

Asian Development Bank
Cambodia National Mekong Committee

TA4212-CAM
Establishment of the Tonle Sap Basin
Management Organization

Tonle Sap Basin Profile
March 2004

Dr Geoff Wright
Dr David Moffatt
Dr Jonathan Wager

Disclaimer: This report was prepared by consultants for the Asian Development Bank. The findings, interpretations, and conclusions expressed in it do not necessarily represent the views of the Asian Development Bank (ADB) or those of its member governments. ADB does not guarantee the accuracy of the data included in this report and accepts no responsibility for any consequences of their use.

TONLE SAP BASIN PROFILE

1. BASIN OVERVIEW

The Tonle Sap Basin is located in the northwest part of Cambodia between approximately latitudes 102° 15' to 105° 50' E and longitudes 11° 40' to 14° 28' N that covers an area of about 80,000 km², including the Tonle Sap Lake, which constitutes about 44% of the total land area of the country. The Basin has a population of about 3.625 million (Population Census of Cambodia, 1998) which represent nearly 30% of the total population of Cambodia (11.5 million persons),

The Tonle Sap Basin is an important region for socio-economic development for Cambodia. Sectoral developments over past decades have caused rapid degradation of the important natural resources that are essential to support the livelihood of its people.

In the dry season (November - April), the Lake occupies an area of about 3,000km² (about 100 km long and 32 km wide) with an average depth of 0.8 - 1 m. During the rainy season (May - October), it expands to about 15,000 km² flooding the forest around the lake's perimeter, largely due to flow from the Mekong River. This creates an enormous fish breeding, nursing and feeding ground with a depth varying from about 10 -12m. About 280 fish species utilize the inundated forests for at least 6 months for their breeding and feeding during the monsoon. At the end of the rainy season, the Tonle Sap River reverses its flow, draining the Lake back into the Mekong River during the dry season.

Presently, about 4 million people in the six provinces around the lake (Kampong Chhnang, Pousat, Bat Dambang, Banteay Mean Chey, Siem Reab, and Kampong Thum), depend on the lake and its floodplain for their livelihood, mainly through fishing and agriculture.

There are abundant resources in the area, such as forests, fisheries, wetlands, agricultural land, and others. Throughout history, the lake's abundant resources have supported large human settlements. The extraordinary achievements of the Khmer Empire at Angkor depended upon the waters of the Lake. Today the Tonle Sap Lake has become not only an important symbol of national identity, but also the **"heart and soul of the Cambodian people"**.

Provinces within the basin	Eight provinces and a municipality have all or part of their land area in the watershed including . Kampong Chhnang, Pousat, Bat Dambang, Krong Pailin, Banteay Mean Chey, Otdar Meanchey, Siem Reab, Kampong Thom, and Preah Vihear,
----------------------------	---

Population (most recent figure)	3.625 million (1998)	Population (projected for 2010)	
Population growth rate	3.7 %	Urban population growth rate	4.4%
Urban population (most recent figure)	12,256	Urban population (projected for 2010)	
Gross land area (barren land and sandy)	331,831 ha	Average population density	52 per person/ Km ²
Income per capita per month (government employees only)	20\$ - 250\$	Population below poverty line	40-60%
Total water available (average)	45.7 billion m ³	Total water exploited	17.08 billion m ³

Water use, share of total		Population access to:		
Agriculture	61 %	Safe water		Sanitation
Industrial	4 %	Rural	24 %	8.6 %
Domestic/municipal	18 %	Urban	60 %	49 %

Tonle Sap Basin Profile

Hydroelectricity			
Potential	0.0 MW	Installed capacity	0.0 MW
Average annual production	0.0 GWh	Share of national energy production	0.0 %

Forestry and Protected Areas			
Total area of commercial forests	4.21 million ha (1996/97)	Total area of protected areas	1.68 million ha
Area of biosphere reserve	0.53 million ha	Total area of protected forests including flooded forests	1.55 million ha

2. WATER RESOURCES OF THE BASIN

2.1. Sub-Basins

Name	Area , Km ²	Average Annual Runoff
1- Daun Tri	3,530	
2- Sang Kae	4,370	
3- Mongkul Borei	11,350	
4- Sisophon	3,120	
5- Sreng	10,380	
6- Siem Reap	3,060	
7- Staung	4,370	
8- Chikraing	2,750	
9- Sen	16,250	
10- Chinit	6,770	
11- Boribo	6,080	
12- Pursat	5,980	

2.2. Meteorology

Average annual temperature	28-33 °C	
Mean annual humidity	75 – 80 %	
Annual evaporation	1,300 - 1,500 mm	
Average annual rainfall	1,200 – 1,300 mm	
Rainy season	150 - 350mm	Rainfall in this period accounts for 90% of annual rainfall.
Winds	Up to 2-3 m/s	Storms mainly occur from 5 to 24 m/s. Their frequency is per 14 years.

2.3. Surface Water Quantity

The Mekong main stream causes reverse flow from the Mekong and Tonle Sap rivers confluence to the Tonle Sap Lake. The reverse flow starts from May and continues by October (wet season). As the result, the Tonle Sap Lake expands its surface area from 2,500-3,000 km² in dry season to about 10,000-15,000 km² in rainy season where the surface area increases during the wet season. The increases its depth from around 1m depth in dry season to around 12m depth at the maximum of wet season. Its regulation capacity is estimated as approximately 72 billion m³. By estimation suggest that the Mekong River is the main source for approximately 62% of the Tonle Sap Lake's wet season volume, with the remaining 38% coming from the Tonle Sap Lake's catchments.

Catchment area	80,000 km ²	
Number of major tributaries (sub-basins)	12 majors rivers	1-DaunTry; 2-Sangke; 3-Mongkul Borei; 4-Sisophon; 5-Stung Sreng; 6-Seam Reap; 7-Stung Stong; 8-Chikraing; 9-Stung Sen; 10-Stung Chinit; 11-Baribo; and 12-Pursat.
Average annual runoff	76,000 million m ³	Data source MRC, 2003
Peak flood flow	2,860 m ³ /s	Data in 2001, MOWRAM, from Prek Kdam hydrological station
Minimum flow	680 m ³ /s	Data in 2001, MOWRAM, from Prek Kdam hydrological station

2.4. Surface Water Quality

The water quality samples have been mostly analyzed in the MOWARM laboratory. Over 2000 water quality samples and sounding have been processed. The water quality is well oxygenated during the dry season because of the effective wind and wave induces mixing over the surface of a shallow water body. During the flood inundated areas are to a large extent anoxic. Most people are contributed to pay money in urban area for domestic water supply, but in the rural area the people are poor, they could not pay money. Due to the lack of a National standard for drinking water quality, individual laboratories (PPWSA; MIME; MOWRAM; MOE and others) use individual standards for chemicals of 31 parameters in drinking water.

The internally adopted water quality standards are mainly adopted from international standards or guideline values (WHO), partly due to the donor driven, with no reference to the actual situation in the country. Add reference to the water in the lake in the dry season is very cloudy. The water in the Stung Sangke is cloudy reportedly because of mining activity in Pailin, whereas the water in the Monkul Borei is less cloudy.

2.5. Floods

Cambodia is hilly to the mountain around its periphery, but the dominant feature of its landscape is the extensive flood of the Mekong, Tonle Sap Rivers and the Tonle Sap Lake (Great Lake). Rainy season from May to October, when the Mekong level is high, water flows upstream along the Tonle Sap River into the Great Lake, which increases the size area from 2,500 to 15,000 Km². In November, the flow starts reversing, and water drains from Lakes of Tonle Sap area to the Mekong around 475 billion m³/annum.

The mean annual rainfall in Tonle Sap area is estimated to be 1,200-1,300 mm/year. The Mekong River inside Cambodia discharges more than 475 billion m³ of water yearly on the average through Kratie hydrological station with an average of 13,700 m³/s and Tonle Sap river through Prek Kdam hydrological station with the maximum flood flow discharges is 2,860 m³/s flows and the minimum is 680 m³/s flows into the Tonle Sap Lake (Great Lake). The flood season is from June to November.

The Tonle Sap is filled with water from the beginning of the flood season until the main flood peak reaches at Chaktomuk (in Phnom Penh). For a short time at the peak, the water level at Chaktomuk and Prek Kdam (Kandal province) become almost the same and flows through the Tonle Sap River before reaching the Tonle Sap Lake. It has been estimated that the Tonle Sap Lake reservoir absorbs approximately 30% of the total Mekong River during the flood season.

Seasonal flooding of the Tonle Sap Basin is very important for maintaining fishery production, maintenance of wetland ecology and replenishment of soil fertility with silt and sediment, water supply and irrigated agriculture. Freshwater fish productivity remains the important source of livelihoods in the rural area. Large agricultural land around Tonle Sap Lake has been cultivated with seasonal flooding of Mekong water.

2.6. Groundwater Quantity and Quality

Cambodia has an estimated groundwater resource of 17.6 billion m³. It is being exploited to an increasing extent, particularly by shallow tube wells, for community and household water supply, and for irrigation. There are at least 25,000 community water supply tube wells and large diameter motorized tube wells for irrigation, and about 2,000 manually operated shallow wells are being installed annually.

The alluvial deposits of the Tonle Sap River and Mekong River floodplain are believed to be very good shallow aquifers, with high recharge rates (5-20 m³/h) and a groundwater table generally within 4-6m of the surface. Groundwater quality is generally satisfactory. However, unpalatably high iron levels are encountered in about 10% of tub wells, particularly in Kandal and Seam Reap provinces, apparently due to contamination by salt contained in the original soil deposits, and recent measurements indicate that water drawn from aquifers in some localities have dangerously high levels of arsenic in Kandal Province.

The groundwater is expected to be able to meet the increasing demand for water in the Seam Reap region. The groundwater development and management should consider how much and from where an aquifer can supply water for a long time without causing adverse side effect.

2.7. Uses of Water

2.7.1. General

Water use is a crucial component for human being. Surface and ground water are the main sources for domestic use in urban and rural areas. The management of water user for rice production, orchards, forestry, and fish production will require active intervention by a basin wide participant that have been jointly between the central and provincial (including community) level.

In terms of water demand for industrial sector user, the demand could be different due to the size of the industry, the kind of processing, etc. It is estimated that the demand by industry ranges from 50 m³/day to 20,000 m³/day. The pollution from domestic activities, agriculture, and wastewater from industry in towns put considerable stress on the quality of the basin water resources. Aquaculture and fisheries of freshwater are supported the important in the Tonle Sap basin.

The water supply for domestic must be clean and safe rather than the supply for other uses. The sources of water pollution include municipal, industrial, and agricultural. It has been indicated that the causes of major environmental issues related to the water supply include sewage, pesticides, and fertilizers. Sewage, both form municipal and industrial sources, is the most environmental issues. With 60% of the total population living in urban areas can access to safe water supply while only 24% of the total population in rural areas can. Unprotected water resources are used by people in rural areas.

The water extraction for domestic use does not result in transboundary impacts due to a small volume of water has been extracted. Currently water contamination, both surface and ground water, by sewage discharge (industrial sector) is not also strong transboundary environmental effect.

2.7.2. Irrigated Agriculture

The under irrigated scheme is expected improvement the irrigated agriculture area is 19.43% of total agricultural area and given the high irrigation potential in the future. To enhance food security provides job opportunities and increases the income of the rural population; through irrigation improvement to mitigate the effects of floods and other emergency situations.

Rainy season yields averaged 1.8 - 2.5 t/ha in the upper land areas and 3.5 - 5 t/ha in the lowland areas (with 6 provinces of around Tonle Sap Lake). About 570 irrigation schemes have been existing, but there are 195 schemes or 19.43 % are fully operational.

	No of schemes	Irrigated Area (ha) and % of total irrigated area	No of land-holders	Cropping intensity (%)
Publicly (national/provincial) owned and managed irrigation systems.	191	302,988 of 19.43 %	121,195	72.5 %
Communally owned and managed irrigation systems.	4	3,770 of 0.24 %	4,750	67.5 %
Privately owned and managed irrigation systems	0.0	0.0	0.0	0.0
Total irrigable area	1,578,706 ha	Irrigation water use	27.87 million m ³ /annum	
Total irrigated area	306,758 ha	Irrigation water use (Share of total available water)	28.3 %	
Total irrigated area (% of total agricultural area)	19.43 %	Value of agricultural production, irrigated area	94.38 million \$	
Population dependent on irrigated area for their principal livelihood	74.32 %	Agricultural production irrigated area (% of total agricultural production)	70.94 %	

2.7.3. Drainage for Agriculture

	No. of schemes	Drained area (ha)	No. of landholders
Publicly (national/provincial) owned and managed irrigation and/or drainage systems.	17	37,540	15,016
Communally owned and managed irrigation and/ or drainage systems.	1	2,700	2,700
Privately owned and managed irrigation and/ or drainage systems	0.0	0.0	0.0

2.7.4. Domestic Water Supply and Sanitation

The percentages of rural and urban water supply with access to safe water supplies are 24% and 63% respectively. In both rural and urban areas, many people take advantage of rainwater collected in large water jars during the wet season and for the rest of the year use. In the rural for many households may entail a long walk for women and children to fetch water. The pipe water supplies are restricted to parts the provincial towns and some other districted towns of Tonle Sap region. The quantities of water supplied each year are 2.6 million m³ in the total 6 provincial towns and some districts, and 27.6 million m³ in the rural area of the Tonle Sap.

Now, pipe water is not consistently potable, because of inadequate treatment or contamination in the reticulation system. Non-revenue water ranges from 30% to 70%, due to leakage and illegal connections. The Long-term objective for water supply in provincial town is to provide water that meets WHO standards to at least 70% of their population. Performance is at present highly variable with the percentage of connections ranging to 22% and supply to 46% of the population of 6 towns at the Tonle Sap area.

In rural areas and villages of Tonle Sap, 2.5 million people are dependent on unprotected water sources of wells, ponds and streams/ rivers. There has been a significant effort by the Ministry of Rural Development, international agencies like UNICEF and NGOs to install wells for rural water supply and to introduce sanitary latrines to reduce pollution for water sources.

	Urban	Rural
Population served by public piped water supply to house	22 %	3 %
Population served by public piped water supply (*)	46 %	20 %
Total domestic water use	2.6 million m ³ /annum	27.6 million m ³ /annum
Population served by piped/covered sewerage (**)	7 %	2 %
Population served by at least primary wastewater treatment	0.1 %	0.0 %

- (*) In rural served by water from well. - (**) In rural served small canal.

2.7.5. Electricity Generation

Hydroelectricity generation	0.0 GWh	Value of hydroelectricity generation	0.0 \$/year
Hydroelectricity generation (Share of total energy generation which includes thermal, etc)	0.0 %	Installed hydroelectricity capacity	0.0 MW
Hydroelectricity (Share of total national energy production)	0.0 %	Hydroelectricity potential	0.0 MW
Firm power potential (hydropower generation that can be guaranteed 100% of the time)	0.0 MW	Installed hydroelectricity capacity (% of potential)	0.0 %

A. Planned Hydropower Projects

Cambodia has the plan on the power development at near future with the aims at the electrifications and supply to cover domestic demand. The size of the mainstream projects of the Tonle Sap area and the large scale on the main tributaries is to be developed for electricity generation and supply to the other uses.

Refer to National Sector Review on BDP (CNMC/BDP, 2003), the short and medium term hydropower development plan in Tonle Sap Area as following:

- The mainstream of Sangke (Battambang) 1; 2 & 3, with installed capacity 73 MW;
- The mainstream of Pursat 1 & 2, with installed capacity 92 MW;
- The mainstream of Seam Reap-upper, with installed capacity 600 kW; and;
- The mainstream of Seam Reap-lower, with installed capacity 2,000 kW.

B. The power demand forecast

The peak power demand in Cambodia reached 542 GWh in energy production and 150MW in generation capacity (in 2001). According to the Cambodia Power Sector Strategy (MIME, 2001), it is estimated that the demand will increase up to 991 MW and generated power will be 3488 GWh at the year of 2020. The majority of this growth will occur in the Phnom Penh.

The power demand forecast in Cambodia (CNMC/BDP, 2003)

Year	2004	2006	2008	2010	2012	2014	2016	2018	2020
Power (MW)	273	331	404	477	558	651	746	860	991
Energy production (GWh)	1036	1215	1454	1700	1968	2292	2634	2915	3488

C. The electricity energy sale of Tonle Sap Area

The compression of the yearly electricity energy sale of 6 provincial towns of the Tonle Sap area is increasing between 1994 to 1998. The energy use shortage is one of the major issues in most of the rural areas. The cutting of forest for firewood and charcoal puts an accumulative pressure on the forestry environment, and the increasing demand for energy consumption. Energy efficiency and promoting alternative sources to firewood and charcoal for cooking and boiling water for drinking purposes is important.

Yearly electric energy sale in MWh, (MIME, 1999)

No.	Provinces	1994	1995	1996	1997	1998
1	Kampong Chhnang	456	456	460	530	567
2	Pursat	183	256	391	1,555	1,478
3	Battambang	4,200	5,971	6,562	6,892	7,375
4	Banteay Meanchey	360	507	510	1,428	1,528
5	Siem Reap	2,110	2,780	3,600	4,320	5,130
6	Kampong Thom	268	310	213.5	674	721

2.7.6. Industry

In the Tonle Sap area there are few manufacturing industries and some handicrafts. Among the primary industries mining is important in some areas, and the tertiary industry tourism is important. The impacts of manufacturing on the environment are minimal up to date. The types of industry that are leaders in industrial development at present, notably the garment industry are not heavy users of water. Tourism/hotels are heavy water users compared with other domestic users, which is already causing problems for supply in Siem Reap. They are able to provide for their own requirements from groundwater, where public supplies of suitable quality and reliabilities are not available. They are, however, significant potential polluters of water, and intensification of these industries will require that this matter is addressed effectively. Freshwater aquaculture and navigation similarly receive little mention in the uses of water could make a significant contribution food security and export receipts.

2.7.7. Fisheries and Aquaculture

The Tonle Sap Area does not only provide significant economic and environment benefits to Cambodia, but also to the GMS in terms of fishery production and biodiversity. More the 500 fish species inhabit the inland water of Cambodia, of which over 200 are known from Tonle Sap Lake. The Tonle Sap alone provides around 60% of the commercial fisheries production of Cambodia. Fishery production comes from any sources:

- Inland fisheries source: approximately 300,000 to 400,000 tons per year
- Aquaculture capture fisheries source: approximately 15,000 tons per year.

The Tonle Sap Lake is a vast wetland, connected to the mainstream of the Mekong River by the Tonle Sap River, and covering 1.8 million hectares comprise the rivers and lakes, flooded forests, grassland, rice field and swamps. Inland fisheries with a value at landing of between US\$ 150 million and US\$ 250 million and retail value of up to US\$ 500 million. The sector contributes as much as 8-10% of Cambodia's GDP.

2.7.8. Transportation

Currently transportation system in Tonle Sap area consists of road, railway, inland port, waterway transport and air transport, which has become constraints to the development of the country economy and social activities. The first priority in developing transportation network is the re-establishment of the road network. The over the past 30 years or so, the conditions of these roads have significantly deteriorated due to war, neglect, lack of maintenance and excessive flooding.

In Tonle Sap Basin, the railway network consists of one line is the Northern part. The line is connecting from Phnom Penh to the Cambodia-Thailand border which across 5 provinces: Kandal, Kampong Chhnang, Pursat, Ballabog and Bantay Meanchey. From Bantay Meanchay to Poi Pet (near Thailand border) need to reconstruct about 48km.

In wet season the main waterways traffic can navigate go into the Tonle Sap Lake from Tonle Sap River with vessels of up to 100 tons can navigate, but In the dry season waterway traffic can only inside Tonle Sap River because Tonle Sap Lake is shallow (1m in places). The traffic on the waterway other sub-main stream or river is small crafts, which constitute a very small volume.

On the Tonle Sap River the depth is about 3.5m up to Kampong Chhnang in the dry season, but from Kampong Chhnang to Chong Kneas (near Seam Reap) on the Lake in dry season depth is 0.8m and reaches between 5 and 11m in the rainy season.

The important domestic ports are in Kampong Chhnang, Chhnok Trou and Seam Reap. The Chhnok Trou and Kampong Chhnang are also road-river transshipment ports. In 1994, it was estimated that about 40,000 to 50, 000 tons could constitute the domestic cargo.

The two major international and domestic airports are Phnom Penh and Seam Reap. The same concessionaire operates both airports; this assures reasonable levels of capital and maintenance funding for these facilities. The traffic is growing rapidly at the two major international airports driven by tourism. There has been also was constructed the domestic airports nearly completed in Kampong Chhnang province (during 1978-79), but now was not continued.

3. OTHER NATURAL RESOURCES AND THE ENVIRONMENT

3.1. Topography and Geology

The Tonle Sap area is about 80,000 Km² in the North-western of the Phnom Penh city. The elevation of this gentle fan plain is lowered to the center of the Tonle Sap Basin. It is from 1- 15m (lowland and along the lake shore line) to 25-30m (mid and upper land). The Tonle Sap Basin is dominated by the broad valley of the Tonle Sap drainage system, including the Tonle Sap Lake and Tonle Sap River, which joins the Mekong River near Phnom Penh. A depression lake from northwest to the southwest formed old bay, and the Mekong carried sedimentation during the diluvial and alluvial epoch. Then, highlands and hills were flattened and the present scenery was formed. The Geologic features of the mountains are Metamorphic rock, Proterozoic era, Sedimentary rock, Andesite and Basalt, Palaeozoic era and Mesozoic era. The feature of the different layer has 4 are:

- 1- Lower layer: Alternation of sedimentation by freshwater and sea. It contains sand, silt and mud.
- 2- Mid-Upper layer: It covers wide rang of the country and is called Battambang layer. It contains gravel, sand and clay and the thickness can be go up to 200m thick.
- 3- Upper layer in the alluvial epoch: It is found in the lowlands along with the Mekong.
- 4- Tonle Sap layer: It covers the central lowland composed of grey silt containing botanical residues, sand and clay.

3.2. Eco-regions

Three distinct eco-regions are identified¹ in the Lower Mekong including the Tonle Sap basin. They are:

- 1 Lower Mekong Flood-lands which include the Tonle Sap wetlands – Tonle Sap Freshwater Swamp Forest, Tonle Sap Mekong Pout Swamp and open water of the lake;
1. Cardamom Mountain Rainforest, and
2. Central Indochina Dry Forest including the Southern Indochina Dry Evergreen Forest.

These ecosystems are heavily modified over large areas by agriculture, both dispersed and shifting agriculture in upland forested areas and rice cultivation on the plains.

The three eco-regions are highly significant in relation to the management and use of the biological resources of the basin. Each eco-region has its specific characteristics and management requirements. The sustainable use and management of natural resources including water in the catchment area and in the lake depends on the appropriate management regimes for the underlying ecosystems. These management regimes provide the basis for natural resources policies and strategic planning of the basin.

3.3. Other Eco-regions

Name	Area	Characteristics
Tropical forest and grassland of Tonle Sap area	4,542,187 ha	Cutting flood-forest to create rice-growing land and rice ecosystem. Burning forest to create grassland.
Rivers and Lakes	284,650 ha	Create the freshwater with about 280 fish species and about 600 bird species from Tonle Sap River and Tonle Sap Lake;
Agriculture	1,578,706 ha	Increasing land is creating different biodiversity and rice ecosystem.
Resettlement of towns	12,256 ha	Villages and towns are linking infrastructure

¹ The Forests of the Lower Mekong Eco-region Complex, WWF, 2001

3.4. Land Resources and Use

The total land resources of the Tonle Sap Basin are presents about 80,000Km² and about 53% is covered by forest (which dense broad-leaved forest, flooded evergreen forest including mosaic of flooded forest and swampy vegetation). Refer to the land cover map of the Tonle Sap watershed from landsat TM in 1997 as show that the evergreen dense and evergreen disturbed forest accounted 16.22%, inundated forest and inundated forest mosaic is 3.38%, and 20% is use for agriculture.

The land use for agriculture is 1,578,706 ha or 19.92% and urban area is 12,256 ha or 0.15% of the total land use in Tonle Sap Basin. Remarkable land use change calculation showed that the flooded evergreen forest and mosaic of flooded forest has been lost and the paddy field, upland crops had been increased between 1991 and 1997. Land use changes, particularly those related to agricultural expansion, were also associated with the degradation of land resource in terms of erosion.

3.5. Ecosystems

There are many numbers of beautiful along the Tonle Sap River and Tonle Sap Lake, including natural ecosystem. The wetland ecosystem of Tonle Sap Lake, which expands to cover up to 16,000 Km² in the monsoon season, is great significance to the people living there. The flood forests ecosystem actually consist of a divers array of habitats including shrub lands, stunted swamp forests, gallery forests, submerged and flood aquatic vegetation and reed beds. About 200 plants species have been recorded. The Tonle Sap's floodplain swamp forest, generally surrounding by a broad belt of 20-30 km wide. The biodiversity is estimated that about 500 fish species in Mekong River basin and about 200 species occur in the Tonle Sap. There are three main ecosystems of TSB in relation to the management and use: 1-) Agro ecosystems is provided the goods as food crops and industrial crops. 2-) Forest ecosystems provide as fuel wood, rainwater (drinking or irrigation), food (honey, mushrooms, fruit and other edible plants). 3-) Freshwater ecosystems is the main ecosystem because water is the life. It provide as drinking, irrigation water, fish, hydroelectricity and other genetic resources.

3.6. Forestry

According to the ecosystem of the Tonle Sap watersheds, there are different types of forests each with a dominant group of trees species. In the Tonle Sap region the forest accounts for the largest portion of forest which covers about 4.21 million ha (53.13%). The other kinds of forests include deciduous forest, mixed forest, secondary forest, flooded forest and flooded secondary forest, which are found in the western Tonle Sap catchment.

Land cover map of the Tonle Sap Watershed shows that the evergreen dense and evergreen disturbed accounted for 16.22%, inundated forest and inundated forest mosaic is 3.38% and agriculture and mosaic of cropping represents 21.93% (Landsat TM, 1996-97).

According to the MRC/GTZ forest cover Monitoring Project, deforestation rate in the Mekong Basin declined to 0.5% per annum between 1993-1997, but inside Cambodia where deforestation has been increased by 13% (FCMP, 1999). Deforestation can therefore seriously affect the water regime and water quality as well as the livelihoods of the people living within the forested catchments areas.

4. SOCIAL FACTORS

4.1. The Poverty

The despite impressive quantitative achievements in the human resources and social sectors since 1979 and show wide disparities in access for the poorest segments of the population, especially in the rural areas, and for women. This is the result of a number of factors, including the hostilities and their aftermath, widespread poverty, the very low level of staff qualifications and training in the social sectors, provincial and district disparities, systematic and severe public under-funding, and the shortage of both strategic management and implementation capabilities. The percentage of the population that is below the national poverty line was about 40-60% and up to 80% in some locations at Tonle Sap Basin Area.

The Tonle Sap area, like all other Cambodia provinces suffers from the poor social condition like high unemployment, low level of education access, poor health condition, and gender disparities. The society and life of the different communities has their own characteristics throughout the plain from the lake to the foothills of the upper land areas. The socio-cultural differences observed are largely determined by geographical and environmental factors.

In Seam Reap province, the Office of Planning tried to estimate different vital data base on localized survey. The per capita annual incomes of a farmer in rural areas, a fisherman in Tonle Sap area and a trader in urban area are estimated as US\$ 80, US\$ 120, and US\$ 150, respectively. By NGO survey also shows that more than two-third of the population can have two meals per day.

4.2. Gender

Although government policy states that men and women have equal access to education and all should be educated, there is no practical measure to ensure that girls remain in school. The girls often do not complete primary education because they have to look after younger siblings, help with housework, and because being educated is not regarded as useful for a girl. The percentage of the girls enrolled in school is lower than 50% at all levels, and starts to become lower towards the end of primary school and drops sharply in secondary school.

The traditionally, Khmer women have borne heavy responsibilities in society from a very early age. A girl is in charge of household or productive activities, which limits her chance of education. After marriage, the married women take major responsibility for the care of children, domestic work as well as in the family income. A newly married couple is often lives with the wife's family until they can have a house and land of their own. The legal age for marriage is 18 for women and 20 for men, but people tend to marry earlier.

There is only one women's organization named 'Women's Association of Cambodia (WAC)'. The WAC is committed to promote women's equal rights, to encourage women to participate in all aspects of political, economic, social and cultural life of the country, to increase the educational level of women and to improve the welfare of women and children.

There are some projects are taken up in the Tonle Sap region by the Department of Women Affairs. They have some economic development programs like cow bank, pig bank, credit, and mix agriculture. There are many OIs and NGOs organizations active in the women development issues. These include International Women's Development Agency, UNICEF, UNDP, PADEK, ADRA, and many others. Most of them are focusing on education, health and income generation.

4.3. Minority People and Resettlement

Cambodian population over 85% are ethnic Khmer, and other minority people make up a further 13.6% of Cham, Vietnam, Chinese, and small numbers of various other races. In the Tonle Sap region are the Vietnamese and Muslim Cham representing up to 10% of the population. Even though most of the Vietnamese were born in Cambodia, they do not have Khmer national and are classified as immigrants. Around the Tonle Sap Lake, the Vietnamese are more concentrated. In Kbal Toal of TSB, Vietnamese minority consists of 74% of the population. The ethnic Vietnamese, many of them are fisher folk as professional fishing and aquaculture remain their traditional occupation. They will impact and affects the freshwater fisheries and seasonally inundated floodplains of Mekong.

5. INSTITUTIONAL ENVIRONMENT

5.1. Legal Basis for Natural Resource and Environmental Management

The roles and responsibilities of any future basin or sub-basin management organizations and particularly relating to any regulatory function to the water law. This law was drafted by Ministry of Water Resources and Meteorology (MOWRAM) in 1999 and finalized, endorsed by the Council Ministers and is with the National Assembly for ratification.

The drafting water law of relevant sub-decrees and operating guidelines for implementation by MOWRAM and municipal and provincial authorities. The Water Law's objectives include establishing principles governing the management, monitoring, utilization and protection of water resources to ensure their effective development.

The draft Water Supply and Sanitation Regulatory Law (MIME, 2003) is to facilitate private sector involvement in this sector and allows for the granting of franchises and the regulatory approach that would control the private operators. Other sub-decrees on Water Pollution Control and Soil Waste Management were endorsed in 1999 by MoE.

The Law on Environmental Protection and Natural Resources Management was prepared by Ministry of Environment (MOE) in 1996. The objectives of the law are to protect, manage and enhance the environment and promote socio-economic development. The Fiat Law on Fisheries Management and Administration is currently being revised with support from ADB.

The Land Law prepared with assistance from ADB-Ministry of Land Management, Urban Planning and Conservation, (MLMUPC) in 2001, addresses outstanding issues on land policy.

There are some other draft Natural Resources Laws, within the context of basin or sub-basin management organizations with responsibilities that take in the overall natural resources of the basin, they are: Forestry Law and Wildlife Protection Law that drafted by Forestry Administration.

5.2. Basin Development Goals

5.2.1. Economic

The major economic activities in the Tonle Sap Basin are reported as farming 85%, fishing 5%, trading 7% and service 3%. The policies, strategies and investment programs that Government intends to implement during 2001-2005 in order to reduce poverty by promoting growth with equity, social development, and sound environmental management. The Cambodia development goal of SEDP-II is poverty reduction. The target of the country wide is to reduce the poverty headcount index from 36% to around 31 %. This target is set in recognition of three facts as following:

- 1-First, the headcount index could be lowered further towards 20 % if the rate of growth in the agriculture sector exceeded expectations and rose to 5-6 percent;
- 2-Second, the index does not measure the depth and severity of poverty and must be supplemented by poverty gap and severity indexes.
- 3-Third, the development outcomes depend not only on effective Plan implementation, but also on a positive response from the private sector, ongoing political stability, and the absence of adverse natural and external economic shocks.

This last factor means that, in assessing Plan implementation and outcomes, an emphasis on policy variables that the Government can control is appropriate.

The goal of Sustained Economic Growth with Equity (SEDP-II) is the development targets as showing below:

- Real GDP (factor cost) average annual growth rate of 6.1%.
- Agriculture sector growth rate of 3.5%.
- Industry sector growth rate of 7.0%.
- Services sector growth rate of 8.0%.

5.2.2. Social/Cultural

The social/cultural goal for development a strategy to reform the public service (SEDP-II) detailing the sequencing & responsibilities for: (a) rationalizing pay and employment structure; (b) priority groups; (c) personnel management based on meritocracy; (d) timely payment of living wages; (e) donor-paid supplementation; (f) reconcentration. The detailed plan should also ensure that donor activities in this area are consistent & coordinated.

The Social/cultural development of the government's goal (SEDP-II) is focus the targets with the sources information of national multi-purpose household surveys; national accounts – National Institute of Statistics and Line ministry records as listed:

1. Infant mortality rate falls to 65 per 1,000 live births
2. Maternal mortality rate falls to 200 per 100,000 live births
3. Percentage of rural population with access to safe water rises from 29% to 40%.
4. Percentage of urban population with access to safe water rises from 69.5% to 87%.
5. Percentage of rural population with access to improved sanitation facilities rises from 8.6% to 20%; and, from 49% to 90% for the urban population.
6. There are 90% of 12 year olds completing Grade 6 and functionally literate and numerate.

5.2.3. Environmental

The environmental condition was carried out to grasp the current situation in water sources, water supply and sanitation condition, water use, and social relation. The development objective on environment with the primary goal is sustainable management and use of natural resources and the environment.

The government's environmental development goals is performed all action plans of improvements relating to stainable use of natural resources, e.g. protect and take action to enhance biodiversity, expand the network of protected areas, improve management of PA and NREM, implement international conventions. By the SEDP-II action plan priority during 2001-2005 is set the action "Consolidation and improvement of the conservation and sustainable management of natural resources and the environment".

5.3. Natural Resource and Environment Related Policy

5.3.1. Policy

Cambodia has rejoined the United Nations, has become a full member of ASEAN, and participates in various region economic initiatives, including development programmes in the Greater Mekong Sub-Region. Significantly for water sector, this outward-looking policy has included membership of the Mekong River Commission since 1995.

The RGC set out the policy for the Second Five Year of Social and Economic Development Plan (SEDP-II) in with the main and immediate policies are the poverty reduction of people in the rural area. It will reduce the poor people and improve people's living standard and well-being of the people that poverty that stipulated in the National Program on development.

In summary of government's national policy, which give rise to the natural resources and environment as following:

- Consolidation of peace, stability and social order;
- Investment promotion;
- Domestic resource mobilisation;
- Allocating investment to priority development sectors and improving agriculture productivity;
- Building institutional capacity and strengthening good governance;
- Integrating the economy into the region and the world;
- Human resource development; and
- Partnership with the donor community and civil society.

5.3.2. Strategies and Action Plans

For second five year period 2000-2005 of the strategy and action plan has been adopted by Minister of Ministry of Water Resources and Meteorology on water sector in November 30, 2000. In practice, the Government's Socio-Economic Requirements and Proposals indicate actions for sub-sectors of water sector and for water resources management in terms of project proposals. The most of them involve international agencies.

The national strategic plan in the water resources is preparing the rehabilitation of irrigation systems, flood protection dikes, water supply, formulating laws, sub-decrees and provisions for water management, watershed map and study-design of multi purpose of hydropower.

The National poverty reduction strategy 2003-2005 (NPRS) indicate the priority reduction actions are: maintaining macroeconomic stability; improving rural livelihoods; expanding job opportunities; improving capacities; strengthening institutions and improving governance; reducing vulnerability and strengthening socio inclusion; promoting gender equity; and priority focus on people.

The national environmental action plan, 1998-2002 (NEAP) has integrated the environmental concerns into economic activity and concentrating on environmental protection. The areas of priorities intervention are forestry policy, fisheries and agriculture in Tonle Sap, coastal fisheries management, biodiversity conservation and protection areas.

The national biodiversity strategy and action plan 2002 (NBSAP) created with a view towards integration of biodiversity conservation and sustainable natural resources use concepts into an overall poverty reduction strategy and provide the framework for action plan at all level.

In March 2002, the FA issued a draft on Statement of the Royal Government on Forestry Policy and solicited comments from stakeholders. The forestry policy will be developed within the broad objectives of environmental protection, biodiversity conservation, poverty reduction and economical development. The SEDP II recognizes that forestry policy and management are needed to serve the people living in and near the forested areas.

The under the Tonle Sap Environmental Management with review of fisheries legislation, a five-year Tonle Sap fisheries management plan is being prepared that important to sustainable management of conservation of natural resources.

The Basin Development Plan covers the key areas of irrigated agriculture; watershed management, fisheries; hydropower; navigation, transportation and river works, and other water related.

5.4. Regional Collaboration

MRC and CNMC try to develop collaboration with regional neighbours in the Greater Mekong Subregion (GMS), CNMC also seeks to develop collaboration among 10-11 key ministries in Cambodia, Lack of collaboration mechanism for Tonle Sap region /basin

The major ministry has responsibility for water is the Ministry of Water Resources and Meteorology (MOWRAM) that has organisational structure (December 2000) and has 759 staffs in the headquarters, and 830 staffs in 24 provincial and municipal departments. Provincial departments are responsible in the MOWRAM organisation chart directly to the Minister and to Provincial governors for operational matters.

Arrangements for inter-Provincial coordination are made (as also some other Ministries), if at all, in the context of the structure of MOWRAM lines of reporting and accountabilities, coordination of Provincial government through the Ministry of Interior, and project implementation. Coordination is also achieved through many workshops and other meetings, arranged by government and external support agencies.

5.5. Collaboration with External Support Agencies

MRC is a key supporting organisation, ADB, GEF, UNDP, and International Conservation NGOs are helping the TSBR. ADB has other projects, e.g. NW Irrigation Project (Need to develop a list with help of CDC). The external support agencies are involved in several sub-sectors of the water, agriculture, and environment sectors, particularly in irrigated agriculture, water supply and sanitation. In the water sector as a whole, ABD is providing technical assistance to the MOWRAM in capacity building. There are 17 water-related projects in the Official Development Assistance/Public Investment Program for 2000-2002.

The Council for Development of Cambodia/Cambodian Rehabilitation and Development Board (CDC/CRDB) is the focal point for coordination of international development assistance (IDA), and seeks to direct IDA to priority sectors and geographical areas. The IDA flows outside the Government's budgetary processes, e.g. as NGO assistance in establishing rural water supply systems.

6. CAPACITY FOR WATER RESOURCES MANAGEMENT

6.1. Organisational Arrangements

The Cambodia National Mekong Committee is an institutional advisor to advise the Cambodian representative to MRC Council on all matters relating to activities within the Mekong River basin that could affect Cambodian interests. The Ministry of Water Resources and Meteorology is an institutional manager for responsibilities defined by RGC Sub-Decree in 1999 include: define policies, research, manage direct and indirect, gather hydro-meteorological data, provide technical advice, and strategic development relating to water resources.

The Ministry of Industry, Mine and Energy is responded the planning water uses for hydropower, and water supply to provincial towns. The Ministry of Rural Development is responded the hydrogeological data collection for MOWRAM, water supply and sanitation, and small land drainage in rural areas. The Ministry of Public Works and Transport is responded the land drainage and sewerage in Phnom Penh and provincial towns, survey of river work for navigation and water transport. The Phnom Penh Water Supply Authority is responded only water supply in Phnom Penh and Municipality of Phnom Penh.

Ministry of Environment has a mandate to protect Cambodia's natural resources and environment quality from degradation. Its legal mandate includes water in the list of media for which it is responsible. Ministry of Agriculture, Forestry and Fisheries is engaged in development of policies and strategies for agriculture, forestry and fisheries that have significant implications for the management of the water resources required for irrigation and capture fisheries/aquaculture.

The Provincial governments have an oversight and coordinating role with regard to the provincial departments of ministries with water-related responsibilities.

6.2. Community, NGO, and Other Stakeholder Participation

Rural development, coordinated and planned by the MRD in the context of SEILA, PRASAC and other programs, increasingly has been implemented through rural development committees at provincial, commune and village levels. The SEILA program in particular has been a significant element in building the RGC's strategy to pass as much responsibility as possible to the community.

The EU supported PRASAC has incorporated Water Point Committees for domestic water supply and Water User Associations for irrigation system in its interventions in over 1,250 villages in 6 provinces around Phnom Penh. UNICEF-assisted Water and Environmental Sanitation program.

MOWRAM-supported the irrigated agriculture development for all aspects of scheme operation to Farmer Water User Communities with Circular No.1 on Sustainable Irrigation Policy since 1999. FAO-intervention special Program for Food Security during 1997-2000, establishing Water User Group/Association.

6.3. Private Sector Participation

The policies on urban water supply and sanitation affirm that private sector provision of these services will be favoured. At present, 3 towns have privatised water supplies, using different models of privatisation.

The private sector activity in irrigation is limited principally to that base on groundwater, where individual farmers are able to install wells and pumps independently. Another means of private sector participation in water is through water vendors, who supply water in localities, particularly in Phnom Penh, where pipe water is unavailable.

6.4. Information Base

6.4.1. Historical Data Available

Theme	Dataset Name	Description of Dataset	Agency Responsible
Meteorology and hydrology	Program: Hymos and Format Excel	All hydrological and meteorological data can setup in the program Hymos, including water quality.	1- Department of Meteorology, (MOWRAM) 2- Department of Hydrology and River Work, (MOWRAM)
Other natural resources	Program: dBASE-V	Groundwater Database Management: Groundwater level; Location well sitting; well diameter, mm; discharge Q, m ³ /h; Lithological description.	1- Department of Water Supply and Sanitation, (MOWRAM)
Environment	National GIS	Map design on forestry, land use, land protected, national park and others	Department of GIS (Ministry of Environment)

Socio-Economic	National Census; National statistics etc. Program: SSP and Format Excel	All Socio-Economic data can setup in SSP program.	Department of Statistic (Ministry of Planning)
----------------	---	---	--

7. PRIORITY BASIN MANAGEMENT NEEDS

The needs and priorities for Basin Management as following:

- Reduce poverty
- Reduce pressure of population use of natural resources to sustainable levels
- Support alternative livelihoods with acceptable impacts on natural resources
- Enough water supply and safe water being assured
- Maintain basin wide ecosystems
- Harvest natural resources sustainability
- Ensure management of water for seasonal fish migration routes and maintain spawning and juvenile areas
- Rehabilitation irrigation system
- Extend area under irrigation
- Improve waterway and management of water for navigation
- Improve mechanism of flood mitigation
- Develop hydropower including micro hydropower at the local level
- Determine boundaries of the managed flood plain
- Determine boundaries of protected ecosystems
- Expand ecotourism and cultural tourism

8. INVESTMENT

8.1. Sources of Funds

In Cambodia, most funds for the development of public infrastructure are from the national budget and foreign aid. Funds for repair and reconstruction of hydraulic systems since 1979 were donated by national and international, non-government organizations and a number of donors such as the EU, France, Japan and Republic of Korea, DNIDA, CIDA, DfID, Finland, etc.. Another part of these funds was loans from the World Bank, ADB and IFAD. A List of funding organisations who are interested in water related might be available from CDC. Including International NGO Water Aid, UNDP country office Mr Olivier Standaard might also advise.

The public water supplies in most provincial towns are under the management of MOWRAM and MIME, and there have been limited funds for maintaining or operating the system. Water supplies in rural areas are under management of MRD, with technical assistance from national and international NGOs.

8.2. Past Investments

Investment funds for water resources planning, management and exploitation in the last 5 years (million USD)	ODAs	Domestic	TOTAL
Water management	26.4	0.27	26.67
Irrigated agriculture and drainage	56.95	2.46	59.41
Flood protection	10.9	0.22	13.1
Municipal/domestic water supply and sanitation	35.85	1.62	37.47
Rural water supply and sanitation	48.25	9.65	57.90
Hydropower	0.0	0.0	0.0
Integrated rural development	N/A	N/A	N/A

8.3. Current Projects

Project Name	Major Purpose	Capacity/Scope	Estimated Cost (,000 US\$)
Small scale irrigation system	Rehabilitation	2004	303
Stung Chinit irrigation system	Rehabilitation	2004-2007	27,000
Irrigation system of 14 projects	Feasibility study	2004	189
Irrigation of 39 schemes	Rehabilitation	2004	2,000
Hydrological network	Improvement	2004	100
Small scale irrigation system	Capacity building	2004-2006	2,000
Flood emergency of irrigation	Rehabilitation	2004-2005	1,855
Farmer Water User Communities	Water Use	2004-2006	313

8.4. Proposed Future Investments

8.4.1. Investment Options

Refer to Cambodia's National Biodiversity Strategy and Action Plan and the National Assessment of Implementation of Agenda 21, the proposed future investment of the Tonle Sap recommended action commitments may be two projects:

1- Tonle Sap Great Lake Floodplain, that will integrated management programs (including land-use planning, resource zonation, community development, small scale industrial development, fish and agriculture production processing, involvement of local authorities) and cooperated implementation of MAFF, MOE and other relating ministries.

2- The Regional Landscape Approach on Tonle Sap Area: (Kampong Chhnang, Pursat, Battambang, Siem Reap and Kampong Thom provinces). The project can have maximum measurable impact and demonstration effect on grassroots communities if a geography focus or foci is adopted.

Siem Reap Water and drainage possibly JICA

8.4.2. Priorities stated by key stakeholders

Both projects may be priorities stated by the key stakeholders that cooperated implementation of Ministry of Agriculture, Forestry and Fisheries (MAFF), Ministry of Environment (MOE) and same other relating Ministries.

8.4.3. Details of “pipeline” projects

Project Name	Funding Source	Major Purpose	Estimated Cost	Proposal Stage
Tonle Sap Biosphere Reserve (TSBR)	1-GEF 2- ADB Loan; UNDP-Capacity 21; ADB-Nonlending Assistance and Other International.	- It will preserve its unique ecology and hydrology, and retain the many benefits provided by its natural resources. - It will assist the country in identifying and protecting globally significant biodiversity in and around the Tonle Sap area. - It will help to develop an appropriate policy and legal framework to protect and management the natural resources of Tonle Sap.	US\$ 20,544,000	
Protection and Management of Critical Wetlands in the Lower Mekong Basin	5822-REG, ADB, 1998.	- To prepare a detailed proposal for investment to develop and support community-based integrated management systems for the fisheries, forestry, and agricultural resources of the Tonle Sap.	US\$ 1,650,000	
Tonle Sap Environmental Management	L1939-CAM; 2002; ADB	- To enhance systems and develop the capacity for natural resource management and biodiversity conservation in the Tonle Sap Biosphere Reserve	US\$ 10,910,000	
Improving the Regulatory and Management Framework for Inland Fisheries	T3993-CAM; 2002; ADB	- To improve the regulatory and management framework for inland fisheries, with special attention to the sub-decree on community fisheries.	US\$ 560,000	
Capacity Building of the Inland Fisheries Research and Development Institute	T4025-CAM; 2002; ADB	- To kick-start the Inland Fisheries Research and Development Institute as an efficient, effective, and relevant research and development institute.	US\$ 900,000	
Establishment of the Tonle Sap Basin Management Organization	T4212-CAM; 2003; ADB	- To design, and plan the development of, the institutional framework for integrated basin planning and management	US\$ 135,000	

Tonle Sap Basin Profile

Tonle Sap Sustainable Livelihoods	[T4197–CAM; 2003; ADB, Finland].	- To prepare a project to sustain and improve livelihoods in the flooded area of the Tonle Sap.	US\$ 1,260,000	
Other non-ADB				
Chong Kneas Environmental Improvement	[T3997–CAM; 2002; Finland].	- To prepare a project to improve the social and natural environment at Chong Kneas.	US\$ 997,000	
Living with Floods on the Tonle Sap	6123–REG; 2003; CFWS.	- To prepare a 20-minute video documentary on the living conditions of poor fishers on the Tonle Sap.	US\$ 85,000	
Participatory Poverty Assessment of the Tonle Sap	[ADTA; 2003; DFID]	- To improve the awareness and understanding of Government agencies, stakeholders, and the general public regarding the causes and nature of poverty in the Tonle Sap region.	US\$ 250,000	