish: 9 (endemic)	Indirect, cumulative, long term	L	L
8	Kut Ting Marshland	RS to be	Bird: 1 (VU); Fish: 1 (VU), 1 (EN), 9 (endemic)	Direct, immediate, long term	M	M
9	Songkhram River floodplains	RS to be	Fish: 1 (CR), 5 (EN)	Direct, immediate, long term	M	M
10	Xe Khampho / Xe Piane Lao PDR	PA, IBA	Bird: 1 (EN), 1 (VU)	Indirect, long term, cumulative	L	L
11	Xe Kong Plains	IBA	Bird: 2 (CR), 3 (VU)	Indirect, long term, cumulative	L	L
12	Mekong Channel from Savannakhet to Khone Falls/Siphandon	IBA		Direct, permanent, both short & long term, cumulative	L	M
13	Khone Falls – Siphandon	IBA	Fish: 1 (CR), 2 (EN); Mammal: 1 (CR); Bird: 3 (EN); Reptile: 1 (CR), 2 (EN), 1 (VU)	Direct, permanent, both short & long term, immediate & cumulative, Negative, irreversible	L	H
14	Mekong Channel from Lao Border to Kratie	IBA	Bird: 1 (CR), 1 (EN), 2 (VU); Fish: 1 (CR); Mammal: 1 (CR); Reptile: 1 (EN)	Direct, permanent, both short & long term, immediate & cumulative, Negative, irreversible	L	H
15	Middle Stretches of Mekong River North of Stung Treng	RS, IBA, PA	Fish: 1 (CR); Mammal: 1 (CR); Reptile: 1 (CR); Bird: 1 (VU)	Direct, permanent, both short & long term, immediate & cumulative, Negative, irreversible	L	H
16	Sekong River	IBA	Bird: 1 (CR)	Direct, permanent, both short & long term, immediate & cumulative, Negative, irreversible	M	H
17	Sesan River	IBA	Bird: 1 (VU)	Direct, permanent, both short & long term, immediate & cumulative, Negative, irreversible	H	H
18	Boeng Chhmar and Associated River System and Floodplain	RS, PA, IBA	Bird: 1 (EN), 3 (VU)	Direct, permanent, long term, immediate & cumulative, negative	L	H
19	Tonle Sap Lake, Tonle Sap River, Prek Toal, and adjacent floodplain (including Chhnuk Tru, Stung / Chi Kreng / Kampong Svay, Veal Srongae)	PA, GMS Hotspot, Biosphere Reserve, IBA	Fish: 1 (CR); Bird: 1 (CR), 3 (EN), 7 (VU), 2 (NT); Reptile: 1 (CR); Mammal: 1 (CR), 1 (EN)	Direct, permanent, long term, immediate & cumulative, negative	M	H
20	Ang Tropeang Thmor Sarus Crane Reserve	PA, IBA	Bird: 1 (CR), 2 (EN), 6 (VU)	Indirect, long term, cumulative	L	L
21	Stung / Prasat Balang	IBA	Bird: 1 (EN), 1 (VU)	Direct, long term, cumulative	L	M
22	Stung Sen / Lower Stung Sen / Santuk / Baray	PA, IBA	Bird: 1 (CR), 2 (EN), 6 (VU)	Direct, long term, cumulative	L	M
23	Basset Marsh Cambodia	IBA	Bird: 1 (VU)	Direct, long term, cumulative	L	M
24	Boeung Veal Samnap	IBA	Bird: 1 (VU)	Direct, long term, cumulative	L	M
25	Bassac Marsh	IBA	Bird: 1 (VU)	Direct, long term, cumulative	L	M
26	Boeung Prek Lapouv	IBA	Bird: 1 (EN), 2 (VU)	Direct, long term, cumulative	L	M
27	Tram Chim National Park	PA, IBA	Bird: 1 (EN), 2 (VU)	Indirect, long term, cumulative	L	L
28	Lang Sen	IBA	Bird: 1 (VU)	Indirect, long term, cumulative	L	L
29	Ha Tien Plain and Phu My Grassland	IBA	Bird: 1 (EN), 1 (VU)	Indirect, long term, cumulative	L	L
30	Kien Luong	IBA	Bird: 1 (CR), 2 (VU)	Indirect, long term, cumulative	L	L
31	Tra Su			Indirect, long term, cumulative	L	L
32	Tinh Doi	IBA	Bird: 1 (EN), 2 (VU)	Indirect, long term, cumulative	L	L

Table 20 gives an overview. The table shows that under the Definite Future scenario 22 out of 32 hotspots will only have minor impacts, whereas 9 hotspots are affected moderately and 1 will experience major impacts. Under the 20 Year Plan scenario the number of minor impacted hotspots reduces to 11,

the number of moderately impacted hotspots is nine and the number of major impacted hotspots increases from 1 to 12, i.e. more than one third of the identified Environmental Hotspots will experience major negative impacts of the 20 Year Plan scenario.

**Table 20: Summary of the Hotspot impact assessment**

	No of impacted Hotspots		
	Low	Medium	high
Definite Future scenario	22	9	1
20 Year Plan scenario	11	9	12

#### 4.4 Background information on the assessment of impacts on a number of the more important environmental hotspots

##### 4.4.1 *Hotspot No. 9, Songkhram River's lower reaches, seasonally inundated forests, and floodplains (Thailand)*

- In-basin precipitation and reverse flow from the Mekong cause extensive flooding for 2 – 4 months a year, forming one massive shallow lake covering an area of about 96,000 ha (or over 30% of the entire lower Songkhram River basin). River levels vary 10 – 12 m in height difference between the dry and wet season. Change in flooding patterns, depth and duration will affect the wetland ecosystems especially seasonally inundated forests of the Songkhram River's lower reaches (one of the last remaining extensive areas of freshwater seasonally inundated forests in Thailand – 26,593 ha). A state of flux between flood accession and recession (river levels vary 10 – 12 m in height difference between dry and wet season) → significant area of seasonal wetland habitats which are very important fish spawning, breeding grounds.
- Biodiversity at risk: >139 food/edible plants; >61 local income-earning plants; >80 medicinal plants; >153 aquatic organisms, including >11 reptiles, >6 turtle species, >4 shrimp species, >12 mollusk species, >4 crab species, >7 amphibians, >8 mammals, >87 birds, >183 fish species (>58 fish species migrating between the Mekong and Songkhram Rivers; >58 are short distance migratory species). At least 6 fish species known to be present are listed in the IUCN Red List of Threatened and Endangered Species.

##### 4.4.2 *Hotspot No. 13, Khone Falls – Siphandon (Lao PDR)*

The location of the proposed Don Sahong Dam is < 2 km north of the international border between Lao PDR and Cambodia. At the site the channel is 100 m wide and 5 km long; the dam may extend above the natural height of channel banks (10+ m). The potential impacts of the dam relate to:

- Alteration and deterioration of the ecologically unique area that is essentially a microcosm of the entire lower Mekong River. So rare in nature. This fascinating 50 km long stretch consists of a maze of extensively braided channels, islands and sandbars, rocky rapids and seasonally flooded habitats, including the largest complex of waterfalls in Asia.
- Short-term/immediate disturbance, damage during dam construction, and the consequences may disrupt social, breeding, foraging behavior of dolphins, increased stress may result in greater susceptibility to disease.
- Dividing dolphin populations into smaller groups, which are genetically-isolated and more vulnerable to extinction; altered conditions in the transboundary Dolphin Pool, a primary dolphin habitat downstream from the dam site.
- Loss of microhabitats in the river which are critical for dolphins and their prey fish survival; reduced abundance and diversity of fish resources – prey species for dolphins; decline in the dry-season distribution of dolphins in the Mekong River, from 190 km to 126 km (34%).
- It is possible that dolphins may leave the Dolphin Pool if conditions become unsuitable, and travel to pools further south (the nearest dolphin group is 64 km downstream in Cambodia). It is unknown what impact this would have on the group undertaking movement, or to resident dolphins. Capture and relocation may be conducted, but this is a high risk and expensive

activity, causing stress to dolphins during capture and transport, with unknown impacts for residents at the arrival location. In both cases, the loss of this dolphin group would result in the extinction of the Irrawaddy dolphin in Lao PDR, and loss of dolphin-based tourism revenues for local communities.

- Decreased Dolphin-based ecotourism value of the site: Dolphin-based tourism is the fastest growing source of external revenue for local communities at the Dolphin Pool. Together with the Khone Falls, dolphins are a principle reason, many tourists visit the Siphandon region in southern Lao PDR. In 2005, at least 9,000 people visited the Dolphin Pool, and over 52,539 tourists visited the Siphandon region (250 – 300 tourists/day in peak season), including 31,891 international tourists and 21,648 domestic tourists. Average duration of visits by international tourists to the Siphandon region was 4.16 days with an average expenditure of 19.63 USD/day, and for the domestic market, 6.71 days with average expenditure 39.12 USD/day. Based on these figures, in 2005 the Siphandon region including the Dolphin Pool, received over 8.2 million USD tourism revenues. It is predicted that by 2015, up to 105,000 tourists/year will visit the Siphandon region.
- Water retention will occur in the Hoo Sahong channel up to a couple of kms upstream of the dam, inundating parts of adjacent islands → change/damage on distinctly different plant communities on sandy, rocky or silty substrata, with that on the rocky islets being endemic to the area.
- Blockage of fish migration. Alteration of flow patterns in the immediate downstream area, especially during the driest periods and could disrupt fish migration. As a key site for all Mekong fish resources, Don Sahong Dam would block the only deep channel that allows fish to migrate through the falls year round. This Dam will block dry season fish movements between the Lower Mekong floodplains, Tonle Sap Lake, and the Mekong basin upstream. The dry season is a critical period for fish migration upstream. Many fish species are also sensitive to changes in water level as ‘triggers’ to migration.
- Don Sahong Dam would threaten the last and only Irrawaddy Dolphin population in Lao PDR, cause direct impacts on critical dolphin habitats and prey fish supplies for the 3rd largest dolphin group in the Mekong River. The cumulative impacts of the dam, when added to existing threats which have already resulted in the near-extinction of this group, would be a big ‘disaster’, difficult to avoid.
- Severe impacts on fisheries for Lao PDR, Cambodia, and the whole region.
- Biodiversity : at least 3 important fish species (including the Critically Endangered Mekong Giant Catfish *Pangasianodon gigas*, the endemic *Mekongina erythrospila* and *Probarbus jullieni*); at least 3 Critically Endangered birds (Giant Ibis *Thaumatibis gigantean*, White-shouldered Ibis *Pseudibis davisoni*, and White-rumped vulture *Gyps bengalensis*); at least 4 important reptile species (Critically Endangered Siamese Crocodile *Crocodylus siamensis*, Globally Endangered Asian Giant Soft-shelled Turtle *Pelochelys cantorii* and Big-headed Turtle *Platysternon megacephalum*, and Globally Vulnerable Asiatic Soft-shelled Turtle *Amyda cartilaginea*) will be directly/immediately impacted.

#### 4.4.3 **Hotspot No. 15: Middle Stretches of Mekong River North of Stung Treng (Cambodia)**

Construction of the Stung Treng Dam may have the following impacts:

- Direct/immediate impacts on Ramsar Site. Changed/decreased ability of Cambodia to meet international obligations with regard to conservation of biodiversity.
- Impoundment → directly and completely inundate low lying habitats being used by wading waterbirds and supporting vegetation that becomes habitats and food sources when flooded in the following wet season, especially all 25 important deep pools within this Ramsar Site. Stung Treng Dam would threaten the Irrawaddy Dolphin population, cause direct impacts on critical dolphin habitats and prey fish supplies. The cumulative impacts of the dam, when added to existing threats which have already resulted in the near-extinction of the Mekong Irrawaddy Dolphin, would be a big ‘disaster’, difficult to avoid.
- Higher velocities and stream power can change sedimentation patterns and prevent benthic spawning fish from breeding.

- Blockage of fish migration. This Dam will block dry season fish movements between the Lower Mekong floodplains, Tonle Sap Lake, and the Mekong basin upstream. Severe fisheries impacts for Lao PDR, Cambodia, and the whole region.
- Biodiversity: All 4 flagship species found at this Ramsar Site will be at high risk. Other species including >167 fish species, >231 bird species (17 globally threatened), >26 mammal species, >43 reptile species, >18 turtle species, will be impacted.
- Disastrous loss of a Ramsar Site - very typically unique wetland ecosystems and very important site for biodiversity conservation of the Mekong and Asian Region.

#### 4.4.4 **Hotspot No. 17: Se San River (Cambodia)**

Dam construction on the Se San River will have major negative impacts, both locally and transboundary.

- Blockage of fish migration routes → reproductive failure. Dams will block dry season fish movements between the Lower Mekong floodplains, Tonle Sap Lake, and the upstream of Se San River.
- Deterioration of water quality downstream of planned dams due to deoxygenation and hydrogen sulfide laden water discharges → interference of migratory behavior and mass mortality.
- Biodiversity: Loss of the only river in the GMS outside Myanmar that still supports an extensive variety of riverine sandbank dependent birds. At least 1 important species of large birds Globally Vulnerable Lesser Adjutant *Leptoptilos javanicus* will be impacted. Large fish species, including rare and endangered species which migrate from the lower mainstream Mekong up into the Se San to spawn, will be directly impacted.

#### 4.4.5 **Hotspot No. 18: Boeng Chhmar and Associated River System and Floodplain (Cambodia)**

- Direct/immediate impacts on Ramsar Site. Changed/decreased ability of Cambodia to meet international obligations with regard to conservation of biodiversity.
- Boeng Chhmar Ramsar Site will be affected by both dry and wet season lake level changes. Duration, depth, and extent of flooding are critical to fish productivity and to the maintenance of wetland vegetation patterns.
- All scenarios lead to a reduction in wet season peak annual lake levels, averaging – 0.36 m for the worst scenario, but generally about – 0.20 m for other scenarios. Reduction in flood areas will occur.
- Changes in flood durations → shorter flood conditions, wetter on the lake side and drier on the landward side → a gradual shift in wetland vegetation structure from wetter types to those more typical of the drier conditions.
- Boeng Chhmar (benefiting from sediment flows to Tonle Sap Lake, from Tonle Sap River annual flow reversal) would be negatively impacted by any reduction in the reverse flow volume and suspended sediment.
- Biodiversity: at least 4 globally threatened bird species, including Globally Endangered Greater Adjutant *Leptoptilos dubius*; Globally Vulnerable Spot-billed Pelican *Pelecanus philippensis*, Lesser Adjutant *Leptoptilos javanicus*, Masked Finfoot *Heliopais personata* will be at risk.

## 5 Flagship species

### 5.1 Introduction

The Mekong Wetlands Biodiversity Conservation and Sustainable Use Programme selected four globally threatened species as so-called Flagship species, they are the Irrawaddy Dolphin, the Sarus Crane, the Siamese Crocodile, and the Mekong Giant Catfish. They are considered representative for the unique ecosystems and habitats of the Mekong River Basin.

These four species have been selected as Flagship species because they meet one or more of the following criteria:

- They inhabit a broad diversity of important wetlands and therefore are representative of threatened wetland habitats and their associated fauna;
- They are regional in distribution and trans-boundary in nature; and
- They provide an opportunity for enhancing regional collaboration for conservation and management of biodiversity and ecosystems.

### 5.2 Description of the Flagship species and major environmental threats under the development scenarios

#### 5.2.1 *Mekong River Dolphin, Irrawaddy Dolphin Orcaella brevirostris, IUCN Red List: Critically Endangered*

Key drivers:

- Vulnerability of species
  - The Mekong Dolphin population is already listed as Critically Endangered and has an alarming mortality rate. During 2003 – 2006, the average number of mortalities per year = 16.
  - Population estimate is 125 – 180 individuals (April, 2005). The entire dolphin population is restricted to the southern Laotian and upper Cambodian Mekong River, inhabiting 9 deep water areas (preferably >8 m) in the 190 km river segment between Khone Falls to Kratie.
- Habitat fragmentation / barrier effects → disconnectivity / genetic isolation
  - The proposed Don Sahong dam is situated < 2 km north of the transboundary ‘Dolphin Pool’ in southern Laos. This dam will divide dolphin populations into smaller groups, genetically isolated and more vulnerable to extinction. Although all permanent population occur below this dam site; but in the wet season, dolphins may visit Hoo Sahong channel and areas above channel for feeding.
  - Sambor dam (given its proposed position and size) is situated within the dolphin habitat range.
  - Both dams, if constructed, would have immediate / detrimental impact and disastrous consequences on the Mekong River dolphin population.
  - Dams will also block fish migration routes and degrade habitats for fish breeding and shelter, and will affect fish productivity of the Mekong Region.
- Degree of habitat loss / change / disturbance → loss / reduction of habitats, food sources, and availability
  - ‘Dolphin Pool’ - a section (ca. 6 km long x 1 km wide or ca. 600 ha, and over 40 m deep) of the Mekong mainstream located at the Laos/Cambodia border, is the most northerly deep pool in the Mekong River used by dolphins in the dry season. It supports the only permanent dolphin population in Lao PDR, the 3<sup>rd</sup> largest dolphin group in the Mekong River (10 dolphins). 2 pools in Cambodia support groups of 20 and 16 dolphins respectively.

- Short-term immediate disturbance during Don Sahong Dam construction can disrupt dolphin social breeding, foraging behavior, increase stress, and may result in greater susceptibility to disease and immediate extinction.
- Nearest deep pool to Don Sahong Dam site is 64 km south, in Cambodia. If critical habitats in the 'Dolphin Pool' are disturbed/changed or become unsuitable, the total dry-season dolphin range in the Mekong River would decline from 190 km to 126 km (a range decline of 34%).
- Loss of microhabitats in the river is critical for dolphin survival. Changes in river flow dynamics and sedimentation patterns can alter habitats for both dolphins and their prey fish species, and so reduce abundance and diversity of prey fish species.
- Cumulative impacts
  - Dams can change habitat quality and availability through increased siltation, reduced and disrupted water flows, and block dolphin movements.
  - Adding to existing threats, very limited existing number of population, and Critically Endangered status, the Mekong River Dolphin will already extinct during the very first stage of 20Y scenario.

### 5.2.2

#### ***Mekong Giant Catfish *Pangasianodon gigas*, IUCN Red List: Critically Endangered***

##### Key drivers:

- Vulnerability of species
  - The Mekong Giant Catfish is one of the most vulnerable endemic species in the Mekong River Basin, already listed as Critically Endangered and has an alarming declining rate (90% decrease in number in the past 2 decades). Captive breeding and re-introduction to the rivers and reservoirs has not resulted in any established populations.
  - Present distribution is limited to the Mekong and its tributaries in Cambodia, Lao PDR Thailand and Vietnam. Current spawner abundance is estimated between 155 – 185 individuals.
- Habitat fragmentation / barrier effects → disconnectivity / genetic isolation
  - Dams can block migration routes and isolate the Mekong Giant Catfish populations. Without ability to move up and down rivers, the fish have fewer opportunities to breed and less chance to interact with other individuals, which cuts down overall numbers and overall genetic diversity.
- Degree of habitat loss / change / disturbance → loss / reduction of habitats, food sources, and availability
  - The Mekong Giant Catfish lives on algae and other tiny plants growing on the riverbed and stones. Any change/disturbance/modification of mainstream channel ecosystems (flows, physical habitats) will affect its feeding and spawning grounds, and the long-term survival of this species in the wild. Change in flow can disrupt the migratory patterns of fish because they are adapted to seasonality.
  - North of Chiang Khong / Huaysai is the only area that can be clearly identified and demarcated as essential habitat.
  - Depth of the river, richness of food in association with the deep pools is a key to the survival. Deep pools with over 60 m in depth are important dry-season habitats. Between Stung Treng and Kratie in the Mekong mainstream, 58 deep pools have been identified, but up to 97 deep pools may exist. The deepest is 80 m. These deep pools serve as dry season refuges. Short-term immediate disturbance during the proposed Stung Treng and Sambor Dams construction can lead to extinction of the wild population.
- Cumulative impacts
  - Dams can change habitat quality and availability and block the Mekong Giant Catfish movements.
  - Adding to existing threats, very limited existing number of population, and Critically Endangered status, the Mekong Giant Catfish will already extinct during the very first stage of 20Y scenario.

### 5.2.3

#### *Siamese Crocodile Crocodylus siamensis, IUCN Red List: Critically Endangered*

Key drivers:

- Vulnerability of species
  - Freshwater crocodile, thought to be extinct in the wild, until found a nest in the southern Laos, Savannakhet, in 2005. Around only 200 Siamese Crocodiles exist in the wild, confined to the south of Lao PDR, Cambodia and Vietnam. Being farmed extensively in Cambodia and Thailand.
- Degree of habitat loss / change / disturbance
  - In the wild, it inhabits a wide range of habitats, including non-flowing and slow flowing streams/ rivers with sandy, rock or mud substrate or riverbanks, oxbow lakes, swamps, ponds and lakes in riverine forests, seasonally flooded grasslands, thickly vegetated swamps, and reservoirs. Feeds on fish, snakes.
  - The Mekong River Basin and wetlands in Cambodia probably have the only remaining large wild populations left in the world. These natural habitats are already being seriously fragmented and depleted.

### 5.2.4

#### *Eastern Sarus Crane Grus antigone sharpii, IUCN Red List: Vulnerable*

Key drivers:

- Vulnerability of species
  - Tallest flying bird in the world. Often make short seasonal movements between dry and wet season habitats.
  - Formerly occurred throughout Indochina. Over the last 50 years, has been decimated throughout this range. Its range has declined dramatically, but still occurs in smaller numbers, ca. 500 – 1,000 birds (or < 1,000 birds) in 3 countries: Lao PDR, Cambodia, and Vietnam.
  - Recorded populations from annual population surveys: at Phu My grassland / Ha Tien Plain – 94 cranes in 2007; Kien Luong – 40 cranes in 2004-05.
- Degree of habitat loss / change / disturbance
  - Use a wild variety of landscape, depending on food availability, cropping patterns and other seasonal factors. Optimal habitats include a combination of small seasonal marshes in open forests and grasslands, floodplains, high altitude wetlands, human-altered ponds, fallow and cultivated lands, and rice paddies.
  - Foraging on underground tubers of native wetland vegetation, grass and sedges e.g. *Eleocharis spp.* Use open forests where wetlands occur as well as open grasslands; where possible, the nests are located in shallow water where short emergent vegetation is dominant. Existence of such habitats is thus vital to Eastern Sarus Cranes. Any change in wetland areas i.e. grasslands, swamps, floodplains, and water depth will affect its population.

## 5.3 Risk of extinction of wild population of flagship species in the LMB

Given above considerations, the risk of extinction of both the Irrawaddy Dolphin and the Mekong Giant Catfish it thought to be extremely high under the 20 Year Plan scenario.

**Table 21: Expected conservation status of the Flagship species under the Definite Future and 20 Year Plan scenario**

Flagship species	Baseline	Definite Future	20-year Plan
Mekong River Dolphin, Irrawaddy Dolphin <i>Orcaella brevirostris</i> (CR)	High	High	Extinct
Mekong Giant Catfish <i>Pangasianodon gigas</i> (CR)	High	High	Extinct
Siamese Crocodile <i>Crocodylus siamensis</i> (CR)	Moderate	Moderate	Moderate
Eastern Sarus Crane <i>Grus antigone sharpii</i> (VU)	Low	Low	Moderate



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