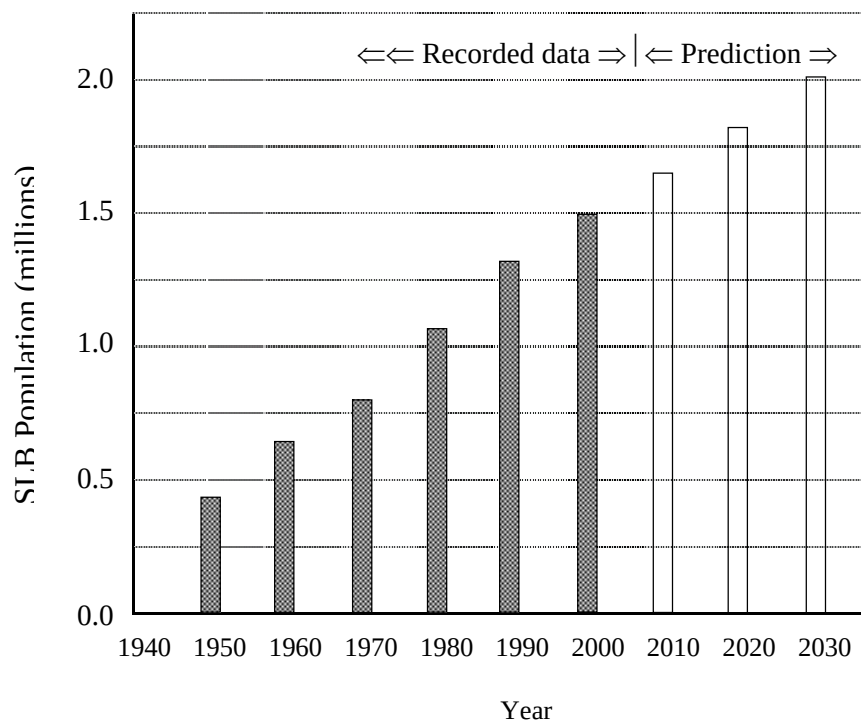


2 ENVIRONMENTAL SETTINGS AND ISSUES

History of Songkhla Lake Basin dates back more than 6,000 years. The Basin population in 2004 totaled approximately 1.6 millions: 69% of which resided in rural area; while 31% were in urban area. Major portions of population are Buddhists and Muslims. Much smaller portions are Hindus, Christians, and others.

From best available statistics, it was found that, in 1950, approximately 430,000 inhabitants lived in SLB; the population has since steadily increased. Assuming that the population increase remains at present rate (approximately 1% per annum), it is estimated that approximately 2 million people in 25 years time will call SLB a home in 2030. It is also anticipated that urban population will increase at a much higher rate, as compared with that of the rural. Fig. 3 indicates the increase of SLB population during the years 1950 – 2000, and predicted population until the year 2030.



Source: (1) NSO, 1970; 1980; 1990 and 2000.
(2) <http://www.library.uu.nl/wesp/populstat/Asia/thailanp.htm>

Figure 3 SLB Population during 1950 - 2030

2.1 NATIONAL RESOURCE AND ENVIRONMENTAL SETTINGS

The Songkhla Lake Basin has in the past undergone rapid social and economic development. Such process has exploited, and before long depleted and deteriorated, the once abundant natural resources. The conflicting issue of utilization vs. conservation of natural resources and environment has become more and more critical, and oftentimes developed into serious social conflicts. In order to maintain a balance between sustainability and social welfare, ecological settings of the SLB must be properly and systematically assessed. This will enable us to understand the root causes of the problems, and consequently to identify effective strategies for the Basin management. This in turn will ensure a delicate balance among ecological system, socio-economic system and community ways-of-life, which will lead to sustainability and betterment of quality of life.

2.1.1 Forest Resources

(1) Forest in Upstream Watershed Area

Forest in upstream watershed area of SLB situates in two major mountain ranges: The Ban Tad mountain range and a comparatively lower mountain range that is part of Sangala Kiri. Both mountain ranges are covered with rainforests. Studies revealed that the Basin was in the past healthy. A great number of flora species were identified: in Thale Noi, Smet khao, Dam tako, Chik nam, etc. were found; in Upper Songkhla Lake, Chik nam, Krathom muu, etc. were found; in Lower Songkhla Lake, mangrove forest species, such as Kongkaang bailek, Ta buun khao, Taatoom thale, were found.

A few studies, however, suggested the declining trend of the flora in the Basin. For example, it was found that a number of selected species have either depleted or become rare, e.g., Mao khai plaa, Kaang plaa, Chiat. In Khu-Khut Non-hunting Area where Di pli nam was reported to be abundant in the 1983-1985 study; only a handful, if any, was found at present. Serious declining trends of several other species have been noted.

SLB has undergone a number of changes, both from natural devastation such as forest fire and siltation, and man-made activities such as forest encroachment. These changes led to deterioration of the Basin ecological system, and consequently declining number of flora and fauna. Urgent measures are needed in: (1) collection of relevant data and information as well as integrated study of the SLB system, and (2) planning and development and rehabilitation for the betterment of SLB environment.

(2) Forest in Conservation zone

Conservation zone, which is part of National Reserves, in SLB comprises: (1) National park (2) Wildlife sanctuary (3) Non-hunting area (4) Forest park.

- **National parks:** These refer to the pristine public land that holds specific identity. Such pieces of land typically comprise of hills and mountain ranges, isolated from human settlements, free from human disturbance. They should be preserved for natural balance, for study about natural resources, as well as for leisure of public-at-large. *The national parks in SLB comprise:*

Khao Pu – Khao Ya National Park. Covering an area of approximately 694 sq.km., it situates in Thung Song and Cha-uad Districts, Nakhon Si Thammarat Province; Muang, Huay Yod, Rasada, Na-Yong Districts, Trang Province; and Si Banphod, Pa Payom, Kong-rha, Si-Nakarin Districts, Phattalung Province. Most area is rainforest. Economic flora species include: Takhian thong, Lum pho, Yaang, rattan and various herbal species; Fauna species found include: rib-faced deers, tapirs, bears, monkeys, gibbons, as well as a number of bird species.

Khao Nam Khang National Park. Covering an area of approximately 212 sq.km., it situates in Nathawee and Sadao Districts, Songkhla Province. It possesses healthy forest and natural resources, as well as a number of natural beauties including waterfalls. Most areas are rainforests with dense and healthy trees. Economic species include Lum pho, Takhian, Payom, Krabaak dam, Yaang, Sayaa daeng, etc; Fauna species found include: wild boar, bear, serow, rib-faced deer, gibbons, tapirs, leopard or panther, as well as a number of bird species.

- **Wildlife sanctuaries:** These refer to land stipulated in the national decree to be a wildlife sanctuary under the National Wildlife Preservation and Protection Act. This is aimed at providing safe habitat for animals, preserving wildlife species, and increasing their number. *The wildlife sanctuaries in SLB comprise:*

Toan Nga-chang Wildlife Sanctuary Covering an area of approximately 182 sq.km., it situates in Hat Yai and Rataphum Districts, Songkhla Province; and Kuan Ga-loung District, Satoon Province. Most areas are rainforests. Economic species include Lum pho, Takhian thong, Takhian hin; and species which contribute to food source for wildlife including Ma-khaam pom, Ngho paa, Sato, etc. A number of fauna species are found including elephant, tapir, tiger, leopard or panther, fishing cat, mouse deer, bears, bats, gibbons, monkeys, flying lemurs, etc. as well as over 200 bird species.

Khao Ban Tad Wildlife Sanctuary Covering an area of approximately 1,270 sq.km., it situates in parts of four provinces along Khao Ban Tad range, i.e., Phattalung, Trang, Songkhla and Nakhon Si Thammarat. Most areas (80%) are rainforests. Valuable species include Lum pho, varieties of Takhians, Khai khieo, Khaa naang, etc. The remaining 20% of the area is Evergreen Hill Forest Fauna species found include avian such as great hornbill, great argus, etc., and mammals such as deer, tiger, tapir, mouse deer, serow, rib-faced deer, gibbon, monkey, flying lemur, squirrels, etc.

- **Non-hunting Area:** These refer to the land designated for common public uses. Designation of non-hunting area must be declared by the Ministry of Agriculture and Cooperatives. The declaration must incorporate a list of types and species of animals that can neither be hunted nor harmed, as well as an appended map of the non-hunting area. *The more important non-hunting areas in SLB include:*

Thale Noi Non-hunting Area Covering an area of approximately 457 sq.km., it situates in parts of three provinces of SLB, i.e., Phattalung, Songkhla and Nakhon Si Thammarat. Eleven per cent of which covers 3 forest reserves totaling 50 sq.km.: Klong Yaun National Reserve with an area of 10 sq.km.; Hua Pa-kiew, 9; and Pa Ban-Nailoom, 31. The remaining area are: animal grazing land which covers 112 sq.km. (25%); wasteland, 136 sq.km. (30%); and land with legal property right, 160 sq.km. (35%). The Thale Noi Non-hunting Area is the home of various bird species. At least 182 species have been found. Rare species include painted stork. Moreover, the reservoir is rich in fish species.

Thalesab Songkhla Non-hunting Area (Khukut) Covering an area of approximately 365 sq.km., it situates in Satingphra, Singha Nakhon, Kuannieng, and Krasae Sin Districts, Songkhla Province. Majority of its area is water body with several isles and islets. Larger ones are Mhak islands and Nang Kham islands in Pak Payoon District, Phattalung Province. Smaller ones include Banthom, Phae, Sue, Tamhieng, Rang kai, Yai Sou and Kra islands. Flora species found in, and along the bank of, the lake include Faat, Pho thale, Ta buun, Kongkaang, Lamphuu, Chaak, seagrass and seaweed, etc. Species found in the rainforests on the islands include Yaang, Chik nom, Takhian, etc. Most larger islands have recently been more populated, forest lands have been transformed into rubber plantation and economic crops. A number of waterfowl species, both migratory and local, have been observed. There are 13 rare species, these are spot-billed pelican, grey heron, white-bellied sea eagle, painted stork, lesser adjutant, white ibis, crested serpent eagle, pied harrier, eastern marsh-harrier, osprey, white-browed crane and weathered hornbill.

- **Forest Park:** These refer to areas in the forest that possess natural beauty and identity, suitable for leisure. Forest parks cover smaller area compared to national parks. Structures and facilities, such as tracks, roads, name tags for trees, may be added to the forest parks to facilitate tourists, without too much disturbance or deterioration to the area. *The more important forest parks in SLB include:*

Chai Buri Old Town Forest Park. Covering an area of approximately 1,875 rais (3 sq.km.), it situates in Muang District, Phattalung Province. It is a steep limestone hill covered with rubber trees, surrounded by paddy rice fields. Most area is evergreen forest. Economic flora species include: Takhian hin, Yaang sian, Krabaak Liang, wild mango, Sai liap, Ngio, Phai, Phlong, Faat, Kao and various herbal species including Khon Thi dam, Khon Thi daeng, Chan daeng, Salatdai, Di Pli chueak, Khop cha nang dum, Khop cha nang khao, Dee nguu, etc. Fauna species found include several species of apes, pangolin, civet, mouse deer, squirrel, flying lemur, porcupine, slow loris, bat, as well as a number of bird species.

Kuan Khao Wang Forest Park. Covering an area of approximately 2,038 rais (3.3 sq.km.), it situates on a small hill, at approx. 200 m. MSL, in Hat Yai and Rattaphum districts, Songkhla Province. Economic flora species include: Payom, Praduu, Kan krao, Lum pho, See siat, Yaang naa, Fauna species found include: deer, squirrel, yellow tree monitor, mouse deer, reptile as well as various bird species.

(3) Wetlands and Peat Swamp Forest

Wetlands play important role to ways-of-life of people in the area and its vicinity. Wetlands serve as water storage, flood mitigation mechanism, shoreline stability protection and erosion prevention, groundwater recharge, water filtration, nutrient storage, sediment and hazardous materials trap, etc. Moreover, wetlands are typically rich in biodiversity. It is a sanctuary for birds, especially waterfowls.

Peat swamp forests are forests in wetlands. The area is covered with water all year round. Most of the soil is organic, and is originated from decayed trees and animals. The area receives water from precipitation, and has little, if any, natural drainage capacity. Flora species in peat swamp forests include trees, shrubs, grasses and aquatic plants. *Prominent peat swamp forests in SLB include:*

Kuan Kee Sian Peat Swamp Forest. This is the first Ramsar Site of the nation and is listed in the "*List of Wetlands of International Importance*". Covering an area of 3,088 rais (4.9 sq.km.) within the Thale Noi Non-hunting area, it is a fresh water swamp, containing Smet khaao, La pho, Kra chut, Kra chut nuu, Ku ra, Yaang naa, Kasae, Chait; and various palm tree species. The forest serves as habitat, food source and nesting ground for waterfowls, both migratory and local, such as purple heron, little cormorant, cattle egret, little egret. In migratory seasons, Black - headed ibis, on the verge of extinction (on the near-extinction list of IUCN³), can occasionally be observed.

Kuan Khreng Peat Swamp Forest. This is the second largest swamp in southern Thailand, after Toh Daeng Swamp Forest in Narathiwat Province. Having its area reduced from almost 320 sq.km. to a mere 137 sq.km. at present (Year 2004) astriding the boundaries of three provinces of SLB: Phattalung, Songkhla and Nakhon Si Thammarat, it receives runoff from Ban Tad mountain range in the west, as well as another hill chain in Ron Phibun and Cha-uad districts in Nakhon Si Thammarat Province, before draining into Songkhla Lake. It also drains into Klong Kuan which connects to Pak Panang River and Klong Daen which drains into the Gulf of Thailand. Dominant trees include Smet khaao, Samet chun. Dominant seasonal plants include Kra chut nuu, and Haeo song krathiam. Kuan Khreng Peat Swamp Forest is the habitat of a number of waterfowl species. At least 31 species have been listed; for example, purple heron, black bittern, painted stork, etc. Deterioration of the swamp has led to an alarming decline of waterfowls with some close to extinction such as the painted stork.

³ IUCN = The World Conservation Union

Massive destruction of Kuan Khreng Peat Swamp Forest occurred during WW II when it was hit by a major storm. This was followed in consecutive years by severe drought and several forest fires. After these assaults, *Mellaleuca* developed and spread rapidly. Top soil was disturbed and became acidic. Thereafter, aquatic animals dwindled, hundreds of hectares of Kra chut was destroyed.

Encroachments by surrounding settlements, as well as other socio-economic development process, have accelerated deterioration of the swamp. Other problems in the Kuan Khreng Peat Swamp Forest at present are illegal fishing practices such as fish electrocution, drug dosing and land impoundment of fishes. Other problems are Kra chut cutting, wood scavenging, forest fires and land encroachments.

(4) Mangrove Forest.

Once abundant in natural resources, Songkhla Lake natural resources have in the past few decades seriously hampered. Among the worst hit is the mangrove forest, which serves as habitat of various flora and fauna. Moreover, mangrove forests help abating natural disasters, reducing shore erosion by wave actions, functioning as traps for sediments, wastes and hazardous materials. Although assessments of mangrove forest in the SLB have been conducted since 1961, data were cursory and not at all reliable. This is due to the fact that surveying methods had not been standardized. In certain year, the swamp (*Mellaleuca*) forest was included in the mangrove; while in other years, it was not. Table 1 depicts 2001 official data retrieved from Royal Forestry Department. Disregarding the questionable data in year 2000 (See Notes under Table 1), derived information indicated that during the 35 years (1961 – 1996), mangrove forest in Songkhla Province has been halved; while that in Phattalung Province decreases tenfold. This has led to severe environmental impacts in the Lake.

Table 1 Mangrove Area, Years 1961 and 2000

Province \ Year	Mangrove Area (Rai)				
	1961*	1986*	1993*	1996*	2000**
Songkhla	8,125	6,031	3,425	3,896	29,344
Phattalung	8,750	656	800	881	19,631

Source : * [http://www.forest.go.th/mgrove/Area04-39\(1\).html](http://www.forest.go.th/mgrove/Area04-39(1).html)

** <http://www.forest.go.th/stat/stat45/TAB3.pdf>

- Note :
- (1) The study team to whom the 2000 data was referenced stated that the data was obtained by interpretation of satellite images (Landsat 5 TM, year 2000) without ground truth verification;
 - (2) Difficulties in acquiring “good” piece of land use information are widely known. Several factors contribute to discrepancies of these data, e.g., Scale of interpretation (macro level, national level, etc.); Interpreters’ interests (certain agencies are interested in certain categories of land uses)

2.1.2 Biodiversity

(1) Aquatic Fauna and Waterfowl

The study of diversity of aquatic lives in the SLB practically began only some 30-40 years ago. They are however scarce, scattered and fragmented. Studies were often conducted during short periods and within confined study areas. A number of studies seemed very localized. Others allowed too long time intervals between studies, thus making data comparison and interpretation difficult, if possible at all. Although there are numerous academic papers on SLB biodiversity, these were based on only a handful of primary data. Others were based on mere observations, without proper data collection; thus lacking scientific assurance for accuracy and precision of data and information acquired.

- **Fish:** is the aquatic animal that attracted most attention from researchers. Several studies have been conducted since 1965 by the National Institute of Coastal Aquaculture (NICA), Phattalung Fresh Water Fishery Station and Prince of Songkla University. Study in year 2002 listed 450 species. Economic and abundant species in SLB include: Brown Spotted Grouper, Giant Perch, Grey Mullet, Marine Catfish, Cyprininds, Sand Goby, etc. Moreover, a number of studies were made on species, sizes and distribution of fish and other aquatic fauna caught by various types of fishing gears such as the winged set bag and cast net.
- **Waterfowl:** During 1978 – 1980, the Thailand Institute of Science and Technology Research (TISTR) conducted a 2-year study on waterfowl in Thale Noi Non-hunting Area and Thalesab Songkhla Non-hunting Area (Khukut). The study listed 44 families, 137 gena, and 218 species. The study also identified 13 rare species. This study enabled us to better understand status of waterfowls; as to which species were local; which were migratory; which were abundant during particular time periods; which were rare. Unfortunately since then there have been no surveillance programs for bird population in either non-hunting area. In particular, there have been no information about rare species which are utmost important indicators of conservation zone.

(2) Swiftlets or *E-An* in the SLB.

According to the 1997 decree on swiftlet nest excise duty, *E-An* means swiftlet that produces edible nests. Swiftlets found in caves on isles in the SLB are of 2 categories: **Edible-nest swiftlet** and **Black-nest swiftlet**. Both kinds are local in Thailand and are covered by law as protected wildlife.

Edible-nest swiftlets are small birds with length from beak to tail of around 12 cm., its back tan or black, its rump white or near white. They flourish in caves on isles, coastal areas and urban settlements near rivers. Outdoor activities are during daytime, at night will gather in large clusters around their nests on cave walls and resume activities outdoors in the morning over swamps in valleys or forests.

Black-nest swiftlet are more or less similar to the *Edible-nest swiftlets* except the slightly bigger size, the brown or black rumps, more hairy shins and curly-end rectangular tails. They flourish in limestone caves near shores or on isles.

Collection of bird nest and its associated business have flourished in Songkhla Lake for more than 400 years. At present, the Thai government is reaping 500 million Bahts for a 5-year concession grant to harvest on the Bird Nest Islands (Ko Si-Ko Ha) in Tambon Ko Mhak, Phattalung Province.

Bird nests from *Edible-nest swiftlet* contains only the bird's saliva, usually called *white nest*. The nest is edible and expensive. That from *Black-nest swiftlet* contains saliva and feather, usually called *black nest*. Feather must be removed in processing and hence the nests are cheaper. In general, high quality bird nest price fetches around 80,000 - 100,000 Baht per kg. A total 1,970 kg. of bird nest were harvested from the Bird Nest Islands, Phattalung in 1998; and 2,638 kg. in 2002.

2.1.3 Land Use

Land use pattern in SLB has undergone significant changes during the past few decades, following socio-economic and demographic changes. According to information as of now (Year 2002), majority of SLB land, 5,660 sq.km. (3,537,827 rais – approx. two-thirds of the Basin area) is used for agriculture. Most of the agricultural land, 60% and 30%, respectively, is used for rubber plantation and paddy rice. Second land use category is forest, which occupies 1,164 sq.km. (727,426 rais - 13.7% of the Basin area); most of which is the rainforest covering upstream area on the hillsides, the remaining areas are mangrove and swamp forest. Other land use categories are natural water body (1,060 sq.km. or 661,848 rais or 12.5% of the Basin area); residential area (224 sq.km. or 139,837 rais or 2.6% of the Basin area). The remaining are for miscellaneous purposes, such as industrial area, man-made water body, roads and undeveloped land. (Table 2)

Table 2 Land Use in Songkhla Lake Basin, Years 1993 and 2002

Unit : rais (Figures in parentheses indicate ratios to the Basin area in per cent)

Land Use Category	Area		Change
	1993 ^{1/}	2002 ^{2/}	(%)
Residential area	120,224 (2.26)	139,837 (2.63)	16.3
Agricultural land	2,982,508 (56.17)	3,537,827 (66.63)	18.6
Paddy rice field	1,412,916 (26.61)	1,126,211 (21.26)	-20.3
Abandoned rice field	*	83,340 (1.57)	*
Rubber plantation	1,428,753 (26.91)	2,125,775 (40.04)	48.8
Mixed orchard, oil palm, etc.	120,373 (2.27)	161,273 (3.04)	34.0
Shrimp farm	20,466 (0.39)	31,341 (0.59)	53.1
Forest land	974,376 (18.35)	727,426 (13.70)^{3/}	-25.3
Water body	*	668,668 (12.59)	*
Natural	*	661,848 (12.47)	*
Man-made	*	6,820 (0.13)	*
Others	*	245,485 (4.63)	*
Total	**5,309,356 (100)		

Note:

* Some figures in Table 2 were deliberately omitted. They appeared as such in the referenced document, and no effort was made to alter nor modify the original information. Should we assume that the total Basin area and the area of water body remain unchanged, from 1993 to 2002, and that no abandoned rice field in 1993 (of which no data is available), the "Others" in 1993 would read 563,580 rais.

** In this study (Year 2004), the Basin area was resurveyed, and was found to be 8,729 sq.km. (ca. 5,455,600 rais). Part of the causes was due to construction of new roads which have turned out to be man-made boundary of the Basin. However, to avoid confusion in comparing the ratio of each land use category to the total Basin area, the original figure of 8,495 sq.km., prior to 2004 survey, were used to compute ratios as shown above.

Source: ^{1/} Dept. of Agricultural Extension, 1993 ^{2/} Land Development Department, 2002 ^{3/} The Study Team

(1) Forest Land

In 2002, only 13.7% of the Basin area was covered with healthy forest including rainforest, mangrove and swamp forest. This translates to 1,164 sq.km. (727,426 rais), as opposed to 1,559 sq.km. (974,376 rais), or 18.4% of the Basin area in 1993. From analysis of GIS data and 2002 aerial photographs, there are evidences of forest encroachment in the conservation zone in every sub-basin of SLB. In sum, approx. 147,614 rais, equivalent to 19% of forest in conservation zone, was encroached during the past 10 years, or averaging 14,792 rais per year (1.9% per annum). Most of the encroached forests have been transformed into rubber plantations, which in turn severely affect erosion.

(2) Rubber Plantation

Area for rubber plantation in SLB has increased from ca. 2,286 sq.km. (1,428,753 rais) in 1993, to ca. 3,401 sq.km. (2,125,775 rais) in 2002. This translates into an increase of 286,705 rais, or approx. 48.8% in 10 years, or an increase rate of approx. 28,670 rais/year. Rubber has long been a very popular economic plant in SLB, despite latex price fluctuation. Now (Year 2004) that the price of latex has become higher and more stable, the plantation area is expected to rapidly increase. Besides forest encroachment, past few years have seen transformation of paddy rice fields in highland into rubber plantation, rendering further decrease in rice farming area.

(3) Paddy Rice Field

Paddy rice field in SLB covers central plains of Phattalung Province and large plains in Satingpra peninsula, which has long been considered the rice bowl of lower southern Thailand. Land Development Department (LDD) study indicated that paddy rice field in SLB has decreased from 1,412,916 rais in 1993 to 1,126,211 rais in 2002, a decrease of 20.3% (Table 2). The same study showed there were 83,340 rais of abandoned rice field.

(4) Shrimp Farming Areas

Shrimp farming in SLB began around 1987, and has expanded rapidly ever since, especially in Ranot District, Songkhla Province and Hua Sai District, Nakhon Si Thammarat Province. In 1991, there were approximately 15,000 rais of shrimp ponds, and expanded to 20,466 and 52,411 rais, in 1993 and 1995, respectively. In analyzing the 2002 satellite image, however, it was found that the shrimp farming area has reduced to approx. 31,341 rais, a decrease of approx. 40.2% compared to the 1995 figure. Shrimp ponds in SLB have in general been transformed from paddy rice farms, lowland and mangrove forest. Study showed that most shrimp ponds were transformed from paddy rice farms. Nonetheless, in terms of proportion of its original land, mangrove forest has been encroached most. The decrease of mangrove forest posed significant impact upon ecology of the area.

(5) Land Use Zoning in SLB

The study team has analyzed the impacts imposed by inappropriate land use, and consequent degradation of natural resources and ecological system in SLB, as well as constraints which have obstructed implementation of land use plan, in order to develop guideline for land use zoning in SLB. The study team's recommendations are as follows (Table 3):

- **Forest Zone**

Forest Reserve Zone: Should cover 954,124 rais or approx. 18% of the Basin area, this zone refers to forest in conservation zone, healthy forest in economic forest zone and forest outside national forest reserve but lies within steep slope mountainous area. It is recommended that the public be encouraged to participate in forest management, strict conservation measures be enforced, while wise common utilization should be regulated.

Economic Forest Zone: Should cover 251,495 rais or approx. 4.7% of the Basin area, this zone refers to forest designated as economic forest by Cabinet Resolution. Most areas are encroached forest, unsuitable for agriculture. They should be rehabilitated and used for planting trees of economic value, as well as to enhance biodiversity.

Table 3 Land Use Management Zoning in SLB

Management Zone	Area (rais)	%
1. Forest Zone	1,205,619	22.71
- Forest Reserve Zone	954,124	17.97
- Economic Forest Zone	251,495	4.74
2. Peat swamp forest/Mangrove forest zone	164,331	3.10
3. Paddy rice zone	1,327,278	25.00
- Irrigated / potentially irrigable paddy rice zone	719,608	13.55
- Rain-fed paddy rice zone	607,670	11.45
4. Tree planting zone	1,612,963	30.38
- Fruit orchard zone	475,616	8.96
- Rubber plantation zone	1,137,347	21.42
5. Agricultural / conservation zone	211,790	3.99
- Acidic soil / Peat swamp soil zone	191,393	3.60
- Saline soil zone	20,397	0.38
6. Water resource zone, fishery development zone, etc.	787,375	14.83

- **Peat Swamp Forest/Mangrove Forest Zone**

Should cover 164,331 rais or approx. 3.1% of the Basin area, this zone refers to peat swamp forest and mangrove forest which spread around the Songkhla Lake. The situation is now badly deteriorated, mostly due to coastal aquaculture.

- **Paddy Rice Zone**

Irrigated / Potentially Irrigable Paddy Rice Zone: Should cover 719,608 rais or approx. 13.6% of the Basin area, this zone refers to area where soil is fertile and which receives irrigated water sufficiently for planting more than one crop of paddy rice annually. Included in this zone is the additional area in the vicinity where potential exists for receiving irrigated water, and consequently can be used for planting paddy rice for export. They are, for example, areas near Ranot plain and irrigation zone in Phattalung Province.

Rainfed Paddy Rice Zone: Should cover 607,670 rais or approx. 11.5% of the Basin area, this zone refers to paddy rice farms where rice can only be planted and harvested during rainy season. This zone spread over places in SLB. They are the areas where mixed farming, based on subsistent economy concept, should be promoted. Paddy rice is to be planted during rainy seasons, while other economic crops with low water consumption are to be planted during dry seasons. Small ponds should be provided where appropriate.

- **Tree-planting Zone**

Fruit Orchard Zone: Should cover 475,616 rais or approx. 9% of the Basin area, this zone refers to area where soil is fertile and is suitable for planting fruit trees. They situate near water resources, or where ones can be developed, or near waterway banks. The rolling plains which has good drainage property is suitable for planting coconut, oil palms, and other large trees.

Rubber Plantation Zone: Should cover 1,137,347 rais or approx. 21.4% of the Basin area, this zone refers to the agricultural land which is solely fed by rain. Most are characterized by highland plains and rolling plains. Soil is a mixture of sand and silt, with low fertility. Main issues in this zone is severe soil erosion, especially in steep slope area.

- **Agricultural / conservation Zone**

Acidic Soil / Peat Swamp Soil Zone: Should cover less than 191,393 rais or approx. 3.6% of the Basin area, this zone refers to lowland which are often inundated over extended period. It is recommended that the production structure of the area be reformed, and soil be improved, to make it suitable for mixed farming, such as modification of rice species, promotion of husbandry, fish pond, etc.

Saline Soil Zone: Should cover less than 20,397 rais or approx. 0.4% of the Basin area, this zone refers to tidal plains around Songkhla Lake. Soil composes of clay or sea sediments. The area has poor drainage capacity. Soil in some area are not only saline but also acidic.

(6) Summary of Impacts from Land Use in SLB

- **Forest Encroachment in Conservation Zone**

Encroachment of upstream forest can lead to various detrimental consequences, such as lowering soil absorptive capacity, causing runoff to increase during rainy seasons, and decrease during dry seasons, hence alternating flood and drought. Flash flooding is usually associated with heavy rain and overland flow, whereas inundation downstream is usually caused by either prolonged impounding in lowland area or overflow from waterways. Deforestation removes ground cover, thus aggravates soil erosion. Besides, the decrease of runoff during dry seasons reduces the amount of fresh water which is needed to push against salinity intrusion during dry seasons.

- **Increase of Rubber Plantation in Steep Slope Area**

Increase of rubber plantation in steep slope area aggravates soil erosion during the first 2 years after land clearing, when ground cover is insufficient. Not only does it destroy the forest and its biodiversity, this process cause massive loss of top soil resources which is necessary for restoring forest conditions. Large portion of SLB area has been facing erosion problem. Approximately 1.8 million rais, equivalent to 27.3% of SLB area, has an erosion rate exceeding 2 tons/rai/year. Out of this, over 0.7 millions rais has an erosion rate exceeding 15 tons/rai/year, which is considered very severe.

- **Coastal Land Use for Shrimp Farming**

Shrimp farming is a highly profitable business. It is however a risky business which requires high investment. Shrimp is susceptible to viruses. Some of the impacts from shrimp farming include: (a) Possibility of destroying mangrove forest; (b) discharge of saline wastewater from shrimp farms contaminates other agricultural activities as well as water resource; (c) Abandoned shrimp farms contain saline soil which are difficult to rehabilitate.

- **Soil Affected by Natural and Man-made Activities**

Soil in wetlands typically contains high sulfides. When the wetlands is drained, the uncovered soil will react with oxygen (oxidized) and yields sulfuric acid. This acidic soil will have low pH, unsuitable for plants, yielding very low productivity. Management of this type of soil requires proper control of water level to prevent sulfides from being oxidized.

Besides, there are problems from solid wastes which have been managed in an unsanitary manner. Solid wastes in SLB is typically disposed of by landfill. Sanitary landfill, which is considered to be among a few appropriate methods for solid waste disposal, is found only in large municipalities, such as Hat Yai and Songkhla. In the remaining communities, solid wastes are disposed of by simple landfill, or open dumping.

2.1.4 Water Resources

(1) Water Supply

- **Surface water:** SLB experiences a tropical monsoon climate: the southwest monsoon and the northeast monsoon. There are two distinct seasons. The rainy season spans from May to January and the dry season spans from February to April. Annual precipitation varies between 1,549 – 2,399 mm., with an average of 2,043 mm.

Groundwater: notable in the SLB are the **Ranot-Songkhla Basin** covering an area of approximately 2,400 sq.km., having an estimated storage capacity of 400 MCM⁴ and expected safe-yield of approx. 80 MCM/year, or approx. 219,000 cu.m./d, and the **Hat Yai Basin** covering an area of approximately 400 sq.km. having an estimated storage capacity of 175 MCM and expected safe-yield of approx. 35 MCM/year, or approx. 96,000 cu.m./d. Both basins give out good quality fresh water but still with high iron. In 2004, 75,600 cu.m./d. of groundwater was extracted from Hat Yai Basin and should be viewed as critical (with safety factor = 1.27).

The level of groundwater monitored in wells dug up in the Hat Yai Basin implicated that in 1992 the area the groundwater level fell below mean sea level (MSL) covered around 27 sq.km. This had increased to 103 sq.km in 2002, with certain areas that groundwater level drops more than 10 m below MSL.

(2) Water Demand (Table 4)

- **Water Demand for Consumption:** Demands vary with population. There were 1.5 million people living in the area in 2003. Postulating that the rural sector needs 60 litres/person/day and the urban sector (within municipality areas) needs 200 litres/person/day, the water demand for the purpose in 2003 can be estimated at almost 50 MCM; concentrated within major municipalities and their vicinity.

⁴ MCM = Million cubic meters

Table 4 Principal Water Demand in the SLB in 2003 over the 12 Sub-basins.

Unit: Million cubic meters.

Sub-basin	Rainfall	Runoff	Consumption	Agriculture	Industry	Total
Klong Pa Payom-Tha Nae	2,232	780	2.9	242	0.05	245
Klong Na Thom	1,549	335	4.9	148	0.05	153
Klong Tha Chiad	1,497	578	1.9	154	0.07	156
Klong Pa Bon	644	105	1.0	50	0.05	51
Klong Phru Por	907	192	1.7	85	0.02	87
Klong Rattaphum	1,079	356	1.9	61	1.56	64
Klong U-Tha Phao	4,085	1,116	19.7	39	30	89
Eastern Coast 1 (Ranot)	811	243	2.8	440	1.08	444
Eastern Coast 2	336	191	1.4	81	-	82
Eastern Coast 3	226	129	3.1	46	0.36	49
Eastern Coast 4	339	193	7.4	18	6.24	32
Total for All Basins	13,705	4,218	48.7	1,364	39.5	1,452

- Water Demand for Agricultural Activities:** The most widely planted tree in the SLB is the rubber tree, followed by rice and fruit trees. Demands for agricultural purposes vary according to site and season. Table 4 shows the water demand for agricultural activities in the SLB over the sub-basins. Thung Ranot area (Eastern Coast Sub-basin 1) displays very high water demand because this is the area where paddy fields are, and rice is often grown twice a year. The total water demand is approximately 1,364 MCM/year for agricultural activities for all sub-basins. Freshwater extraction from Songkhla Lake aggravates salinity intrusion: An average of 58 MCM. of freshwater per year is extracted from the Lake for irrigating paddy rice farms in Ranot district, Songkhla Province, and part of Huasai district, Nakhon Si Thammarat Province. In the dry season, salinity intrudes as far as the northernmost part of Upper Songkhla Lake. In severe dry season, salinity in the Upper Songkhla Lake reaches upto 10 psu.
- Water Demand for Industrial Activities:** Statistical figures of industries within the SLB between 1997-2003 were grouped according to category. In 2003 there was a major change in the method of listing: registration for category 1 industry, which is the small-scale industry such as rice mills was abolished. Hence, the number of industries dropped dramatically. In 2002 Songkhla Province registered 1,507 establishments but in 2003 there were only 1,166. In 2002 Phattalung Province registered 748 but this became only 371 in 2003. Nakorn SriThammarat Province with only 2 districts (amphoes) within the SLB area (A. Hua Sai and A. Cha-uat) showed a slight decline in number. Water demand for industrial purposes for all SLB sub-basins totaled approximately 40 MCM/year.

- (3) **Water Quality and Water Pollution** Principal Pollution Source is categorized into 1) Community settlements 2) Industries 3) Swine farms 4) Shrimp farms and 5) Other agricultural lands. The first 4 categories is termed “point sources” and the last category as “Non-point sources”.
- **Community Settlement Wastewater** Settlements in the SLB region are sporadically spaced with high-density clusters in major towns and hence the amounts of wastewater generated differ. The sub-basin water quality is most affected is the Klong U-Tha Pao Catchment, followed by the Sathing Pra Peninsula. The total amount of wastewater generated in the SLB in 2004 was roughly 100,000 cu.m/d. with BOD of approx. 17,000 kg./d. There are 2 wastewater treatment plants in the SLB; Hat Yai City Municipality and Songkhla City Municipality. However, the combined treatment capacity covers for only 7% of the Basin population (approx. 100,000 inhabitants in 1.6 million population). Moreover, the wastewater treatment systems were designed to treat organic matters in terms of BOD and suspended solids; and there is no nutrient treatment facility, a crucial factor in Eutrophication remedy.
 - **Industrial Wastewater** Nearly all industries in Songkhla Province are clustered along main roads whereas most in Phattalung Province are small-scale plants affiliated with the Rubber Cooperative Fund. In Songkhla Province there were 7 factories that generated BOD more than 100 kg/d and 16 factories between 40-100 kg/d. The rests are small-scale industries that generate less than 40 kg/d. Industrial wastewater problem tends to be increasingly severe especially in the areas around Klong U-Tha Pao where there are 74 medium and large-scale industries, adding some 3,000 kg BOD per day into Klong U-Tha Pao.
 - **Swine Farm Wastewater** Swine farms is one major source of agricultural pollution in the SLB at present. There are 108 registered swine farms scattered throughout but is more dense in Phattalung Province. The rate of wastewater generated is estimated at 20 litres/swine/d in smaller farms (6 - 60 uoa.)⁵ with BOD of 1,500 mg/l. In larger farms (61 - 600 uoa.) the rate is about 15 l/swine/d with BOD of 2,000 mg/l. Most swine farms discharge wastewater directly into the basin.
 - **Shrimp Farm Wastewater** In 2003 shrimp farms in the SLB totaled 31,340 rais. At present the abandonment is around 30-50% resulting from market downturn. A part of shrimp farms, however, discharge their waste into the Gulf of Thailand. From analysis, shrimp farms discharge wastewater into the SLB totaled 6,800 - 9,500 rais. Wastewater from shrimp raising ponds generates pollution in terms of BOD at an average of 2 kg/rai/d. Thus, BOD from shrimp farms in the SLB is between 13,600 - 19,000 kg/d which is a very high loading particularly when no treatment is performed prior to discharging it into public environs.

⁵ uoa. = unit of animal

Water Quality in the SLB is generally tolerable but water from streams flowing into the Lake is quite polluted particularly the Klong Lum Pum, Klong Kwang and Klong Sum Rong. For Klong U-Tha Pao, however, it was noted that after the Hat Yai wastewater treatment plant is in operation the water quality has improved to a fair level. Water quality close to communities around Thale Noi is rather polluted since around Thale Noi areas there are quite a few high-density settlements and wastewater is often discharged raw. In the Upper Lake and the Middle Lake the overall water quality is fair to good almost all year round.

The areas more problematic in the Lower Lake are the Hua Khao Daeng settlement, Ko Yor settlement, Songkhla City and Khao Seng coastlines. The former 2 settlements have causes from dense aquaculture practice, particularly confined fish farming. Organic matters accumulate on the seabed underneath these large creels and under certain environmental and temperature conditions these organic matters are digested by bacteria using up much of the dissolved oxygen especially at night-time and create a “Hypoxia” phenomenon (dissolved oxygen less than 2 mg/l). This is the suspected root cause of more and more frequent mass-dying of aquacultured fishes during the past 3-4 years.

- (4) **Eutrophication** is a state when a water body holds more than enough nutrients (nitrogen and phosphorus) for water plants. EmSong (1998) reported that in 1992 some 4,165 tons of nitrogen nutrient was discharged into the Lake together with 637 tons of phosphorus. In general, Eutrophication can be indicated from the amount of chlorophyll a, or primary products. A water body that suffers from eutrophication will have a concentration of chlorophyll a of more than 10 µg/l. These suffered water bodies usually exhibit densely packed macroalgae on shallow water surface while in deeper water bodies the appearance will be microalgae or phytoplanktons.

Eutrophication, as indicated by macroalgae blooms in the SLB have been noted for over 20 years as were published in the Data Book of World Lakes in 1984. Sections of the Lake exhibit temporal eutrophication. The Upper Lake exhibits eutrophication all year round while the Middle Lake and the Lower Lake exhibit eutrophication at end of year. Occasionally in certain months chlorophyll a in the Upper Lake are very high (up to 160 µg/l), indicating that the area has suffered severe eutrophication problem over some years particularly during 1996-1997.

Recently, a severe eutrophication problem occurred in the Middle Lake. In 2002 a rapid microalgae bloom, mostly of the *Najas* sp., covered an area more than 160 sq.km in the middle of the Upper Lake. The wet weight of this has been estimated at 0.6 million tons. In 2003 there was a widespread *Najas* sp. all-year-round bloom covering the western Upper Lake up to Klong Lum Pum estuary. Moreover, there were dense green macroalgae (*Cladophora*) on top of the *Najas* sp. over a vast area.

- (5) **Sedimentation and Shallowing Problem** Sedimentation in the SLB is from 3 sources; (1) *Coastline sediment* accumulated at the Lake mouth from tide influence (2) *Runoff sediment* generated from soil erosion, the amount of which depends on runoff quantity and erosion rate (3) *Decay sediments* found usually around areas where water plants densely grow. When salinity suddenly changes these plants die and rot and accumulate on the seabed.

In sedimentation estimation a few mathematical models had been employed. The result range is between 0.04 - 0.19 mm/yr. From Cesium isotope ¹³⁷Cs technique, sediment of 5-6 mm/yr was reported. The Songkhla Lake Basin Planning Study by John Taylor & Sons in 1985 reported a sedimentation range of 0.1-0.4 mm/yr. Sedimentation and its rates are thus evidently unclear; the rate from isotope technique is 10 times higher than from the rainfall-runoff relationship model.

In this Study, the rate of sedimentation in the Lake has been calculated from hydrographic maps of the area drawn by the Royal Harbor Department (at present the Marine Department) in 1975 and 2002. It was found that sedimentation occurs more on the west of the Lake especially in the Lower Lake, the calculation yields an average increased thickness of 0.186 m or 6.9 mm/yr.

Results including this done for the Master Plan point to a sedimentation rate of 5.0 - 6.9 mm/yr. If this rate is sustained, the Lake will only remain a lake for another 300 - 400 years.

- (6) **Need for an Integrated Water Resources Management System** Water resource on one hand is normally limited and problems will become increasingly severe when rainfalls discontinue over an extended period, creating adverse effects for agricultural activities as well as that for human consumption. On the other hand, if rainfall is over abundant, settlements upstream and communities in low lands will often face flash flooding and inundation problems. On top of this, the ever expansion of settlements creates wastewater problems resulting from various activities; daily consumption, agricultural use of fertilizers and weed control chemicals that pollute natural catchments. Industrial developments also use chemicals and if not properly controlled will add more toxic wastes to water bodies. Water resources management has multiple dimensions including root causes, project identification, impact and remedial measures. System integration must include, among other things, techniques, ecology, economy, enforcement, social and community participation.