**Kingdom of Cambodia**
**Ministry of Environment**

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**Tonle Sap Ecosystem and Value**

Technical Coordination Unit for the Tonle Sap, 2001

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Introduction

Tonle Sap Lake lies in the central floodplain of Cambodia territory, surrounded by six provinces with the total catchment of 80,000 km² (MoE) and the population of 3.41 million. The topography is relatively flat within national road N5 and N6, ranging from 1m to 10 m asl. The water

Table 4: Ecosystem diversity

<table>
<thead>
<tr>
<th>Ecosystem unit</th>
<th>Abiotic Condition</th>
<th>Biotic Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DO&lt;sup&gt;1&lt;/sup&gt;</td>
<td>Flood&lt;sup&gt;2&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>%</td>
<td>duration</td>
</tr>
<tr>
<td>Open lake and stream</td>
<td>105 – 71.50</td>
<td>Year round</td>
</tr>
<tr>
<td>Area: 289,739 ha</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flooded forest</td>
<td>62.4 – 46.6</td>
<td>8 month</td>
</tr>
<tr>
<td>Area tall forest:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>19,646 ha</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Area shrub:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>abandoned: 34936 ha</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flooded grassland or</td>
<td>na</td>
<td>3 - 5 month</td>
</tr>
<tr>
<td>Veal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Area 115,291 ha</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Area grass abandoned:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>157,662 ha</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Agricultural land</td>
<td>-</td>
<td>5 days</td>
</tr>
<tr>
<td>Area: 406,020 ha</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1. Based on TCU/SPEC limnological research (Sept - Dec 1998) between the surface and depth of 4m.
2. Tes Sopharit (1997)
3. Topographic map (1960)
regime is characterized by the high water fluctuation between the dry and wet season, which varies from 1 m to 9 m with the volume increasing from 1.3 billion m³ to 70 billion m³ accordingly. Similarly, the Lake surface also changes from 2500 km² to about 13,000 km², resulting in flooding large area up to the national roads. It is suggested that the Lake originated in about 5000 year ago, when Tonle Sap Lake began connection with the Mekong Rivers.

Tonle Sap Lake represents one of the richest wetland ecosystem in the World, providing robust resources base for country economy and people’s livelihood for centuries. The unique hydrological regime of the Tonle Sap and the Mekong plays a significant role not only in the perpetuation of productive biodiversity, such as fish, wildlife, and forest, but also in the present land use pattern and diverse cultural landscape. Cambodia culture is adopted and flourished in harmony with Tonle Sap Lake and the Mekong, which serve as a source for spirit and material needs. The present farming, fishing, taste, and traditions are closely connected with the rise and fall of the Tonle Sap waters. The ancient sculpture depicted at the bas-reliefs of Bayon Temple bears witness of the great affection of Cambodia people with Tonle Sap Lake. Today about half of Cambodia population directly or indirectly benefit from the Lake’s resources. In addition, the Lake is fascinated by the rich cultural landscape ranging from the ancient Angkor heritage, the rural farmer villages, and the floating communities.

The importance of Tonle Sap Lake goes far beyond the national boundaries in terms of biodiversity significance and flood regulations. The capacity of the lake to absorb a large quantity of floodwaters from the Mekong serves to maintain the ecological stability for downstream livelihood from the Tonle Sap rivers till the Mekong delta. The Tonle Sap Lake is a rich biodiversity stock, particularly for fish and waterfowls, which replenishes the Mekong water system. For instance, a dozen of globally threatened bird species are displaced within the region, using the lake as transit place for breeding.

Recognizing the ecological, economical, and socio-cultural value of the Lake, the Royal Government of Cambodia decided to designate the whole Tonle Sap Lake as Biosphere Reserve under the Man and Biosphere Programme of UNESCO in October 1997. The Lake is divided into three zones, namely three core areas, a buffer zone, and a transition zone. The three core areas are unique ecosystem of high conservation value. The buffer zone is covered by flooded forest, where fishery activities are dominant. The transition zone is the farmland, where rain-fed rice and floating rice are cultivated. The TSBR is designed to reconcile the needs for biodiversity and environmental conservation with economic development in an integrated manner. TSBR has three functions: conservation functions, sustainable development functions, and education and research functions.
Khmer Culture Identity

The Tonle Sap Lake is described by Cambodian people as the heart of culture and country economy, based on several reasons. The largest cities with high population density are established in the central floodplain along the Mekong and Tonle Sap. It is not unusual that Khmer institutions and culture were born in close connections with the rise and fall of Tonle Sap waters. The three famous Cambodia capitals since 9th century, including the Walled City (Bayon temple), Long Vek city, and the present Phnom Penh capital have been built on the bank of the Mekong and Tonle Sap. The complacent attachment with the Great Lake and waters can only be explained by both economic and cultural reason. It is believed that the success of the construction work of Angkor temple could not be achieved without the service provided by the rich natural endowment of Tonle Sap Lake, mainly rice and fish. The sculpture depicted on the bas-relief of Bayon temple is one of the examples indicating how the then Cambodian life depended on Tonle Sap Lake and prospered. The ancient Khmer architecture enjoyed very much the building of waterway or moats around temples, which are remained until today. The present religious building like pagoda find similar architectural heritage in combination with ponds and lotus flowers.

Some beliefs and traditions such as agriculture practices, fishing, eating, living and festivals are influenced by the water regime of Tonle Sap. Khmer farmers learn how to grow several crops per annum around Tonle Sap floodplain, including rain-fed rice (Srov Vossa), dry season rice (Srov Prang), floating rice (Srov Vea). All these farming practices were recorded by a Chinese missionary Chou Ta Kuan, during his stay in 1296. Of particular interest is the floating rice cultivation, which is unique to Tonle Sap Lake, as such rice farming can not be practiced in somewhere else. Floating rice can not survive in the area where the rate of flooding is faster than 10 cm per day (Jean Delvert, 1956). So farmers have to know precisely when, where, and which rice species should be planted. Several fishing practices such as fishing lots, lop rav, daay also adopted based again on fish ecology of Tonle Sap Lake. Fishing normally begins during the water recession and intensifies during 5-7 days of the full moon period, when fish migrate from flooded forest of Tonle Sap Lake back to the Mekong River. Even building bamboo fences for surrounding the fishing lots need special knowledge about when and where to do it. The fishing villagers also master the building of floating house for easy move according to the flooding regime, using bamboo or aquatic plant as platform.

Cambodia celebrates many festivals, some of which are just related to Tonle Sap. Water festival (Bon Om Touk) commencing in November 10-12 is the biggest festival, which devotes to the outflow of water from Tonle Sap Lake to the Mekong River. Probably similar festival was observed by Chou Takuan in late 13th century. Now the festival is celebrated with great pleasure by the whole nation ranging from farmers, government officials, religious groups to the King, in which spectacle boat race with Royal patronage, Sam Peah Preah Khe (moon festival), fire works and light flotilla are organized under the full moon. The festival also marks the beginning of fishing season, when Khmer farmers, and professional fishermen like Vietnamese and Khmer Islam compete to get fish out of the Lake. At this time some rice farming is ready for harvest, particularly the earliest sticky rice is served as special feast for the moon festival (Oak Ambok Sam Peahpreah Khe).

Khmer people mostly engage in rice farming and dwell in the rural areas. Population census for 6 provinces around Tonle Sap Lake in 1998 reveals that 77% of the active population are farmers. Rice is described by Khmer as God Mother (Preah Me) with high respect, because rice for Khmer can not be replaced by other nutritional food. Khmer farmers can eat rice with just prahok (fermented fish) or fish sauce. Khmer are more experienced in rice farming than any other occupation. According to some chronicles about 5,000,000 ha were cultivated by Khmer farmers during Angkor period. Per capita rice consumption for Khmer population is estimated around 600-700g a day, or about 200 kg in average per year (Jean Delvert, 1956).

After rice, fish is the second diet and the most favored source of protein (70%) for Khmer society. Per capita fish consumption is estimated around 60kg/year. Khmer people are not professional fishermen as they are more involved in small scale fishing with traditional fishing gears. Most of their fish products are primarily used for family consumption. The way how Khmer people preserve fish for long-term use is just a unique cultural phenomena. Prahok, pha ak (fermented big fish), mam (fermented small fish), dry fish, smoke fish can be preserved and used for one year or more, a full cycle of fishery production. This type of fish products are easily transported and distributed in far distance from the catching places.
Biodiversity

The overwhelming recognition of Tonle Sap Lake as the heart of the country economy and culture is based primarily on the ability of the Lake to sustain the massive production of biodiversity (not only in quality) much more than needed for centuries to support the culture and the economy until today. The evidence of strong linkages of Cambodian past civilization with Tonle Sap Lake can be found in the bas-relief of Bayon Temple. Today, more than one million people depend directly on the Lake’s biological resources for livelihood. Apart from the economic role, the biodiversity richness of the lake is of regional interest as a stabilizing factor in the regional ecology of the Mekong Basin.

It is worth noting that one would not have a correct understanding of the ecosystem diversity without paying due attention to the unique hydrological regime of Tonle Sap Lake. The seasonal change of water level caused by the Mekong floodwaters and the flood duration are the key factors characterizing the distribution pattern of the flora and fauna, and land use surrounding the lake. Table 4 illustrates a diversity of ecosystems with a distinction of flora and fauna species diversity according to the variation of abiotic conditions, particularly the change of flood duration, topography, and altitude. Though more researches are needed, the functions of these ecosystems or habitats are varied and interconnected. It is clear also that the distribution of species correlates with their adaptability to the environmental conditions.

Flooded forest

There is a lot of consensus about the paramount role of the flooded forest in the support to the species richness and abundance within the Tonle Sap Lake. From the ecological point of view, the flooded forest is the regulatory factor and catalyst for the maintenance of complex giant food chains. As most of us see the flooded forest as an ecological niche, not much action is duly taken to address its continuing degradation that may cost a higher price at the expense of biodiversity lost. On the other hand there is still deficiency of understanding of the forest ecology. Existing old literatures are mostly devoted to upland forests, due probably to logging interests.

The flooded forest variation and distribution is owing mainly to the water regime of the Tonle Sap Lake, characterized by a seasonal change of water level and flooded duration. It is clear that these flooded forest species, except floating vegetation, cannot survive in a long persisted flooding, as we observe that the permanent lake is open without any tree. Usually, maximum flooding duration is about 6 – 8 months, but no research has ever been conducted on the flood tolerance of individual plant species. Based on this factor, it can be assumed to classify the flooded vegetation into three groups: the tall flooded forest with height up to15-20m (Mcdonald calls it a gallery forest), the thickets or shrub with height of 2-4m, and the herbaceous community. Unlike mangrove forest, all flooded forests have very small leaf and have no aerial rooting system. The flooded vegetation is largely distributed in Battambang, Kampong Thom, while in Kampong Chhnang, Siem Reap and Pursat it is severely degraded (see land use cover map 1997). There are about 190 plant species recorded in the Tonle Sap inundated area.

The tall flooded forest species are normally bordered along the shoreline of the lake, and covers 19,646 ha (Land cover 1997). The common tall flooded forest species are Barringtonia acutangula, Terminala cambodiana, Diospyros cambodiana, Crudia chrysanth, Coccoceras anisopodom, Croton caudatus, Elaeocarpus griffithii, Garcinia loureiri, Hydnocarpus anthelmintica, Samandura harmandii (B. Rollet). Today Barringtonia sp. is the most dominant, probably due to the selective cutting of the species of better fuel value such as Terminala cambodiana and Diospyros cambodiana. All the flooded forest species are endemic to Indochina, of which Terminala cambodiana is endemic to Tonle Sap (Andrew McDonald, 1996).

The shrub communities cover a large part of the inundated zone, accounts for about 60% of the flooded vegetation (Land use cover 1997, Forestry Department). They may be distributed as understory of the flooded forest or as in isolation. The shrub vegetation is described by B. Rollet and McDonald as the zone of the most diverse flora species. The common species are Barringtonia acutangula, Bridela cambodiana, Brownlowia paludosa, Capparis micratha, Cissus hexagularis, Combretum deciduum, Croton mekongensis, Croton crabas, Dalbergia pinnata, Gardema cambodiana, Gmelina asiatica, Phyllanthus emblica, Poppowia diospyrifolia, Stenocaulong kleinii, Terminala cambodiana, Vitex holoadenon. The liana species as co-dominant include Calamus sp. (Phdau Tuk), Combretum trifoliatum (Vor tras), Uncaria homomalla (Sang khor).

Locally called veal, the herbaceous vegetation can be divided into floating and submerged rooting aquatic plants, covering the area of 115,291 ha (Land use cover, 1997). The main species are Sesbania javanica (Snao), Ipomoea aqatica (Tra
Koun), Eichhornia crassipes (Kam Plaok), Ipomoea chrysioides (Vor Ta Euk), Nymphaea nouchali (Pro Lit), Ludwigia adscendens (Kamping Pouy), Utricularia aurea (Saray), Bo Bos (unidentified sp.), Kamplong (Unidentified sp.), and Treng (Unidentified sp.), Sbov (Imperata Cylindrica), Kak (Unidentified). The formation of the herb communities is poorly studied. The rooting herbs occur mainly on the fringe of the lake at maximum flooding, and but some species such as Treng and Bobos grow in a small quantity along the shoreline as well.

The floating plants like water hyacinth can be distributed almost everywhere, where water is stagnant or low velocity with rich nutrient content. The water hyacinth infestation now occurs in some localized parts of the lake as weed already, particularly during the dry season, which may have adverse effects on the fish population and fishing industry in the near future. One of the causing factors of infestation problem may be associated with the forest degradation, as such weeds are rarely found in the tall flooded forest. However research and monitoring of the cause-effects of this weed and its extent should be planned.

Waterbirds

The abundance of fish coupled with the dense flooded forest are one of the favorable conditions for waterbird to make Tonle Sap Lake a breeding and feeding habitats. The assemblage and abundance of waterbirds within Tonle Sap Lake has been well presented in several research activities by WPO/IUCN, TCU/UNESCO SPEC, WCS, WI and others, because the waterbird study is much easier conducted than other researches.

<table>
<thead>
<tr>
<th>English name</th>
<th>Khmer Name</th>
<th>Scientific name</th>
<th>Location of abundance</th>
<th>Population 1998-99</th>
<th>IUCN Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Spot-billed pelican</td>
<td>Tong Prapheh</td>
<td>Pelicanus philipensis</td>
<td>Prek Toal and Boeng Chhmar</td>
<td>2700</td>
<td>GT</td>
</tr>
<tr>
<td>2. Greater Adjutant</td>
<td>Tra Dak Thum</td>
<td>Leptoptilos dubius</td>
<td>Prek Toal Boeng chhmar</td>
<td>70</td>
<td>GT</td>
</tr>
<tr>
<td>3. White-winged duck</td>
<td>Tea Prey</td>
<td>Cairina scutulata</td>
<td>Prek Toal Boeng Chhmar</td>
<td>-</td>
<td>GT</td>
</tr>
<tr>
<td>4. Milky stork</td>
<td>Ro neal sar</td>
<td>Myncteria cinerea</td>
<td>Boeng Chhmar</td>
<td>2</td>
<td>GT</td>
</tr>
<tr>
<td>5. Lesser adjutant</td>
<td>Tradak Touch</td>
<td>Leptoptilos javanicus</td>
<td>Prek Toal Boeng Chhmar</td>
<td>131</td>
<td>GT</td>
</tr>
<tr>
<td>6. Painted stork</td>
<td>Roneal Por</td>
<td>Myncteria leucocephala</td>
<td>Prek Toal Boeng Chhmar</td>
<td>2355</td>
<td>GNT</td>
</tr>
<tr>
<td>7. Asian open bill</td>
<td>Kreal kchang</td>
<td>Anastomus oscitans</td>
<td>Prek Toal Boeng Chhmar</td>
<td>6300</td>
<td>GNT</td>
</tr>
<tr>
<td>8. Black headed ibis</td>
<td>Kngar kloun sar</td>
<td>Threskiornis melanocephalus</td>
<td>Prek Toal</td>
<td>276</td>
<td>GNT</td>
</tr>
<tr>
<td>9. Glossy ibis</td>
<td>Kngar kloun rolong</td>
<td>Plegadis falcinellus</td>
<td>Prek Toal</td>
<td>50</td>
<td>THNT</td>
</tr>
<tr>
<td>10. Masked fin foot</td>
<td>Kngar kloun sar</td>
<td>Heliopais personata</td>
<td>Prek Toal Boeng Chhmar</td>
<td>4</td>
<td>GT</td>
</tr>
<tr>
<td>11. Grey-headed fish eagle</td>
<td>Ak trei kbal prapheb</td>
<td>Ichthyophaga ichthyaeus</td>
<td>Prek Toal Boeng Chhmar</td>
<td>15</td>
<td>GNT</td>
</tr>
<tr>
<td>12. Black-neck stork</td>
<td>Angkot khmao</td>
<td>Ephippiorhynchus asiaticus</td>
<td>Boeng chhmar</td>
<td>6</td>
<td>THT</td>
</tr>
<tr>
<td>13. Bengal florican</td>
<td>Sat ksep</td>
<td>Houbaropsis bengalensis</td>
<td>Srayov commune (Kampong Thum)</td>
<td>15</td>
<td>GT</td>
</tr>
<tr>
<td>14. Oriental darter</td>
<td>Smaonh</td>
<td>Anhinga melanogaster</td>
<td>Boeng Chhmar Prek Toal</td>
<td>32</td>
<td>GNT</td>
</tr>
</tbody>
</table>

GT: Globally threatened
GNT: Globally near-threatened
THT: Threatened in Thai

There are more than one hundred species identified of which a dozen is considered as of international significance. These rare waterbird species are concentrated in Prek Toal and Boeng Chhmar core areas of Tonle Sap Biosphere Reserve. Like other wildlife, waterbirds are threatened by collection of eggs and chicks and hunting for consumption.

Fish

Some specialists suggest that without the Tonle Sap Lake, the Mekong water would not have had so much fish as observed today. There is no doubt Tonle Sap Lake serves as an ecological niche not only for sustained massive reproduction of fish, but also for the rich diversity of fish species. Such fish richness is recognized as one of the factors leading to a diversity of predator-life that depend on fish as a source of food.
Among 1200 fish species identified in the regional Mekong waters, 500 fish species are from the lake, and that list is not yet complete (Rainboth, 1998). According to Nao Thouk, these fish species can be classified into three categories: white fish, black fish and small fish according to their adaptation to the environmental aquatic conditions. The white fish is the longest migratory fish, which usually occur between the Tonle Sap and the Mekong. The black fish, which can adapt to the low oxygen conditions, mainly migrates diagonally between the flooded forest and the open lake body. Of 500 fish species, about 70 fish species are abundant, of which 13 fish species (Channa micropeltes, Channa striata, Cyclocheilichthys enoplos, Pangasius hypophthalmus, Henicorhynchus siamensis, Barbodes gonionotus, Hampala dispar, Cirrhus microlepis, Osteochilus melanopleurus, Morulius chrysophekadion, Mystus nemurus, Mytus spp, Trichogaster microlepis, Channa marulius) are the most abundant, accounting for 82% per catch sample (Treuong Roth, 1999). Similar abundance was observed by Chu Takuan “Of all the fish, the black carp is the most abundant”, which he probably referred to Channa micropeltes. A number of species, such as Mekong giant catfish (Pangasianodon gigas), giant barb (Catlocarpio siamansis), Seven-line barb (Probarbus jullieni) are now close to extinction.

<table>
<thead>
<tr>
<th>No</th>
<th>Biological unit</th>
<th>Number of known Species in Tonle Sap</th>
<th>Number of Common species in Tonle Sap</th>
<th>Number of Endemic Species</th>
<th>Number of Endan-gered Species</th>
<th>Number of all species per 10,000 Km²*</th>
<th>Number of all bird species in the country*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Flooded Forest</td>
<td>190</td>
<td>8</td>
<td>unknown</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Fish</td>
<td>500</td>
<td>70</td>
<td>179</td>
<td>4</td>
<td>-</td>
<td>1,200</td>
</tr>
<tr>
<td>3</td>
<td>Waterbird</td>
<td>104</td>
<td>89</td>
<td>-</td>
<td>15</td>
<td>165</td>
<td>500+</td>
</tr>
<tr>
<td>4</td>
<td>Reptile</td>
<td>46</td>
<td>12</td>
<td>1</td>
<td>6</td>
<td>32</td>
<td>82</td>
</tr>
<tr>
<td>5</td>
<td>Mammal</td>
<td>14</td>
<td>8</td>
<td>-</td>
<td>6</td>
<td>47</td>
<td>123</td>
</tr>
<tr>
<td>6</td>
<td>Amphibian</td>
<td>2</td>
<td>2</td>
<td>-</td>
<td>-</td>
<td>11</td>
<td>28</td>
</tr>
<tr>
<td>7</td>
<td>Invertebrate</td>
<td>33</td>
<td>15</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Total</td>
<td>886</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

* source from World Resources, a guide to the global environment 1996-97

**Mammals**

The status of the mammal species is the least written subject as no systematic survey has ever been conducted on the mammal species diversity, distribution and abundance in the Tonle Sap Lake area, except a few notifications. The only observation that most of us agree with is that the population and diversity of mammal species are uncommon to the Tonle Sap Lake area at present. With this scarce information, there is a great concern about the fact that Cambodian people may not care or dare to investigate whether such dramatic decline is just a normal natural condition or the result of human activities, and let it pasts forgotten. But some past chronicles can be used at least as a qualitative fact about what the Lake environment looked like in 1000 year, 800 or 100 year ago. Chou Takuan during his mission in 1296-97, described about the wild life he observed “Among quadrupeds, the rhinoceros, the elephant, the wild buffalo, and mountain horse…the great abundance of tigers, panthers, bears, wild boars, stags, gibbons, foxes et cetera” (Chu Takuan, 1296). There is no doubt that there were species more than Chu Takuan could list as he was not specialized in this field. Around 1950-60, according to local villagers in Battambang province, there was still sighting of elephants descending to Tonle Sap lake for food. Irrawady Dolphin was also seen in the Tonle Sap Lake. Now these large animals are the past.

At present however, based on the observation of field studies by TCU/WCS, a list of small mammal species has been identified. The list includes global-threatened hairy-nosed otter (Lutra sumatrana), Smooth otter, near-threatened oriental small-clawed otter (Aonyx cinerea), common palm civet (Paradoxurus hermaproditus), Leopard cat (Prionailurus bengalensis), slow loris (Nycticebus coucang), Asiatic jackal (Canis aureus), Berdmore’s squirrel (Menetes berdmorei), variable squirrel (Callosciurus finlaysonii), wild pig (Sus scrofa), near threatened Fishing cat (prionailurus viverrinus), near-threatened long tailed macaque (Macaca fascicularis), near-threatened silvered langur (Semnopithecus cristatus), large flying fox (Pteropus vampyrus), greater long-tongued fruit bat (Macroglossus sobrinus), are observed (Long Kheng Oct. 2000, Joe Walston, Doroughenko1999). Their population and distribution have never been studied. Long-tailed macaque is still abundant, though capture for trade is on the increase.

**Reptiles**
The species diversity of reptiles has been recently explored, particularly since 1998 by TCU/SPEC and now with WCS. Much more studies need to be conducted on species diversity, abundance and distribution, habitats and harvest. At present, there are 23 snake species (including 10 watersnake species), 8 turtles and 1 crocodile species, 1 Tokay gecko (Gecko gecko), 6 lizard species, 1 Indo-chinese water dragon (Physignathus cocincinus) and 2 skink species identified within the flooded forest of Tonle Sap Lake (Nicolai Doroshenko 1998, Bryan Stewart 2000).

At least 5 water snake species of colubrid subfamily Homalopsinae (Enhydris enhydris, Cerberus rynchops, enhydris bocourti, Homalopsis buccata and Erpeton tentaculatum) are common of which Enhydris enhydris is the most abundant species accounted for 80% in the market sample (Bryan L. Stuart et al, and Nicolai Doroshenko). Nicolai Doroshenko approximately estimated the density of these 5 species in Prek Toal, Boeng Chhmar, and Stoeng Sen 50-100/ha, 20-30/ha, 20-30/ha respectively, except Enhydris enhydris which is abundant in all the places. Most of water snakes are highly concentrated in Prek Toal core area of Tonle Sap Biosphere Reserve. King cobra (Ophiophagus hannah), asiatic cobra (Naja naja), rock python (Python molurus) and reticulated python are rare as they are also targeted for commercial trade. It was estimated about 7000 –14,000 kg of snakes per week brought to Chong Kneas port mainly as food for crocodile farming in 1999 (Bryan L. Stuart, Jady Smith, 1999).

13 turtle species are found, of which 3 species (Malayemys subtrijuga, Hieremys annandalii and Cuora amboinensis) are very common (Long Kheng, Oct 2000). The most abundant species is Malayemys, which accounts for 88% of the catch sample. Their population is on the steady decline. There is one crocodile species Crocodylus siamenses. Large crocodiles as boats, which have four feet and are exactly like dragons, with no horns as described by Chu Takuan is never seen any more in the wilderness, and a large number of crocodiles are in captivity for commercial purpose. Turtles and water snakes are harvested for exports to China and Vietnam.

Biodiversity hotspots

Biodiversity hotspots are defined as an area rich in biological resources of conservation value, which may be characterized by the presence of endemic and endangered species, important habitats, species richness and abundance, and unique ecological functions. Based on the overview of the present status of biodiversity as illustrated above, three locations are identified as the most significant biodiversity hotspots, which presently demarcated as the core areas of Tonle Sap Biosphere Reserve, namely Prek Toal, Boeng Tonle Chhmar, and Stoeng Sen core areas (see maps).

Prek Toal Core Area: It is the most unique habitat with high richness of flora and fauna species, abundance, and the presence of endemic and endangered species. The area is rich in large water birds of global significance, all kind of watersnake with high density, a variety of habitats (grass land, flooded forest, and shrub). The area is home to many mammal species, particularly macaques and silvered langur. It is the most productive area for fish harvest. Probably Prek Toal is one of the most important biodiversity hotspots in wetlands of Southeast Asia.

Boeng Tonle Chhmar: Boeng Chhmar is ranked second after Prek Toal, due probably to the prolonged human disturbance. Nevertheless the area is home to a variety of flooded forest, fish diversity, and waterbirds. The area is the most important habitat for mollusk species. Boeng Chhmar is a beautiful place of high scenic view value. The area serves as an important feeding ground for migratory birds. Local informants reported the presence of endangered giant barb of 80 kg in weight caught last year. The fish species assemblage is different from that of Prek Toal core area. The abundance of mollusk and bivalve is also an interesting physiognomy of the Boeng Chhmar ecosystem.

Stoeng Sen core area: the best tallest primary flooded forest is found in Stoeng Sen core area and fishing sanctuary N2 in Kampong Thom province. The recent visit by the working group on 25 October found
the area as the last remnants of the pristine flooded forest, which would be an interesting place for the researchers to use it as indicator for the assessment of the present distribution of flooded forest within Tonle Sap Lake.

IV. Environmental concerns

**Deforestation**: degradation of flooded forest is caused by a number of economic activities. B. Rollet stated in his research that exploitation of flooded forest was very ancient, the intensive production for fuel wood was estimated about 500,000 stair since 1930, which is equal to 166,666 cubic meter. Than the flooded area was subject to extensive agricultural conversion during mid 20 century. After that during the Pol Pot regime a large part of flooded forest had been converted to slash and burn agriculture. After the 1979 liberation, flooded forest has been exploited for fuel, cleared for agriculture, and human settlement. Based on this fact, one may suggest that most of the present flooded forest is secondary. As the dense shrubs are succeeded rapidly after clearing, the chance for tall trees to grow in such condition is very marginal. This probably why we see more shrub or grass than the tall tree, which is only remained in Stoeng Sen area. The infestation of weed like water hyacinth and *Mimosa pigra* may be also associated with the accelerated deforestation and contaminated nutrients. Deforestation would result in less diverse fish and wildlife species.

**Habitat fragmentation**: it is again the result of socio-economic developments. The increase of human settlement, agricultural expansion, infrastructure development are only a few examples that we observe today. The lake is now surrounded by an agricultural belt, national road with increased population, which cut the ecosystem into isolated piece. Natural corridor for animal migration, except waterbirds, between the lake and upland forest is now fully eliminated. Many elephants, tigers, wild pigs, and wild buffalo are not accessible to the lake any more. The division of the lake area into fishing lot also offers opportunity for ecosystem fragmentation because of intensive fishing and human disturbance.

**Increased nutrients load**: with the increase of population in the lake watershed, agricultural development, and waste discharge, the nutrients enrichment will be likely up. The consequence of such nutrient richness is the eutrofication and weed infestation. As the flooded forest decreases, the effects of nutrients on the lake ecology would be added. As observed water hyacinth and *Mimosa pigra* are on the increase. Algae bloom has been often observed on the lake surface during the dry season.

**Decreased water level**: may be the result of energy development, water supply, and irrigation. Though the capacity of water during wet season is enormous, the lack of technology and knowledge to appropriately manage the water volume would lead to the lowering of water level in the dry season, thus affecting the fish stock.

**Sedimentation and siltation**: for most of the lakes, sedimentation of the lake is just a matter of time. With heavy deforestation in the upland and low land watershed and intensive agriculture would speed up the filling up.

**Biodiversity degradation**: the present resources management as shown in table 3 would cumulatively affect the quantity and quality of biological resources. Over-fishing and over exploitation of wildlife and forest are the key factors leading to the biodiversity degradation. In addition, the increased demand from neighbors, especially from China as a result of economic integration will further decrease the fish and wildlife natural stock.

<table>
<thead>
<tr>
<th>No</th>
<th>Threat</th>
<th>Forest</th>
<th>Fish</th>
<th>Bird</th>
<th>Rep-tile</th>
<th>Mam-mal</th>
<th>Description of possible impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Agriculture (rice, lotus, vegetable)</td>
<td>****</td>
<td>****</td>
<td>****</td>
<td>***</td>
<td>****</td>
<td>clearing flooded forest and ecoton vegetation, destruction of wildlife corridor</td>
</tr>
<tr>
<td>2</td>
<td>Irrigation</td>
<td>*</td>
<td>***</td>
<td>*</td>
<td>**</td>
<td>*</td>
<td>Obstruct fish migration and water storage of the lake</td>
</tr>
<tr>
<td>3</td>
<td>Population increase</td>
<td>****</td>
<td>****</td>
<td>****</td>
<td>****</td>
<td>****</td>
<td>Increased human settlement, fishing, agriculture, hunting</td>
</tr>
<tr>
<td>4</td>
<td>Fuel wood</td>
<td>**</td>
<td>****</td>
<td>***</td>
<td>***</td>
<td>****</td>
<td>Forest degradation</td>
</tr>
<tr>
<td>5</td>
<td>Waste discharge</td>
<td>*</td>
<td>****</td>
<td>**</td>
<td>***</td>
<td>***</td>
<td>Water quality deterioration</td>
</tr>
<tr>
<td>6</td>
<td>Sedimentation</td>
<td>*</td>
<td>***</td>
<td>*</td>
<td>**</td>
<td>*</td>
<td>Shallow water and lake</td>
</tr>
</tbody>
</table>
V. Current Government Efforts and International Support

5.1 At national level

Legal and Institutional Issues: A royal decree for Tonle Sap Biosphere Reserve has been adopted as a legal basis for the implementation of biosphere reserve concepts. The critical elements of the draft decree are the formulation of directions and management objectives for each zone, inter-ministerial coordination body, and institutional arrangement for TSBR implementation. Fishery and Forestry laws are under revision to reflect the current social, ecological and economical needs. As an example, the Prime Minister has abolished a large part of the fishing lots in favor for the community fishery management. Workshops and meetings are organized to discuss the future strategy for the sustainable development and conservation of Tonle Sap Lake resources. Inter-ministerial coordination mechanism is foreseen to be set up under Cambodia National Mekong Committee to promote coordination and networking among stakeholders concerned, thus contributing to good governance.

5.2 At Local Level:

Under the Tonle Sap Biosphere Reserve Proogram, the Ministry of Environment has initiated a pilot project in Prek Toal, Koh Cheveang commune, Battambang province which was started in 1997. The pilot project aims to promote environmental education and awareness at the grass root level, to conduct regular ecological research and monitoring, to promote conservation of flooded forest and wildlife of international significance, to identify alternative livelihoods and incentive for community participation, and to explore the ecotourism potential. An Environmental Research Station was the first ever built as facilities for carrying out daily activities in accordance with the above objectives. The station employs 12 villagers and administered by two environmental staff under the overall supervision of the chief of the Technical coordination Unit for the Tonle Sap, with the financial support of UNESCO. Currently, the research station has a number of activities as follows:

Conservation of Endangered Waterbird Species: Prek Toal Core Area of Tonle Sap Biosphere Reserve is home to a large number of wildlife species, especially large waterbirds. Due to their high value and frequent disturbance from poachers, two observation posts were erected on the trees so that local staff are put on duties day and night to watch and observe the birds. Financial support was obtained from WCS. Thank to these efforts, this year many nesting sites are safe and new bird babies are born. They also recorded the number of all species counted.

Environmental Awareness: various forms of environmental awareness have been implemented since the installment of the research station. Currently out school children and school children are invited to the station to learn about the birds, wildlife, and flooded forest so that they can learn to love the surrounding environment. It is hoped that the message they get from the station will be passed on to their parents. Besides, brochures, posters, and awareness materials are disseminated to adults and communities across the communes.

Alternative livelihoods: several programs have been initiated to identify alternative incomes for communities who depend on wildlife hunting, waterbird collection, and forest cutting. A credit program in conjunction with the micro-intervention
projects funded by Belgium Cooperation Division were executed in Koh Chiveang commune. About one hundred families were provided loan and grants for small-scale fishing, pig raising, chicken and duck raising, aquaculture, fish&vegetable trade... with a small interest rate. With this small financial intervention, poor families have incentives and compensation to stop illegal activities such as wildlife hunting and forest cutting. In addition it helps reduce pressure on natural resources.

Ecotourism: the presence of waterbirds of international value offer high potential for ecotourism development, thus provide value added income to the government. The station initiates ecotourism enabling activities since 1999 with travel agencies and NGO. So far the number is still small compared to tourist arrival in Angkor, but it is on the increase from year to year. Though at present ecotourism income is relatively small compared to fishing lot, it would promise a considerable portion in the next 10 years if administration and regulations are clear. The major constraint is the access which is difficult during the fishing lot operation. Experts estimate around 1 million dollar US if everything is settled. This year about 30-40 tourists per month visited the reserve.

5.3 International assistance

A number of UN and International NGOs currently supporting environmental conservation and natural resource management include UNESCO, FAO, WCS…etc.

Three preparatory projects are under way now for additional financial assistance from ADB, GEF/UNDP, and CAPACITY 21. ADB project is preparing a loan investment plan for infrastructure development (ports), community based management (5 communes from each province), and environmental education center in the Tonle Sap region. GEF grant funding would help support the government in conservation of global biodiversity, particularly in the three core areas of Tonle Sap Biosphere Reserve. The Capacity 21 would direct the grant assistance in capacity building of institutions and communities in sustainable development of natural resources. The total budget is about 15 – 30 millions USD.

In addition the government also launches decentralization program in selected communities in Battambang, Pursat, Siem Reap province through SEILA/UNDP project. The project assists in the capacity building of local communities in planning, organization, and participation.

Conclusion

Tonle Sap Lake is a complex ecosystem, which is ecologically sustained and stabilized by hydrological cycle of Mekong system and Tonle Sap watershed. The Great Lake is still considered one of the most productive lakes in the world, particularly in terms of fish. The lake is also home to rich biodiversity, including species of conservation value. The Lake’s resources represent strong economic and cultural interest for Cambodia government and her population. Tonle Sap Lake is endowed with rich cultural landscapes, composed of the famous ancient Angkor capital, traditional floating communities, in combination with growing modern towns and agricultural landscapes. Rice and fish constitute the major source of income for the rural population.

Tonle Sap Lake is under growing pressures driven by population growth, logging, agricultural expansion, intensified fishing, wildlife hunting, human settlement and urban development, and regional integration. The majority of the population is under subsistent economy, depending on farming, fishing, wildlife hunting, and forest cutting.

The Lake is under the jurisdiction of a complex institutional structure ranging from ministries, provincial authorities, private business, and communities with different interest. In addition the lack of reliable information, together with inadequate research and monitoring programs, hinder the appropriate analysis of resources sustainability and taking rigorous actions. The existing law and policy is sectoral oriented and is out-of-date to address the social, ecological and economic conditions. Integrated ecosystem management and environmental consideration are not taken seriously because of the shortage of political commitment and ecosystem understanding.

The recent policy of the Prime Minister to allocate 56% of fishing ground to the community culminates in the new administration of the fishery sector. It opens a possibility for introduction of community fishery to help manage sustainably the flooded forest and its related resources at grass root level.

The adoption of the Royal Decree on Tonle Sap Biosphere Reserve serves a breakthrough for integrated resources management. Though environmental conservation is a complementary obligation, however the government commitment to forestry, fishery, and land reform remains the key strategy for long-term resources sustainability. Information sharing and public involvement must be fostered to make the reform achievable in the long run with minimal conflicts and maximum harmony. In addition good governance and rigorous policy enforcement should be seriously engaged to combat corruption and to promote environmentally sound and socially equitable resources development. Environmental awareness must be designed to raise public understanding on environmental ethics, ecosystem functions and linkages, global environmental issues, and cost-benefit of environmental conservation. A regional environmental planning has to be developed for Tonle
Sap region to guide sustainable development and prevent adverse environmental effects.

It must acknowledge that the healthy Tonle Sap Lake is crucial to maintain long-term national security, preserve cultural identity and ensure robust economic growth for both the Tonle Sap region and the whole country.

Ministry of Environment
Technical Coordination Unit for the Tonle Sap

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