Fisheries 7

The Mekong River has one of the most diverse and abundant fisheries in the world. There are more than 1200 species in the river.[1] The yield of the Mekong's capture fishery is an estimated 1.5 million tonnes per year,[2] with another 500,000 tonnes raised in reservoirs and other forms of aquaculture. In Cambodia alone, fishers annually catch between 300,000 – 400,000 tonnes, which makes Cambodia's fishery the fourth largest in the world, after China, India and Bangladesh.[3] Estimates of annual mean fish yield for the Tonle Sap Great Lake in Cambodia are 230 kg per hectare for the Tonle Sap Lake and floodplain.[4] This figure is much higher than that for other Asian floodplain fisheries, which average about 100 kg per hectare per year.[5]

The Mekong owes its abundance to the annual monsoon flood and low gradient in the lower basin. Each year during the southwest monsoon from June to October, torrents of water pour into the basin's catchment and swell the Mekong's tributaries from small streams to turbulent rivers. These waters in turn increase the discharge of the Mekong 20 to 25 times.

Floodplains are the most highly productive part of any river system. The rise and fall of the annual floods result in the recycling of plants, animals and nutrients with each 'flood pulse'. The annual change from dry to wet season causes dramatic changes in aquatic habitats, water quality, food availability for fish and fish recruitment. Floodplains that expand and shrink dramatically each year support higher yields than do stable aquatic or terrestrial ecosystems.[6]

The Mekong's fishery is of enormous importance to the 55 million people living in the basin. Some 40 million people or two thirds of the basin's population are involved in the Mekong's fishery at least part-time or seasonally. Not only do they derive their livelihood from the fishery, they also depend on fish and other aquatic animals for food security. It is estimated that on average, people consume about 36 kg/person/year. The 2 million tonnes of fish and aquatic products caught and cultured in the basin are worth $1,400 million at first point of sale. The great majority of this is consumed within the basin.

Hauling in a catch of fish from a dai *fishery unit*

More than 30 percent of the people in the basin have incomes below the poverty line, and they rely on the basin's fishery for most of their animal protein and essential micronutrients (notably calcium and Vitamin A). Thus preserving the fishery is of enormous importance. As the population of the Lower Mekong Basin grows by 2025 to an estimated 90 million, even more people will depend on the fishery. If it were to seriously decline, as fisheries have done in so many parts of the world, the consequences would be grave for the livelihoods and food security of rural people.

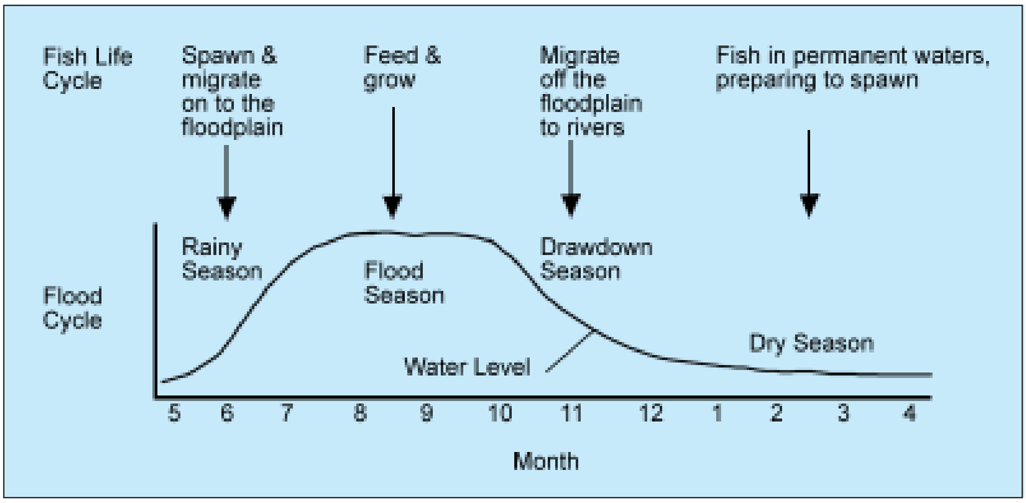
Flood plain river systems are highly vulnerable for a number of reasons: they often face conflicting demands from different sectors (fisheries, forestry, water abstractions, hydropower, water drainage, industry, navigation, etc.); and impacts from upstream such as damming, pollution, and deforestation. These all have negative impacts on flora, fauna and the livelihoods of people downstream. Inland waters of the Asian region provide more than half the world's inland capture fisheries yield, and yet, despite their high values, flood plain river habitats are now amongst the fastest disappearing of all ecological habitats.[7]

As this chapter indicates, the Mekong Basin's aquatic ecosystem is still in good condition, but there are a number of threats to the fishery which must be understood and addressed, or the fishery could be decimated in as little as a generation. In the chapter that follows, research findings are presented on capture fisheries, aquaculture and other aquatic products such as food, medicines and building materials which are harvested from wetlands. The topics covered in the chapter include: biodiversity; the numbers of people involved in the fishery; consumption, yield and economic value; threats to fisheries; and the extent of, potential for, and threats to aquaculture.

1. The importance of varied habitat and migrations

The habitat mixture in the Mekong River Basin is extremely diverse and while this resource complexity is maintained by appropriate management measures, the fishery resource will remain rich in both biodiversity and productivity. Habitat diversity is greatest in the floodplain areas of flooded grasslands, flooded forests, as well as small and large river channels and permanent and temporary lakes and pools. Each type of habitat is used by different fish species for different activities such as spawning, nursing, shelter and feeding. Key habitats must be kept accessible through the floodplain channels.

Figure 1. Generalised life cycle of migratory Mekong fishes, in relation to seasonal conditions.

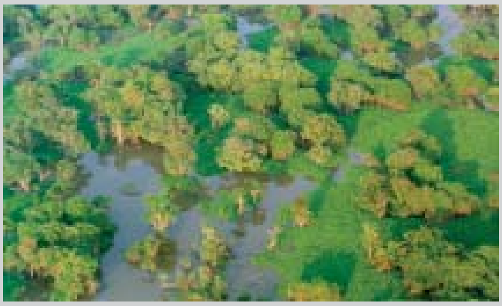


Source: Adapted from Hoggarth *et al*. 1999

The main river channels are comparatively unproductive because stronger currents and shifting substrates result in lower primary production.[8] The quantity and quality of water in rivers is vital for maintaining system productivity.

Tonle Sap

The Tonle Sap Great Lake area varies dramatically in area from 2,500 - 3,000 km^2 in the dry season to up to 13,000 square km in the wet season, when the water level rises eight metres or more above the average dry season level.[12] This provides fish with temporary access to enormous quantities of food, especially in the flooded forest areas. Many fish species release eggs just before or during the floods and their seed are thereby widely dispersed across the floodplains.



Rising waters, turbidity and/or the first rains trigger adults of many Mekong fish species to spawn.[9] Long distance migratory fish species or "white" fish have adapted to spawn at the onset of the monsoon season (May-July), so that their fry and juveniles are ready to enter and feed when the plains become flooded from July to September.[10] Short distance migratory or "black" fish species also migrate to spawn and feed in the inundated floodplains.[11]

Deep pools and channels in the mainstream of the Mekong near Kratie in Cambodia, in the Nam Theun and Nam Hinboun in Lao PDR, and in the Se San River in Cambodia are widely acknowledged as dry season refuges for fish, which re-colonise flooded areas during the following monsoon.[13]

Important spawning areas are located in the Mekong in Kratie and Stung Treng Provinces. The long distance fish migrations within main river channels and their main tributaries are referred to as "longitudinal migrations". Such long distance migrations can cover distances of hundreds of kilometres from the Mekong Delta in Viet Nam, through Cambodia, to (i) Thailand or Lao PDR through the Mekong River mainstream, (ii) Lao PDR through the Se Kong River, or (iii) the Central Highlands in Viet Nam through the Se San and Sre Pok Rivers.[14]

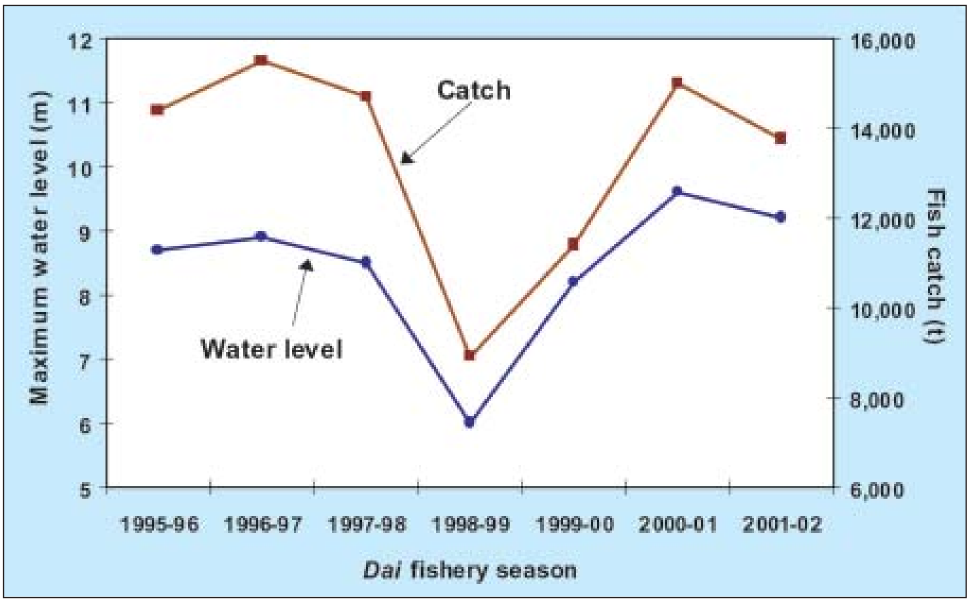
A small section of the Sambor Rapids, northern Cambodia

Another type of fish movement in rivers is the passive downstream movement by fish larvae, or "larval drift". During the flood season, larvae of some species may drift several hundred kilometres from upstream spawning areas to downstream nursery areas in the floodplains.[15]

The most comprehensive study to date on fish migrations in the Mekong River was produced by Poulsen and his co-authors in 2000.[16] Migration studies confirm the critical importance of migration events in the biological functioning of the fish resource. Some 63 percent of the total catch taken by large and middle scale gears in the Tonle Sap fisheries constitutes longitudinally migrating fish.[17] Other important migration patterns include lateral migration from the mainstream to the floodplains, breeding migrations of adult broodstock, migration of eggs and juveniles with water currents, feeding migration and migration to dry season refuge habitats with water currents as water levels decline. All these migrations are essential features of the Mekong fish resource.

Although rivers and their associated floodplains encompass a range of different fish habitats, they are all ecologically linked in a complex "fish migration network". Therefore, from the point of view of migrating fish species, the Mekong River Basin functions as one ecological unit.[18] The fish migration corridors interconnect upstream spawning habitats with downstream nursery habitats and dry season refuge habitats with wet season floodplain habitats.[19] The large floodplain areas in the Mekong Delta and around the Tonle Sap Great Lake in Cambodia, are crucial nursery habitats for the Mekong fishery.[20]

Figure 2. Relationship between the maximum flood level of the season and the fish catch of the *dai* or bagnet fishery in the Tonle Sap river.



Note: This is a small fishery of 63 bagnet units (60 in 2001-02) targeting "white" fish migrating out of the floodplains around the Great Lake to the Mekong river.
Source: Sverdrup-Jensen 2002

2. Capture fisheries

2.1 Biodiversity

The Mekong River Basin is characterised by a high degree of biodiversity and endemicity. That is, many of its fish species are only found in the Mekong Basin,[21] and often only in the basin of one of the Mekong's tributaries (see for example Kottelat 2000).

The number of fish species found in any river is difficult to determine because, besides fish species which complete their life cycle in freshwater, there are other species that may or must spend part of their lives in the sea. Some of these typically live in the estuaries, while others have life cycles that require them to move between river and ocean at well-defined and regular stages.[22]

It is thus not surprising that the number of fish species in the Mekong River is contentious. As the following indicate, leading fish taxonomists give quite different estimates:

- Rainboth (1996) – 'The total number of species recorded or expected from the Mekong, as inferred from the known zoogeography of southeast Asia, includes about 1,200 species. This number will undoubtedly increase as additional taxonomic studies and fish surveys are completed.'

- Kottelat (2001) – 'There are documented records of about 700 species from the Mekong Basin.'

- Dr. Walter Rainboth (personal communication 2001) – 'The new Atlas on the Fish of the Mekong will include 1,700 species. Many of the species are marine vagrants.'

- Dr. Tyson Roberts (personal communication 2002) – '1,100 freshwater species.'

ICLARM's Fish Base lists 748 species from the Mekong at the moment,[23] and MRC's Mekong Fish Database 2003 currently counts 924 species.[24]

There is, however, no doubt that the Mekong is among the most species-rich rivers in the world. The number of fish species per unit area of catchment in the Mekong is several times that found in the Amazon River Basin.[25] Species cataloguing is incomplete, and further taxonomic studies are required in the upper reaches of tributaries, particularly in Lao PDR and Cambodia where new fish species still remain to be discovered.[26]

One notable aspect of the fish fauna is the large number of fish families present. In Laotian waters alone, the native fish fauna comprises 47 families.[27] The Mekong Fish Database 2003 lists 91 families in the basin, which indicates that the Mekong has the highest number of fish families of any river in the world.[28] In addition, the Mekong fishes, in common with fishes in other large rivers is characterised by a high degree of within-species diversity (i.e. genetic diversity).[29]

The fish occurring in the lowlands and floodplains of the Mekong Basin have been broadly categorised into two groups – black fish and white fish.[30] Black fish, which are mostly fish-eating carnivores and eaters of aquatic debris, live year round in perennial waters, including swamps, and make limited local, lateral migrations. This group includes the families of snakeheads (Channidae), air breathing catfishes (Clariidae), bagrid catfishes (Bagridae) and climbing perch (Anabantidae).[31]

White fish are species that show strong lateral movements between habitats (for example between flooded forest and deeper water in the Tonle Sap Great Lake) as well as swimming long distances up or down river,[32] and often across national borders.[33] The white fish group includes the sheatfishes (Siluridae) and the river catfishes (Pangasiidae), as well as species belonging to the minnow and carp family (Cyprinidae).[34]

The release of a tagged specimen of Siamese giant barb (Catlocarpio siamensis)*, Cambodia*

There is clear evidence that some fish species, particularly the large, slow-growing, late-maturing species are becoming scarcer.[35] Based on the limited information available, it appears that the population sizes of the three giant species, namely the giant Mekong catfish (*Pangasianodon gigas*), the seven-line barb (*Probarbus jullieni*) and the giant barb (*Catlocarpio siamensis*) have decreased substantially over the last few decades.[36] The Mekong giant catfish and the seven-line barb are both classified as 'endangered' on the 2000 International Union for the Conservation of Nature (IUCN) Red List. The giant barb is becoming increasingly rare. Catches in Cambodia have dropped from 200 tonnes in 1964, to 50 fish in 1980 and 12 fish in 2000.[37] The giant species are particularly susceptible to over-fishing because of their sheer size, their mobility and their comparatively late age of sexual maturity.

To date, no fish species within the Mekong Basin has become extinct, though a number of species have become locally rare or absent, although not necessarily due to fishing.[38]

2.2 Numbers of people involved in the fishery

Most of the 12 million rural households in the LMB earn their living by rice farming and fishing. An estimated 40 million rural dwellers (66 percent) are active in the fishery, with captured fish being an important element in household nutrition and income generation.[39] Seventy-one percent of rural households (2.9 million people) in Lao PDR are reliant on fishing to varying degrees for subsistence and additional cash income.[40] The wild fishery is particularly important for the poorest and landless rural households, making significant contributions to their nutrition, food security and income.

More than 1.2 million people living in fishing communes around the Tonle Sap Lake area depend almost entirely on fishing as their principal livelihood.[41] The net result is very high participation in the fishery, with recorded involvement ranging from 64 to 93 percent of household.[42] In Cambodia, the so-called small or "family fisheries" produce higher catches than the large-scale commercial fisheries.[43]

2.3 Consumption and fisheries yield

It has become obvious that people in the region are far more dependent on the Mekong's fishery for household nutrition, income and livelihoods than was previously believed.[44] In the 1990s, household surveys on the quantities of freshwater fish, fish products and aquatic animals eaten and their supply source were conducted by several different agencies in 15 of 87 provinces in the LMB.[45]

The surveys found that people in the region are consuming less than 20 kg per person in mountainous areas that have limited access to fish resources, and about 60 kg per person in floodplain areas of Cambodia and Viet Nam where fish is abundant most of the year.[46] In Northeast Thailand, home to about one-third of the population in the basin, annual fish consumption is about 35 kg per person.[47] The overall average total for fish and other aquatic products consumed in the LMB, is 36 kg/ person/year (see Table 1).

The results of other household consumption and expenditure surveys conducted by the national statistical authorities in Lao PDR and Cambodia between 1998-2000 are largely consistent with the household consumption figures given above.

2.4 Size and value of the fishery in the Lower Mekong Basin.

A busy market where many species of Mekong River fishes are traded

Estimating the yield of the fishery in the LMB is extremely difficult using traditional fisheries statistics collection methodologies. In the LMB, the fisheries are widely dispersed, effectively operating along the lengths of all the main rivers and most tributaries. There are no centralised landing ports where data can be easily collected. There are numerous species, the catch of which varies seasonally and with the many different types of gears. Most importantly, the fisheries operate at a commercial, semi-commercial and subsistence level. Statistics on family or subsistence level fisheries have not been collected in the past by fisheries authorities in the LMB, and this has led to serious underestimations of fisheries yields, and hence the economic and nutritional importance of the fisheries.*

Sjorslev[48] used these data and regional population figures to determine regional consumption of fish and other aquatic products. For the 15 surveyed provinces, mean fish consumption figures and census population data were used to calculate total annual provincial fish consumption volumes. The 72 provinces that were not surveyed were classified according to area and type of water resources and fish habitats, before being assigned the mean consumption figure of the most similar surveyed province. Extrapolation of the household survey findings as above gives an annual total consumption of freshwater fish, fish products and other aquatic animal products in the LMB of about 2,033,000 tonnes (see Table 1).

To use fish consumption data as an estimate of fisheries yield requires the assumption that the import and export of fisheries products in the region are similar in magnitude. Unfortunately, there are no reliable data on the import and export of fishery products in the LMB. However, export is considerable: for instance in Cambodia, at least 50,000 tonnes of freshwater fish are exported to Thailand annually.[49] We do not know regional import levels. Nevertheless, one can reasonably assume for the present purposes that import into the LMB is approximately equal to export out of the LMB.

* The data presented here are preliminary and are currently being re-analysed to provide a more accurate estimation of the size and value of the fishery.

Table 1. Estimated freshwater fish and aquatic product consumption in the Lower Mekong Basin.

Country	Population in LMB 1999/2000	Assessed consumption in per capita per year of all fisheries products. Average (range), kgs	Assessed total consumption of freshwater fish, fish products and aquatic animals (tonnes) 1999/2000
Cambodia total	10,775,000	47 (10-89)	508,000
Lao total	5,087,000	26 (17-36)	133,000
N-E Thailand	22,439,000	35 (20-41)	795,000
Viet Nam - Mekong delta	17,958,000	33 (15-60)	597,000
TOTAL	**56,259,000**	**36**	**2,033,000**

Source: Sjorslev (in press)

Given this assumption, it follows that fish consumption is approximately equal to the amount of fish caught plus that produced from fish farming. In 1999-2000, 260,000 tonnes of fish were produced by the aquaculture industry,[50] and 240,000 tonnes of fish were taken from reservoirs[51] in the LMB. Therefore, the total yield from the freshwater *riverine and wetland capture* fishery is at present about 1,533,000 tonnes per year.

The validity of this estimate can be cross-checked using data from studies on fisheries yields from wetlands in the LMB. Estimates of mean fish yield range from about 205 kg per hectare per year for the Great Lake area to 375 kg per hectare per year for the floodplain near Phnom Penh, though these means are based upon small survey areas. Based on a much larger survey area, Baran *et al*. (2001) estimate the annual yield of the Tonle Sap Lake and floodplain to be 230 kg per hectare. An average yield of 230 kg per hectare from the 9.69 million hectares of wetlands in the basin[52] extrapolates to a total yield of 2.23 million tonnes per year. Therefore, the estimate of 1.533 million tonnes (equivalent to 158 kg/ha of wetlands) of freshwater fish and aquatic products captured from the river and wetlands fishery in the LMB each year is considered realistic, and possibly conservative.

The Mekong fishery is probably the largest river fishery in the world.[53] In 1999 the total world capture fisheries (marine and freshwater) catch was 92.3 million tonnes.[54] Based on the figures presented here, the Lower Mekong Basin freshwater fishery is about 2 percent of the total world capture fisheries yield.

A river catfish, very important in the capture fishery and in aquaculture

The value of the fishery in the LMB is very difficult to estimate, because the relative proportions of fish, processed fish products and other aquatic animals are not well described, and the average prices of these different products in different regions are not known. Nevertheless, we can get an approximate idea of the value of the fishery if we apply fish prices to the total yield of fish, fish products and other aquatic animals. We can use an average farm gate price of $1.05 per kg for cultured fish [55] and an average first hand sale price of $0.68 per kg for capture fish.[56] For the reservoir fisheries, the conservative value of $0.68/kg is used, because although the fish are produced by both aquaculture and capture fisheries, the relative proportions cannot be estimated. This results in an estimate of $1,478 million for the value of the fishery. This is for first sale price only, and so does not include any estimate of the multiplier effects of the fish trade.

2.5 Nutritional value

Nutrition, health and poverty baseline surveys in Cambodia confirm that fish and aquatic animals provide more than 75 percent of animal protein intake in rural areas.[57] In the lowland areas of the LMB, where the bulk of the population lives, between 40-80 percent of animal protein is supplied by aquatic animals.[58]

The average protein requirement for adults is between 0.8-1.0 g protein/kg body weight/day. In the LMB this is normally, or very nearly, met on an annual basis.[59] However, in some areas of the LMB, seasonal malnutrition is quite common.[60] Rice provides more than half the daily protein requirement in the LMB, but it is deficient in lysine, an essential amino acid. Fish and other aquatic products contain 33 percent more lysine than terrestrial animal protein sources such as poultry, beef and pork.[61]

Calcium intake is also particularly important in human nutrition for skeletal growth of young children, for foetal growth, for lactating mothers and for the elderly to prevent brittle bones (osteoporosis). The World Health Organisation and the Food and Agriculture Organization (FAO) recommend a daily intake of 400-500 mg of calcium per day for adults and 500-700 mg per day for adolescents.[62] Milk and other dairy products supply most of the calcium used by humans in western countries. In Southeast Asia, where rice and most fruits lack calcium, it is primarily provided by small fish, that are often eaten whole, and other traditional products made from small fish.[63] Small dried fish eaten whole contain more than 1,000 mg of calcium per 100 g, while dried fermented fish exceeds 2,000 mg of calcium per 100 g. Importantly, the calcium uptake by the human body is the same for small fried fish eaten whole as it is for fresh milk.[64] As well as supplying animal protein and minerals such as calcium, fish are important in the human diet as a source of vitamins (including vitamin A).[65]

The annual catch from the *dai* fishery in Cambodia ranges from 7,000 – 18,000 tonnes. Most of the catch is processed to make a traditional fish paste called *prahoc*.[66] The majority of the catch (55 percent by weight) consists of small cyprinids *Henicorhynchus* spp. and *Paralaubuca typus*.[67] Fish yield in the LMB peaks seasonally during the dry season and at the start of the rainy season. To provide fish at other times, fish are sun dried, salted, pickled, smoked, fermented and made into fish sauces, oils and pastes.

2.6 Economic value

Table 2 shows that the entire fisheries capture and culture sector in the LMB is estimated to be worth $1,478 million annually. The value of the wild riverine fishery in the LMB is estimated to be $1,042 million, the aquaculture sector is worth $273 million, and the reservoir fishery is valued at $163 million annually. (See Table 3)

Cambodia's freshwater capture fishery of 400,000 tonnes has an estimated value at the landing sites of $200 million and an estimated retail value of over $300 million annually.[68] Studies on livelihood strategies found that villagers around the Great Lake spent less time on fishing activities but generated 3.5 times more value than for their farming activities.[69]

High value fish such as snakeheads (*Channa micropeltes* and *C. striata*) and sand goby (*Oxyeleotris marmorata*), are sometimes exported out of the region. Sand goby, for instance, is considered a delicacy through much of eastern Asia and can fetch prices as high as $10 per kg in Viet Nam, Hong Kong and Singapore.[70] Export of fish and aquatic products from Cambodia to neighbouring Thailand and other countries is being stimulated by the construction of improved roads and bridges and the greater availability of ice for cold storage.

Cultured and captured river catfishes *Pangasianodon hypophthalmus* and *Pangasius bocourti* are increasingly being exported from Viet Nam. Processed river catfish are exported to Australia under the name of Pacific Dorado[71] and they are also exported frozen to the USA.[72] (See Table 2)

Table 2. Fish production and value in the LMB

Fish and aquatic product source	Quantity (tonnes)	Price ($ per kg)	Value ($ millions)
Riverine capture fisheries	1,533,000	0.68[1]	1,042
Aquaculture	260,000	1.05[2]	273
Reservoirs	240,000	0.68*	163
TOTAL	**2,033,000**		**1,478**

Note: * The reservoir fishery consists of both capture and aquaculture sectors, but the respective proportions of each are unknown. To estimate the value of the reservoir fishery, we have been conservative in using the lower price estimate of $0.68.

Sources: 1. Aeron-Thomas in prep; 2. Phillips 2002

Table 3. Species composition and value of the ten most common fish species groups in the 1995/1996 catch, by type of fishery, around the Great Lake and the Tonle Sap River

Fish Species Group	Large-Scale Fisheries				
	Fishing Lots [%]	*Dai* Fisheries [%]	Middle-Scale Fisheries [%]	Total Catch [%]	Total Value [%]
Henicorhynchus spp.	11	40	20	21	9
Channa micropeltes	16	-	8	9	19
Cyclocheilichthys enoplos	8	1	13	9	8
Dangila spp.	5	6	7	6	2
Osteochilus spp.	2	10	2	4	2
Cirrhinus microlepis	5	3	2	3	4
Pangasius spp.	8	0	1	3	3
Barbonymus gonionotus	3	0	4	3	2
Paralaubuca typus	1	11	0	3	1
Channa striata	5	-	1	2	6
Weight percentage of 10 species groups (in the particular fishery)	64	70	59	63	56
Number of species recorded	>75	44	62	>75	

Note: Family and rice field fisheries are not included because of insufficient data.
Source: Deap Loeung and Van Zalinge 1998

Table 3 shows the 10 most common fish species caught by the large- and middle-scale fisheries in the provinces around the Great Lake and the Tonle Sap River in Cambodia. Seventy-five fish species are routinely found in the catch, of which at least 44 species are found in the *dai* fishery and 62 species in the catch of the middle-scale fisheries. The most expensive fish are the snakeheads (*Channa* spp.), because they have good quality meat and they can be kept alive for a long time in the market.

The rich biodiversity of the Mekong wetlands also has an economic value for purposes other than the fishery. For example, the Irrawaddy dolphins living in the Mekong River below the Khone Falls have a high economic 'existence value' for tourism because of their rarity.[73]

Irrawaddy Dolphin

2.7 Factors impacting on fisheries resources

2.7.1 Dams and water extraction

Development of water resources, particularly dam and weir construction for hydroelectric power, irrigated agriculture, water supply and flood control has led to water abstraction, water diversion, water retention, and increased water evaporation. At impoundment sites and at locations downstream from them, aquatic habitats have been lost or modified. Dams for reservoirs, headponds, and weirs change rivers and streams and also change the timing, duration and quantity of flooding further downstream.[74]

To date, the only dams that have been built across the mainstream Mekong are the Manwan and Dachaoshan Dams in Yunnan Province of China.[75] The 300 metre high Xiaowan Dam is under construction and China has proposals to construct more mainstream dams on the Lancang Jiang River, as the Mekong River is known in Yunnan.[76]

Dams are of concern because they cause fragmentation of aquatic habitats, block fish migration routes, change water flow patterns and water levels through water abstraction and water retention, and increase water loss by evaporation.[77]

The construction of a diversionary weir at Nam Song in Lao PDR seriously disrupted the natural river flow patterns of the Nam Song River, which is part of the Nam Ngum sub-catchment. Following completion of the Nam Song weir in 1996, 40 fish species disappeared and 20 trans-boundary migratory fish species were lost from catches in neighbouring countries (Table 5).[78] Of these, 20 species were trans-boundary migratory (TBM) or long distance migratory species (LDM).[79] (See Table 4)

Prior to the construction of a dam in Northeast Thailand, there was a large-scale fishery for the trans-boundary long distance migrating *Pangasius macronema* at Pak Mun. After the construction of the dam, a series of more than 50 rapids, which were important spawning grounds for *P. macronema*, were flooded. This has caused a significant decrease in the size of the *P. macronema* fishery.[80]

Before filling the Pak Mun Dam, which has a catchment area of 117,000 km^2, 265 fish species were recorded in its diverse variety of aquatic habitats, and the fish spawning grounds were accessed by fish from the Mekong mainstream. Following the construction of the dam, only 96 fish species have been recorded upstream of the dam, and of those, 51 fish species have declined in abundance. The construction of the dam has caused the upstream extinction of long distance trans-boundary migratory species, which previously returned annually to spawn in the rapids.[81]

A variety of fish have evolved to fill the specialised feeding niches, which are available in the Mekong River Basin. Many Mekong River fish species in the Cyprinidae and Gyrinocheilidae families feed primarily on periphyton (algae attached to substrate). Changes in light intensity, increased water levels, increased turbidity, and reduction in nutrient levels caused by construction of dams and weirs can wipe out the periphyton populations on which specialised feeding fish depend. Increased water levels caused by the Nam Hinboun and the Theun-Hinboun hydropower projects in Lao PDR wiped out periphyton communities and with them, the periphyton-feeding fish species.[82]

Table 4. Indigenous fish species that disappeared from the catches downstream of the diversion weir in Nam Song in Lao PDR after its completion.

Family CLUPEIDAE		**Family PANGASIIDAE**	
Tenualosa thibaudeaui	TBM	*Helicophagus waandersi*	TBM
		Pangasius bocourti	TBM
Family CYPRINIDAE		*Pangasius djambal*	TBM
Bangana behri	TBM	*Pangasianodon hypophthalmus*	TBM
Barbonymus altus		*Pangasius larnaudii*	TBM
Barbonymus schwanenfeldii		*Pangasius sanitwongsei*	TBM
Cirrhinus jullieni			
Cirrhinus microlepis	TBM	**Family SISORIDAE**	
Henicorhynchus sp.	TBM	*Bagarius bagarius*	LDM
Labeo chrysophekadion	TBM	*Bagarius suchus*	LDM
Labeo erythropterus		*Bagarius yarrelli*	TBM
Lobocheilos melanotaenia			
Luciosoma bleekeri		**Family DATNIOIDIDAE**	
Mekongina erythrospila	TBM	*Datnioides undecimradiatus*	LDM
Neolissochilus blanci			
Paralaubuca typus	TBM	**Family OSPHRONEMIDAE**	
Probarbus jullieni	TBM	*Osphronemus exodon*	
Probarbus labeomajor	TBM	*Osphronemus goramy*	
Raiamas guttatus	TBM		
Scaphognathops stejnegeri		**Family CHANNIDAE**	
Tor tambroides		*Channa gachua*	
		Channa micropeltes	
Family COBITIDAE		*Channa marulioides*	
Acanthopsis sp. 1			
Acanthopsis sp. 5		**Family SOLEIDAE**	
		Brachirus harmandi	
Family GYRINOCHEILIDAE			
Gyrinocheilus pennocki			

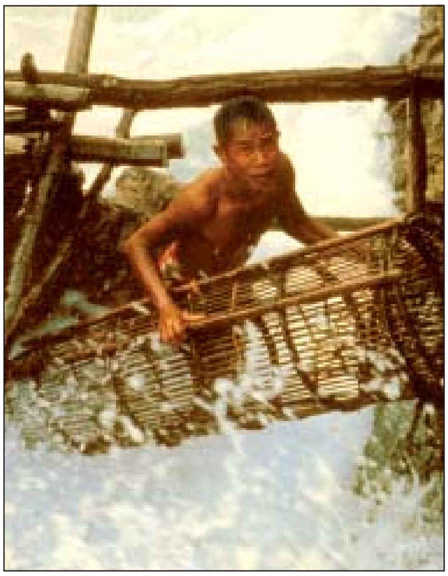
***Note*:** TBM= Transboundary Migratory Fish Species; LDM= Long Distance Migrating Fish Species
Source: Schouten (*in press*).

Filter-feeding mussels are commonly found in highland streams and rivers of the Mekong Basin and are an important food source for fish species such as seven-line barb (*Probarbus jullieni*), botia loaches (*Botia* spp.), and the pangasiid *Helicophagus waandersi*.[83] Since mussels are sedentary or static, they depend on the current to bring them sufficient food to survive. Changes in water velocity patterns and water quality following dam and weir construction can negatively impact bivalves and the fish and other aquatic animals, which feed on them.

Dams also impact water quality, affecting downstream total suspended solids and nutrient levels, especially total phosphorus and dissolved oxygen levels. Reservoirs deeper than 10 metres become stratified with warmer water at the surface and cooler water at the bottom. Oxygen-consuming decomposition of organic material mainly occurs at the bottom, and the bottom water can become hypoxic or even anoxic if the reservoir is stratified. If oxygen-depleted bottom water is released from a dam, fish kills can occur downstream.

2.7.2 Barriers to fish migration

Dams and other structures across streams are barriers to migrating fish. A mainstream dam, on the Mekong below the Khone Falls, for instance, would prevent the migration of adult white fish from the floodplains and others to their spawning grounds upstream in northeast Cambodia.[84] At times of peak migration from the Tonle Sap to the Mekong River, the movement of fish species is concentrated in time and abundance. At these times at least 50,000 fish per minute are swimming past a given point in the Tonle Sap River.[85] No existing fish ladder design could cope with these numbers of fish.[86]



Catching fish in area with rapids or water fall

Floodplains can be altered through land use and modified by development of water resources, resulting in changes in water flow and the timing, frequency, duration, and height of flooding. Other important aquatic habitats such as rapids and riffles, backwaters, and deep pools can also be impacted by changes in water flow regime. Fish migration is closely related to annual fluctuations in water flow and water levels. If natural water flow fluctuation patterns change drastically, fish will be unable to complete their migrations, and spawning and recruitment will be reduced, and hence fish resources will be reduced.

While the spawning of the majority of Mekong fish species is triggered by monsoon rains, rising water levels, and turbidity, other species such as members of the genus *Probarbus*, spawn during low flow periods.[87] All three species in this genus are extremely popular as food fish and are all included on the IUCN list of endangered species.[88] Dry season spawning species are likely to be especially susceptible to water released from dams during the dry season because they may be unable to find suitable spawning sites or their eggs may be washed away or smothered by sediment deposits.

If an integrated approach to fish and water resource management is to be undertaken, methodologies are needed that can quantify the importance of migrations in the production cycle and quantify the impact of dams on migrations, fish yield, and the livelihoods of fisher communities.

2.7.3 Habitat loss

Fresh waters account for less than 1 percent of the world's surface area, but they provide at least 8 percent of global fisheries yield. These productive ecosystems are, however, under pressure from a growing human population, conversion and draining of wetlands, construction of dams, water diversions, canals, increased water consumption and pollution.[89]

Fisheries productivity and diversity varies with habitat type. Productivity is often considered to be highest in flooded forests and lowest in rice fields, but there is no literature and no studies from the Mekong region to support this opinion.

In the Mekong, destruction of flooded forest for fuel, or conversion to rice fields or other uses has a negative impact on recruitment to the wild fishery and fish growth.[90]

The conversion of floodplains into arable land, especially rice fields, is a serious threat to a crucial ecological habitat, and therefore to fish production and diversity. It has been determined by aerial photo surveys conducted in 1973-1976 and 1992-1993, that 33 percent of the flooded forest area of Cambodia was cleared in that 20-year period.[91] Around the Great Lake, 27 percent of the flooded forest cover was cut during the same period.[92] It is imperative that as much flooded forest as possible be preserved if fisheries productivity is to be maintained. To achieve this, the communities responsible for fisheries management must be convinced to conserve and protect flooded forest and wetland habitats, because the loss of critical fish habitats is usually irreversible.[93]

Development projects for the Tonle Sap Lake, such as the building of harbours, roads, and oil and gas exploration, will increase accessibility and employment in the area and bring in more people. Increased population pressure will result in destruction of natural habitats and ecological damage as land is converted for agriculture and trees are cut for fuel. Another solution would be to create employment opportunities in areas outside the floodplains to relieve development pressure on the flooded forests and critical wetlands.

2.7.4 Fishing pressure

The Mekong fishery comprises at least 120 commercial species, hundreds of fishing gear types, and 40 million fishers, many of whom have low levels of literacy. At least 180 different fishing gears have been identified in Cambodia alone.[94] There are an equally diverse number of gears in Lao PDR.[95] Given this situation, it is difficult to accurately monitor fishing yield and effort.

The most valuable long-term fish capture data sets have been collected from the *dai* fishery on the Tonle Sap River by the MRC Fisheries Programme. Time series data indicate that fish yield is correlated with average peak flood levels. Annual *dai* catches for October in the Tonle Sap River closely follow the average October water level in the same river.[96] Flood control measures, including dam construction, that lower average peak flood levels can reduce fish catches.[97]

Giant lift nets in action

The mean fish size for different fish species caught in the gill net *Scaphognathops* fishery in Khong District, Champasak Province, Lao PDR from 1993 and 1998 [98] was also variable for all species, but no species was declining in mean size. The number of species caught between 1993 and 1998 varied from 30 to 76, but the data give no indication that the number of species in the catches is declining.

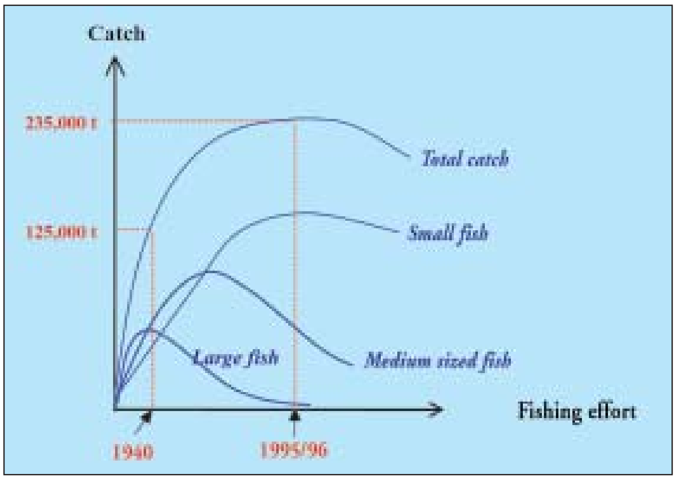
Fishers also complain that their catches have declined over time, and data show that catch per fisher has declined approximately 44 percent between the 1940s and 1995. Despite this, the total fish yield in the Tonle Sap area has increased 84 percent from 125,000 to 230,000 tonnes during the same period because of the massive increase in the number of fishers. While the overall catch volume of the Tonle Sap fishery may yet increase further, and the proportion of small, prolific, fast maturing and growing species like *Henicorhynchus* spp. in the catch might increase, the overall value of the fishery may decline.[99]

This indicator is a classical symptom of a fishery under heavy exploitation. Systematic and continued monitoring of the fishery is therefore of critical importance if the fishery is to be managed sustainably.

Modelling of the fish and hydro-biological resources of the Mekong Basin identified water level, flood duration, timing of the flood, continuity of flooding, floodplain area, area of different flooded vegetation types, dry season refuges and fish migration as the variables most likely to influence fish catch.[100]

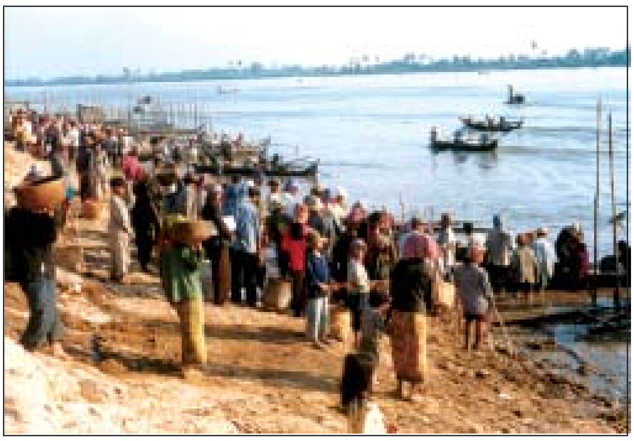
The current very high yield levels for the Tonle Sap area reflect both high exploitation rates and the increasing proportion of small, early maturing species in the catch.[101] Even so, piscivorous (fish eating) snakeheads still represent 11 percent by weight and 25 percent by value in the fishing lot and medium-scale fisheries in Cambodia.[102]

Figure 3. Illustration of the fishing-down process



Note: In 1940 the Tonle Sap Great Lake region catch of 125,000 tonnes consisted mainly of large and medium sized fish, while the 1995-96 catch of 235,000 tonnes contained hardly any large fish and was strongly dominated by small fish.
***Source*:** Sverdrup-Jensen 2002

When multi-species fisheries are heavily fished, the following changes logically occur: (i) annual catch of large- and medium-sized fish decrease, while small fish species, which reproduce faster and feed low in the food chain form a greater proportion of the catch by weight; (ii) more time is needed to catch the same amount of fish; (iii) the number of fish species caught declines; and (iv) there is an increase in conflicts between stakeholders in the fisheries sector.[103] Data held by the MRC fisheries programme indicate that (i), (ii), and (iv) are already occurring.



The dai *Fishery in Cambodia*

Even though the total yield may in fact be increasing, there are indications of selective over-fishing.[104] Species that need more than one year to reproduce are declining quickest.[105] The LMB population is growing at an average of 1.45 percent per annum,[106] though with the growth rate in Cambodia at 2.6 percent and Lao PDR at 2.8 percent,[107] there will be greater pressure on natural aquatic resources in years to come.

2.7.5 Other impacts

River modification

River modification includes construction of navigation channels, locks and weirs, which alter river topography and water flow patterns. Some of the likely impacts on the fishery are typified by investigations conducted for the Mekong River Channel Improvement Project (MKRCIP), designed to increase the navigability for shipping in the upper Mekong River, 360 km from the Chinese border down to Ban Houei Sai in Lao PDR.[108] The MKRCIP plans the removal of assorted sand bars (mid-channel bars, bank-attached bars, tributary-mouth bars, and bedrock bars).

Roberts [109] considers that the blasting of rapids, rock bars and islands, the dredging of substrate, construction of ports, and other development, may lead to fish kills in the project zone, but also there will be significant international "trans-boundary" implications.

Deforestation

There is currently no information available on the impact of deforestation in the highlands on the fisheries resources of the Mekong Basin. The serious implications of removal or conversion of flooded forest on the floodplains is covered in Section 2.7.3, and within the LMB, the deep pools, which are important dry season fish habitats, would be in danger from excessive silt deposition resulting from increased erosion caused by deforestation.

In general terms, deforestation is associated with increased erosion and instantaneous run-off to streams and rivers. Erosion increases sedimentation, turbidity, total suspended solids, and conductivity. High suspended solid loads irritate fish gills and smother fish eggs, preventing oxygen exchange. Increased run-off to rivers also increases nutrient concentrations and nutrient loads in rivers. Deforestation alters water temperature and decreases the leaf litter available to the aquatic food chain. All the above adversely affect aquatic flora and fauna.[110]

Conversion of flooded forest to agricultural land is a threat to fish production

Destructive fishing practices

Destructive fishing practices include the use of fine meshed nets, fishing during spawning seasons and in dry season refuge areas, and using electricity, poisons and explosives. Fishers use explosives in deep pools and channels in northeast Cambodia during the dry season.[111] This illegal fishing method destroys spawning populations, which are sheltering in the deep pools until the next flood pulse.[112]

Juvenile pangasiid catfishes have traditionally been captured in fine meshed *dai* nets in the Mekong River in southern Cambodia and northern Viet Nam for stocking in grow-out cages or ponds. Only 15 percent of this catch is kept; the other eighty five percent are killed and discarded in the separation process.[113] These are the larvae of 160 non-target species. Thus approximately 9 kg of non-target fish seed are killed for each kg of river catfish seed collected. Fearing the damage done by this destructive fishing method, the capture of wild pangasiid fry and fingerlings has been prohibited in both Cambodia and in Viet Nam.[114] Despite Viet Nam producing more than 270 million river catfish fry by artificial propagation in 1999, fish farmers believe that wild fish grow faster and prefer to buy wild fry, even if they are more expensive.[115] As a result, the illegal collection of river catfish seed still continues, particularly in Cambodia.[116]

Fishing with explosives cost this Stung Treng fisher the lower part of his right arm

Introduction of exotics

Exotics are generally introduced for aquaculture, for biological pest control, and for the aquarium trade. The big head carp (*Hypophthalmichthys nobilis*), silver carp (*Hypophthalmichthys molitrix*), grass carp (*Ctenopharyngodon idellus*), common carp (*Cyprinus carpio*), rohu (*Labeo rohita*), catla (*Catla catla*), mrigal (*Cirrhinus cirrhosus*), tilapia (*Oreochromis sp*.), and the African catfish (*Clarias gariepinus*), are now widely used for aquaculture in the four LMB countries. Most of the above mentioned species have probably established breeding populations in all or part of the basin.[117] It has further been reported that fishes introduced in the Mekong Basin in China are now appearing in Thailand.[118]

The guppy (*Poecilia reticulata*) and the mosquito fish (*Gambusia affinis*), originally introduced as ornamentals and to control mosquitoes are now widespread in ditches and ricefields throughout the basin. These same habitats have been colonised by the South American loricariid catfish (*Hypostomus plecostomus*), which is common in polluted water bodies.[119]

There is also a growing, but as yet unregulated, aquarium fish trade from Thailand to Singapore, and also from Lao PDR to Thailand and to Viet Nam. Fish species are also traded into the Mekong Basin from outside the region. There are concerns that without appropriate management measures, trade in aquarium fish will negatively affect biodiversity in the near future. [120]

Risks from the uncontrolled introduction of exotic fish species include competition and displacement of indigenous fish species, reduced biodiversity, hybridisation, loss of genetic diversity and the possible introduction of disease pathogens and parasites.[121]

Pollution

Pollution would become a major concern for the Mekong fishery if it formed a biological barrier to the dispersion of fish eggs or the migration of fish larvae and adults. Pollution includes agricultural run-off (fertilisers, herbicides and pesticides); human sewage and storm water from urban areas; and industrial effluents. Point sources of pollution are currently not a major issue for the fisheries of the LMB, although there have been instances of localised pollution which have been sufficiently severe to cause fish kills. [122]

Commercialisation of agriculture increases the use of fertiliser and pesticides

Fertiliser run-off into water bodies often results in eutrofication as the water becomes overly nutrient rich. Eutrofication may increase the yield of certain fish species, but it is generally accompanied by a decline in the number of fish species and biodiversity. The increase in land area under agriculture production and the intensification of agriculture has also increased the use of insecticides and pesticides.[123] An analysis of 20 fish samples of two fish species in the Mekong Basin in Thailand in June 1988 showed that all samples were contaminated with at least one type of organochlorine pesticide. Dieldrin, DDT and its metabolites were the most encountered organochlorines, even though both DDT and Dieldrin are banned from importation into Thailand.[124]

Recently, the use of pesticides banned in Thailand, Viet Nam and many other countries has been reported in Cambodia.[125] In 1999, 100 percent of 81 specimens of 27 different fish species (16 freshwater and 11 marine) taken from Cambodia were contaminated with organochlorines and polychlorinated biphenyls. DDT was the predominant pesticide found at levels ranging from 0.5 – 25 nano gm per gm of wet fish. DDT levels were higher in freshwater fish than marine, suggesting that the DDT originated from inland river catchments.[126] DDT is used extensively during the early rainy season to control insects, and mosquitoes in particular.[127]

3. Aquaculture

3.1 Importance of aquaculture

Aquaculture in the region is a diverse activity encompassing production and sale of fry and fingerlings and the raising of wild or artificially-produced fry and fingerlings in enclosed or semi-enclosed water bodies for sale and home consumption. In addition to the farming process, the supply of inputs, and the handling, processing and marketing of aquaculture products are the basis of rural livelihoods in many remote parts of the basin. [128]

Giant fresh water prawns

Capture fisheries and aquaculture are closely interlinked with the culture of several farmed species being completely or partially dependant on capture fisheries for seed supply.[129] Wild river catfish (*P. bocourti*) seed is stocked in culture cages along the Mekong River in Thailand. Wild river catfish seed and giant freshwater prawn (*Macrobrachium rosenbergii*) post-larvae are still the only sources of seed available for culture in some areas of Viet Nam. Small wild fish are also an important feed source for intensive cage culture of snakeheads, catfish, sand goby and seabass (*Lates calcarifer*) in Cambodia and Thailand.[130]

Extension services are crucial for successful development of aquaculture

Total freshwater aquaculture production in the LMB has risen from 60,000 tonnes in 1990 to 255,000 tonnes per annum in 2001. This is worth an estimated $244.6 million.[131] See Table 6, in which marine prawn aquaculture in the Mekong Delta is excluded. The Mekong Delta of Viet Nam and Northeast Thailand, in that order, are the most important producers of cultured fish in the LMB. In these areas better infrastructure facilitates easier access to inputs and markets than in the more remote rural areas of Cambodia and Lao PDR. At least two million rural households in the LMB are culturing fish. In Northeast Thailand, for example, more than 6 percent of the 2.6 million rural households are involved in small-scale aquaculture, while in Viet Nam the proportion is 60-70 percent.[132]

Harvesting a village pond

Small-scale aquaculture contributes to food supply in areas where wild fish are not available and in seasons when wild fish are in short supply. It provides opportunities for flexible supplementary income and helps families diversify from fishing and rice farming activities.

Aquaculture appears to have particularly good potential where there is food insecurity and in areas where wild fish stocks are insufficient to meet demand. There are a number of important factors influencing development, including infrastructure, access to markets, supply of inputs, access to extension and other support services, and availability of fish seed. In Lao PDR, for example, economic factors are a major constraint and include a poorly developed market economy outside major towns and limited access to long-term credit.[133]

3.1.1 Viet Nam

Viet Nam has the largest aquaculture area in the basin, covering 330,000 hectares. Freshwater aquaculture production in the Mekong Delta of Viet Nam in 1999 was 171,570 tonnes. Production is high, with a mean annual pond production of 4.8 tonnes per ha. Over 100 hatcheries in the delta of Viet Nam produced an estimated 1,615 million fry and 595 million fingerlings in 1999.[134] The most commonly-cultured fish species are river catfish (*Pangasianodon hypophthalmus*), silver barb (*Barbonymus gonionotus*)¸ common carp (*Cyprinus carpio*), tilapia (*Oreochromis* spp.), giant gourami (*Osphronemus goramy*), sand goby (*Oxyeleotris marmorata*), hybrid catfish (*Clarias gariepinus ´ C. macrocephalus)*, silver carp (*Hypophthalmichthys molitrix*), Indian carps, and snakehead (*Channa striata*). Polyculture of mixed species is the norm, and pond production is generally integrated under the ‘VAC’ system, an acronym from the Vietnamese words for ‘livestock’, ‘pond’ and ‘vegetables’.[135]

Table 5. Freshwater aquaculture production in the LMB (based on latest available statistics 1997-2001)

	Number of households engaged in aquaculture	Estimated annual production (tonnes)	Estimated value ($)[1]
Thailand	>156,000	33,521 [2]+30,000[3]	20,400,000[4]
Lao PDR	55,400[5]	5,378[6]	7,000,000
Cambodia		14,100[7]	17,200,000
Viet Nam	1,606,000 – 1,873,000[8]	171,570[9]	200,000,000
Total		**255,569**	**244,600,000**

Notes: 1: This value is the theoretical cash value of production and does not reflect the actual income/expenditure on aquatic resources; 2: DOF 1997 official production statistics for NE Thailand; 3: Estimated unreported small-scale aquaculture production; 4: Estimated from 1997 DOF data on the average freshwater fish price of Baht 27/kg and 1997 annual production figures and an exchange rate of 1US$=Baht 45; 5: Lao Agricultural Census, 1998/99. Steering Committee for the Agricultural Census. Agricultural Census Office. Vientiane, February 2000 ; 6: Pond production estimated as: estimated pond area x average productivity 800 kg/ha, rice fish culture area x 120 kg/ha. 7: Official DOF figures for 1998; 8: Le Than Luu 2001; 9: The figure excludes shrimp production – in 2000 there were 82,656 tonnes, 191,516 ha and 79.1% of the total productivity 0.432 t/ha/year in the Mekong Delta region.

Source: Phillips 2002

Feeding fish in cages

Eighty thousand hectares are presently under rice-fish culture. Silver barb, common carp, silver carp, tilapia, Indian carps, climbing perch (*Anabas testudineus*), and snakeskin gourami (*Trichogaster pectoralis*) are most frequently stocked in rice-fish systems. The mean annual production is 0.37 tonnes per hectare.[136] Fish are often held in the rice fields for two or three successive rice crops.

There are nearly 5,000 fish cages in the waters of the Mekong Delta in Viet Nam, ranging from 50 to 400 m^2 in size. River catfish, snakehead, red-tail tin foil barb (*Barbonymus altus)*, silver barb and common carp are the common species reared in these cages. Cages are most often stocked with wild captured fry or juveniles. Fish are fed wet sticky balls of mixed rice bran, broken rice, trash fish and vegetables. Fish are cultured for 10 to 14 months and yields range from 80 to 120 kg/m^3. Cage culture of high value species requires investment levels beyond the reach of poor and marginal farmers.

The government of Viet Nam has recently begun promoting giant freshwater prawn (*Macrobrachium rosenbergii)* culture in the Mekong Delta. In 1999, there were 2,940 hectares of *Macrobrachium* ponds, typically 50 – 200 m^2 in area and stocked with 1 – 5 post larvae per square metre. There were also 6,730 hectares of rice-prawn plots, stocked with 1 – 2 wild-caught post larvae per square metre. In ponds, *Macrobrachium* are fed a mixture of rice bran, broken rice, fishmeal or trash fish. No feed is provided in rice-prawn systems. Mean annual production in 1999 was 0.33 tonnes per hectare.[137] Present giant freshwater prawn production is about 5,000 tonnes per year, but the government of Viet Nam has set a target of 60,000 tonnes by the year 2010.[138]

3.1.2 Northeast Thailand

Aquaculture in Northeast Thailand has expanded significantly over the past ten years. Fish culture in ponds, rice fields, ditches and cages contributes over 33,500 tonnes per year, according to official Department of Fisheries statistics. These statistics underestimate total production since small-scale producers are not included. With production from small-scale operations estimated to be in excess of 30,000 tonnes per year, a conservative estimate for the total annual aquaculture production is 65,000 tonnes.[139]

Pond culture makes the biggest contribution to total production. Both exotic and indigenous species are produced. Species include a mixture of indigenous catfish, snakeheads, silver barb and exotic species including tilapias, and Chinese and Indian carps. Pond culture is based largely on the use of agricultural by-products, such as manures and vegetable matter, inorganic fertilisers and the increasing use of pelleted diets. Larger integrated farms are found around urban centres where organic matter from pigs and chickens and agro-industrial processing wastes are readily available. Rice-fish culture is also practiced.

Floating fish feed factory in An Giang Province, Viet Nam. The feed is produced from dried fish (mostly imported from Cambodia) and used in the cage culture of Pangasiid catfishes in Viet Nam.

Cage culture of tilapia, supported by larger agro-industrial concerns, has expanded in the past three years in reservoirs and the Mekong mainstream. Cage culture of river catfish *(Pangasius bocourti* and *Pangasianodon hypophthalmus)* using wild seed is also conducted in the Mekong River, and its expansion can be anticipated if the breeding technologies become more widely adopted. Northeast Thailand is also an important supplier of seed and feed to areas in Lao PDR bordering the Mekong River.

3.1.3 Cambodia

In Cambodia, over 80 percent of aquaculture production comes from cages and pens in the Great Lake and the Tonle Sap, Mekong and Bassac Rivers.[140] The major species are river catfish and snakeheads. Juvenile river catfish and snakeheads are collected from the wild fishery. Pond culture and farming fish in rice fields is less developed in Cambodia, although its importance has been increasing in recent years as a result of NGO and international donor-assisted projects.

Rice fields are important for aquatic animal production

There are two basic pond systems used in Cambodia. Intensive catfish culture is common in and around Phnom Penh and Kandal Province near urban markets. Fish fingerlings are collected from the wild, held in small ponds, and intensively fed rice bran or wild fish when these are abundant. The second type is low-input pond culture, rice-fish and other integrated fish/livestock/vegetable culture techniques using various exotic and indigenous species. Although pond and rice-fish culture makes a limited contribution to total production, small-scale farming provides an important opportunity for poor households to improve nutrition and to generate cash income in fish-deficient areas farther from the Tonle Sap and other major rivers.

3.1.4 Lao PDR

Fish culture in ponds and rice fields is widely practised in Lao PDR, and a variety of systems are used, depending on the agro-climatic characteristics of the area. The attraction of aquaculture to rural farmers is most obvious in locations where capture fisheries are inaccessible or require excessive effort for a limited catch. There is a small amount of cage culture in reservoirs and rivers, but this system presently makes only a small contribution to national production. Most ponds are hand constructed and shallow, with water depths of less than 50 cm. Low productivity figures for aquaculture ponds reflect the limited amount of inputs applied, limited stocking of fish seed and a short grow-out season. A diverse number of species are cultured, including exotic carps and indigenous fish.

3.2 Factors impacting the sector

3.2.1 Availability of seed

The availability of good quality and healthy fish fingerlings is a pre-requisite for the development of aquaculture. The supply of seed for aquaculture has increased substantially in the past 10 years, especially in Thailand and Vietnam, where significant hatchery and nursery development has occurred, involving both the government and private sector. In Cambodia and Lao PDR, many ponds are not regularly stocked, one of the reasons being the lack of access or availability of fish fingerlings, although with increasing numbers of farmers and infrastructure, the market incentives and supply of seed will increase. The widespread adoption of the ‘hapa’ technology within the basin (the nursing of fry to large fingerling size in small net cages), has contributed to the availability of larger fingerlings that are less vulnerable to predators when stocked in ponds.

There are an estimated 5,000 fish cage operations in the delta in Viet Nam

Fingerling fish ready for stocking

At least two billion fingerlings are used for producing around 250,000 tonnes of aquaculture product within the basin.[141] For aquaculture to grow, a significant expansion in hatchery and nursing capacity will be required. The development of local small-scale hatcheries, “hapa’’ nursing, nursing and trading networks, and on-farm breeding has proved to be a catalyst for rural, small-scale aquaculture development. Further development of “hapa” nursing and nursing networks will therefore be essential to support aquaculture, particularly in areas lacking good infrastructure in Cambodia and Lao PDR. Without local networks, seed will be transported over large distances between watersheds, with attendant risk of disease spread and genetic mixing of fish stocks.

The role of government and private sector investment in seed production centres needs to be carefully analysed in the context of development of effective genetic management and species strategies for the basin.[142]

3.2.2 Availability of feed and fertilisers

Inputs come from on-farm and off-farm. Rice bran is an important ingredient in feed, but there are other inputs, depending on local resources. These include vegetation, chemical fertilisers, human "night soil" and waste from integrated livestock/vegetable/ aquaculture systems. Geographically, off-farm inputs are more readily available in Viet Nam and Thailand. Fish farmers in Cambodia and Lao PDR will have access to more inputs as infrastructure develops and as markets for agricultural inputs (fertilisers and lime) expand. The infrastructure changes in these countries will gradually open more options for pond inputs.

Waste from livestock supplies feed for fish

It is likely that more high-input aquaculture will develop near urban centres where there is a market for high priced products. In rural areas, however, low-intensity aquaculture, producing both for household consumption and as a cash crop, will become increasingly important.[143]

3.2.3 Availability of water and land

Most of the small-scale aquaculture ponds in the basin are rainfed and therefore use of ponds and their success varies from year to year, depending on climate. The use of water is not likely to be a constraint with rainfed ponds, unless there are dramatic changes in climate. In irrigated farming areas, or where there are multiple users of water, other considerations may arise. Aquaculture can be an efficient user of water, particularly when integrated with agriculture.

Ponds in several parts of the basin are faced with productivity problems due to poor and acidic soils, and inappropriate management practices. In more 'open' farming systems such as cages, or the culture of fish in rice fields, water pollution from various sources, including pesticides, is a concern. The use of integrated pest management (IPM), which employs a variety of techniques, can reduce the need for pesticides and can benefit both rice and fish culture. In cage and pen culture located in publicly-accessible waters, more attention needs to be given to environmental management and planning to ensure that water pollution is controlled and that water surface area is fairly shared with other users.

Overall, adequate land is available to support aquaculture development in the LMB. Rice land or marginal land in rice growing areas is available in many parts of the basin for pond construction, although in some areas, such as the upland areas in Lao PDR, flat land is scarce and primarily used for rice cultivation. [144]

3.2.4 Habitat degradation

The Government of Viet Nam has identified 1.8 million hectares of water surface suitable for aquaculture. [145] However, freshwater and coastal aquatic resources are under threat from environmental degradation, over-exploitation and poor management practices.[146] Construction of large prawn ponds in Viet Nam and failed harvests caused by disease has resulted in indebtedness. An estimated 75 percent of the mangroves and 95 percent of the *Melaleuca* forests have been destroyed in Viet Nam,[147] although only a small part of this fisheries habitat loss is attributable to aquaculture developments.

Flooded forests are crucial habitat for fish

3.2.5 Disease

To date, the epizootic ulcerative syndrome (EUS) in the 1980s has been the only large-scale fish disease outbreak in freshwater aquaculture in the region. However, it is likely that such problems will increase in future with further expansion and intensification of aquaculture. Prawn aquaculture in the Mekong Delta has recently been plagued by major disease outbreaks. Intensive cage culture in the Mekong and Bassac Rivers, and in reservoirs in central Viet Nam, have suffered losses of fish during the past five years. Low-level health problems are known to be a constraint in small-scale pond culture.

The infection of humans from liver flukes (trematodes) is a serious health concern in parts of the Mekong Basin where raw fish is consumed. [148] Aquaculture can be a means to reduce infection of trematodes, though it may also be a source of infection. In Lao PDR, trematode infection of wild fish occurs where rivers, streams and paddies are used as latrines. Ponds with over-hung latrines in the Mekong Delta (a practice which is actually illegal) are still a major source of cultured fish, and also a possible source of infection for humans. However, the risk factors and management strategies relating to these issues require further research.

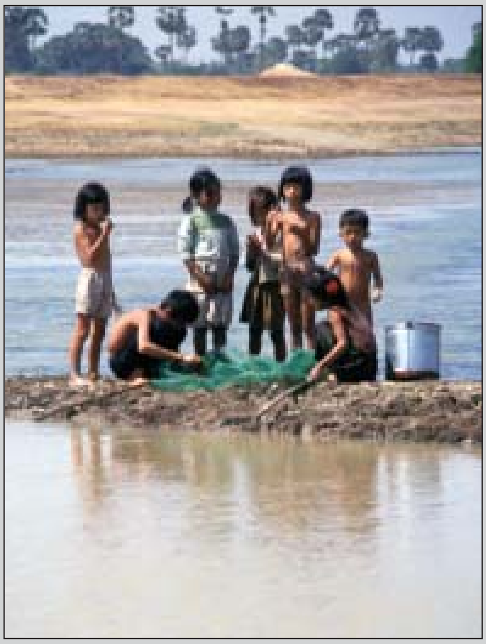
3.2.6 Extension services

Aquaculture extension systems are well developed in Thailand, less so in Viet Nam, and quite limited in Cambodia and Lao PDR. Within government agencies, there has been a tendency to focus on peri-urban aquaculture (due to accessibility, private entrepreneur involvement, better availability of inputs and access to markets). Focusing government support on small-scale aquaculture and poorer rural households will provide a necessary balance to more commercially-oriented aquaculture. However, this has to be supported by skills development. [149]

4. Aquatic products from wetlands

The wetlands of the LMB are vital life support systems for communities throughout the region. They are responsible for providing a vast array of *goods* and *services* to the people in the region. *Services* are the ecological functions provided by wetlands such as habitats for fish and wildlife, support for the food chain, retention of water to prevent flooding, a trap for sediment, and purification and replenishment of ground water. *Goods* are the plants and animals that people harvest for food, medicine, construction, household products and so on.

The goods from wetlands products are very significant for the livelihoods of people in the Lower Mekong Basin. Most of the estimated 40 million rural people concentrated along the Mekong River, its tributaries and related wetlands, are subsistence farmers obtaining their livelihoods through a combination of rice farming, fishing and foraging from nearby wetlands and forests. Besides supplementing their food supply, the harvest from wetlands supplies protein during the dry season when fish are less available and ensures food security in years when the rice crop fails.



Because little research is conducted on the harvesting of aquatic animals other than fish, their importance in insuring food security often goes unrecognised

Isolated communities in the basin with limited access to markets and roads depend on locally-available flora as their primary source of edible fruits, vegetables, fodder for livestock, medicines and construction materials. Thus wetlands have been called the “poor man’s supermarket”. The abundance and diversity of species, plus their availability in different seasons, are crucial factors in providing the “safety net” that increases rural food security. However, few people outside the basin are aware of the importance of harvesting these key aquatic resources.

4.1. Aquatic animals for food

Aquatic animals, other than fish, are sometimes considered “less serious” catches. This may be because the catching is usually the work of women and children. They use smaller fishing gear, and do their catching and gathering around the edges of the lakes, seasonal wetlands, or in rice fields. Although the catches are “low profile”, added together they provide crucial food security for rural households through periods when other foods may be in short supply. The catch is mainly for daily home consumption, but often the excess catch is sold to obtain cash income.

Aquatic products are largely harvested by women and children

4.1.1. Molluscs – snails clams and mussels.

Snails are abundant in the dry season, providing animal protein at a time when fish are less plentiful

The Mekong is known to have a rich molluscan fauna (see Chapter 4). At least six species of bivalves and four kinds of snails are commonly consumed in Lao PDR and other riparian countries.[150] Snails are abundant in the dry season around the edges of lakes or rice fields, and at the beginning of the rainy season (May-June) when the fields are filled with new water. In the rainy season, snails come out from their dry season refuge in the ground and can be seen and easily caught. A typical harvest at one time is 2-10 kg, enough for 2-5 family meals. The excess catch of smaller snails (*hoi jeub*), is sold in local markets while larger snails (*hoi pang* and *hoi kong*), which are more valuable, are sold to traders or in the district market.

In Cambodia, the harvest of *leah* (bivalves) from natural lakes is very important for consumption and the local economy. The catch takes place when the water recedes, from November to April. Over 138 tonnes were caught annually by 130 families in the three sampled villages near Beoung Thom Lake, Kompong Cham Province. *Leah* is sold to village traders, with farm-gate earnings of between $90 and $180 for each family every year. *Leah* is cheap and widely consumed with beer after being cooked by the sun, or stir-fried with herbs and eaten with rice.

4.1.2 Crustacea – shrimps and crabs.

Small freshwater shrimps (*Macrobrachium* spp.) are commonly caught in the shallow water around the edges of lakes or ponds, as water recedes from November to March. Usually women and children engage in this catch, using hand nets or bamboo baskets. The catch is about 0.5-2 kg for 1-3 hours work. Shrimps may be caught daily or only once or twice per week, depending on the distance of villagers from the source, and the availability of family labour. The estimated catches of lakeside communities range from 15 – 600 kg per year, amounting to up to $250 per family per year.[151] Shrimps are boiled or stewed with various vegetables or prepared as salad. Crabs are also commonly collected in rice fields and eaten. Commonly-eaten species apparently all belong to the genus *Somanniathelphusa* and are known in Lao PDR by the common names *pou na, pou khilek* and *pou hin.*

Small freshwater shrimp are caught in shallow water at the edges of lakes and ponds during the dry season

4.1.3 Insects - water bugs, beetles and others

Insects are an important source of supplementary protein for local communities throughout the year, and more significantly, in the early dry season. At least 14 kinds of aquatic insects are known to be consumed in Northeast Thailand and other LMB countries.[152] The most commonly eaten are giant water bugs (*Lethocerus indicus*: Belostomatidae) or mangda (in Laotian and Thai), beetles (mainly Dystiscidae**),** dragonfly larvae (Odonata) (*mang nio* or *mang rangum*), and blackflies (Simuliidae).

Mangda, large water insects, which are caught in rice fields and wetlands in Cambodia are sold at the Thai border for $90 per kilo

Aquatic insects are mainly harvested in November and December, as the water in rice fields and ponds dries up. Some insects are caught in water bodies by women and children using a circular basket made of bamboo, while flying adult insects are attracted by flourescent lamps fixed to poles and caught when they land on a sheet of plastic beneath the light. Some insects are stewed with vegetables or grilled in banana leaves with spices, while Simuliidae are used as an ingredient in soup.

Unlike other aquatic insects, *mangda* are used to flavor other foods, rather than eaten on their own. In Thailand, especially in the Northeast, where *mangda* are widely consumed, their essence is extracted and bottled for sale in local grocery stores. Due to the high levels of pesticides and fertilisers used in farming in Thailand, the catch of *mangda* has greatly declined in recent years and as a result, *mangda* are now an exported from Cambodia, through the border town of Poipet. At the border, *mangda* are sold for $90 per kg (about 100 insects/kg). The *mangda* trade from Cambodia to Thailand is estimated to be several tonnes per year.

4.1.4 Amphibians - frogs and toads

Several species of frog are commonly consumed in the basin. Large frogs such as *Hoplobatrachus rugalosa* are hunted for domestic consumption and local trade. Frogs are most abundant and easily caught in large quantities at the beginning of the rainy season, in May and June. Hunters use torch lights to search for frogs at night in the rain. In southern Lao PDR, the average catch is between 3-5 kg per night.[153] The average rainy season catch (in 2-3 months) around Beoung Thom Lake is 20-30 kg/family/year, or 3.6 tonnes from the four villages surveyed. The excess amount is sold in neighbouring villages or markets at $0.75-1.00/kg, which is equal to one day's wage for farm labour in Cambodia.[154]

Frogs are an important source of animal protein from March to May when fish are scarce

Tadpoles are collected by methods similar to those used with the aquatic stages of insects. They are widely consumed in Northeast Thailand, and considered a delicacy by city people. One kilogram sells for as much as $5 – two to three times the price of fish.

Frogs are key sources of protein for rural families during the peak of the dry season (March to May), when fish and other aquatic animals are scarce. Frogs hibernate in the dry season, and usually are caught in holes in rice fields, or on the edge of drying ponds or streams. Although the frog catch is sporadic and much smaller than in the rainy season, together with snails and crabs, they provide important supplementary food for rural people throughout the dry season.

4.1.5 Reptiles - turtles, snakes and lizards

A number of snakes and turtles are hunted for consumption or sold for food or medicine in local markets. In the past decade, income from these animals has increased as Cambodia, Lao PDR and Viet Nam have adopted market economies. Bocourt's watersnakes (*Enhydris bocoti*), puff-faced watersnakes (*Homalopsis bacata*), water dragon (*physignathus*), reticulated phython (*Phython reticulatus*) and the Tonle Sap watersnake (*Enydris longicauda*) are all commonly hunted for food and trade. Turtles, which are sold for meat and for medicine, are mostly caught in Cambodia and Lao PDR, as wild stocks in other parts of Asia have diminished.

Turtles are sold for meat and medicine

4.2. Aquatic plants as food

At least 20 kinds of aquatic plants are commonly harvested by basin residents for food, and some surpluses are sold in local markets. These plants give fishers and farmers a supply of fresh vegetables nearly all year round.

The tuber, stems, and seeds of lotus (*Nelumbo nucifera*) are collected and consumed basin-wide. Young seeds of lotus are sold fresh as snack food, and mature lotus seeds are processed into a sweet by glazing them with sugar. These are important commercially for communities around Tonle Sap Lake in Cambodia. Water hyacinth *(Eichhornia crassipes*) flowers are eaten fresh as salad or with sauce or paste made from fish. Young riang leaves (*Barringtonia acutangula*) are collected and commonly eaten with a meal of fish and rice, or as a condiment in noodle soup. Throughout the basin, water morning glory *(Impomoea aquatica*) is the most frequently consumed aquatic vegetable.

Water hyacinth is eaten as a vegetable and also fed to livestock

In seasonally-flooded areas along the Songkram River and its tributaries, bamboo shoots are of significant value, both for food and for income generation. This harvest is 200-500 kg/family/year. For rural households in this area, bamboo shoots and other wetland products contribute more food and income than rice production. Each year, tonnes of fresh and canned bamboo are sold in both local and regional markets. Canning and trade in bamboo shoots are the main income generation activity undertaken by several women's groups and village cooperatives in the Songkram Basin.

Water morning glory, water lily and water hyacinth are the most commonly-consumed plants in Cambodia. About 400-700 bunches of these vegetables, worth around $35, are collected per family per year by Boeung Thom lakeside communities. Wild plants comprise about half the total vegetable consumption in many rural communities in the basin.[155]

Other commonly consumed wild plants include water cress (*Neptunia oleracea*), water chestnut (*Trapa bicornis*), aquatic fern (*Ceratoperis thalictroides*), *pak waen* (Marsilliaceae), and *bon* (*Colocasia).*

4.3 Aquatic plants as animal feed

Fodder plants for local livestock are also important, in particular in Cambodia and Lao PDR. Assorted plants such as *Utricularia, Eichchornia, Lemna, Ludwigia,* and *Rhynchospora* are harvested and fed to ducks, cows and pigs. A water fern, *Salvinia cucullata* and water cabbage *(Pista strattiotes)* are boiled and fed to pigs and poultry. In the floating villages of the Tonle Sap, pigs as well as their owners eat floating plants most of the year.

Along with fisheries, changes in water flows could also reduce the abundance of aquatic vegetables

4.4. Aquatic plants for non-food uses

In addition to their use as food sources for people and domesticated animals, plants are harvested for a variety of other essential uses.

4.4.1. Medicinal plants

Mcdonald and Veasna[156] recorded the use of 35 species of wetland plants for medicinal purposes in the community of Prek Sramaoch on Tonle Sap Lake. Medical uses include the elimination of parasites (*Diospryos spp.)*, the reduction of fevers (*Heliotropium indicum, Ludwigia dscendens,* and *Quisquallia indica*) and as an anti-inflammatory (*Stenocaulon kleninii*). Uses of particular plants seem to be widely known, confirming old traditions of use of medicinal plants.

4.4.2 Firewood

Most rural communities in Lao PDR, Cambodia and Viet Nam depend solely on charcoal and firewood for their heating and cooking needs. Firewood is also needed for processing rice wine, smoking fish, making rice noodles, processing palm sugar and boiling aquatic plants/rice bran for pig and poultry feed. Lowland communities, such as those in Cambodia and in the Viet Nam Delta, cut their firewood primarily from wetland shrubs and trees and have done so for many years. Firewood from the highlands is of better quality, but is expensive because of transportation costs.

Most rural people use firewood for cooking

Fourteen plant species from secondary scrubland provide most of the firewood for local communities around the Tonle Sap Great Lake. Particular species are usually preferred for special uses. For example *toau* (*Terminalia cambodiana)* is preferred by veteran fish smokers because of the aroma it gives to the fish.[157]

In the Boeung Thom area, household cooking consumed an average of 8-10 m^3 meters of firewood per family per year. Additionally, about 5 percent of all households from villages within 10 km of the lake carry out small processing activities requiring wood. About 90 percent of this firewood demand is supplied by shrubs and trees from Boeung Thom flooded forest.[158]

The annual firewood supply from Beoung Thom flooded forest is estimated to be 62,000 m^3/year for nearby communities, with a value of over $150,000. The cost to lowland families if they had to buy highland firewood would be about $40 per household per year – a very high amount for families whose annual income is usually less than $300 per year.

4.2.3 Materials for construction tools and crafts

Native plants from wetlands provide materials for house posts, floor planks, roof thatching, beam ties, etc. *Diospyros Cambodiana* (*ptual*) is preferred for house stilts and posts. *Impomoea obscura, Stenocaulon kleinii* and *Derris laotica* are used in tying beams off, securing roof thatching, and fixing fish traps and nets.

Poorer villagers close to the shores of Beoung Thom Lake use sedge (coarse marsh grasses) harvested from along lakeshore streams and channels for roofing and walling their houses. A 4 x 5 metre house uses up to 15 m^3 of sedge for a roof and walls, which must be replaced every two years.

Stems and branches of wetland plants also provide other basic rural household goods and farming tools, including handles for knives, axes, hoes, spades, rakes, sickles, ploughs and harrowing tools. Strings made from sedge are widely used to tie newly-harvested bundles of rice stems before they were transported home for drying and threshing.

Wetland plants are used for many household purposes, including making fish traps

Stems and branches of wetland trees and shrubs are also used for making pig stables, chicken houses and fences for home vegetable gardens. Branches are commonly used to make supports in gardens for climbing plants such as cucumbers, string beans and wax gourds. *Barringtonia* branches are piled up in the shallows of lakes to make brush parks for fishing (*samrah*). This tangle of submerged branches can later be fenced and the fish easily caught. This method of fishing is, however, illegal in some Lower Mekong countries.

Water hyacinth and sedges are also used by many rural families to produce craft items for income generation. These plants are harvested and dried, and their dyed fibre used to make craft items. The softer and finer fibre of water hyacinth is woven into accessories such as hats, wallets, purses, jewellery boxes, and baskets. The durable fibre of sedge is woven to make floor and place mats.

Women earn important cash income from making household products and crafts

The processing and selling of these crafts provides jobs and supplementary income for rural women and children in the dry season. With the growth of tourism, making crafts from wetland products is becoming an increasingly important source of income, especially in Cambodia and Viet Nam. Nearly 50 percent of families in some villages near wetlands engage in mat weaving, producing about 30-100 mats per family per season. The farm gate price for a 1 x 2 m mat made from sedge is $1-3, with round sedge products earning the higher price. Remote villages residing close to lakes depend on these crafts to supplement their earnings from fishing, and they are especially important in supplementing income for villages with limited land holdings.

5. Conclusion

The Mekong River and its many sub-basins constitute an extremely diverse and complex ecosystem, which is highly dynamic in time and space. This combination has created one of the most diverse fish communities in any river system in the world. The ecology of the many fish species is intimately linked to the hydrology of the system. Fish are still abundant and the stocks are healthy, due to a relatively unpolluted and intact environment with no dams on the mainstream outside China. The Lower Mekong River Basin, with 1.5 million tonnes of fish landed annually, still sustains one of the largest freshwater capture fisheries in the world, providing food and employment for many of the 55 million people living in the basin.

A rapidly growing population means more mouths to feed. Increasing fishing pressure has contributed to the decline of the large and slow-growing species. They are gradually being replaced in the fishery by small, fast-growing opportunists that mature sexually after one year. Looking across all fisheries, it appears the total catch is probably close to being fully exploited so further expansion of fishing will become increasingly problematic.

In spite of an impressive expansion in aquaculture over the last decade, it is not a substitute for capture fisheries. It does, however, have an important role in providing food and income for rural dwellers, particularly those remote from the rivers and their fisheries. Aquaculture of exotic species poses some threats to natural stocks of fishes, if the exotic species happen to establish reproducing populations in the natural environment. Some aquaculture systems are based on the collection of fry from capture fisheries, as well as the supply of fish as food for the cultured fish. Unlimited fry collection and the use of fish as a feed source in aquaculture are not in the best interests of the fisheries or the people dependent on them.

While at the macro level, development of the Mekong's water and related resources could benefit national economies and the economy of the region, if not well planned and carefully managed, it could also significantly impact the wetlands upon which rural people heavily depend, both for food security and for their livelihoods.

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Agriculture 8

Rice yields range from 5 tonnes per hectare in the Mekong Delta to 1.5 tonnes in upland, rainfed areas

The agriculture sector is of critical importance to the economic lives of the people of the Lower Mekong Basin (LMB) as well as to the environmental well-being of the region. Agricultural activities provide the livelihoods of the majority of the basin's population and comprise, arguably, the most important use of, and pressure upon, natural resources. Over 40 percent of the basin's land area is devoted to agriculture, and there are important interconnections between the ongoing expansion of the agricultural cultivation area and land use change, especially deforestation.[1] In terms of water use, irrigation – either through the storage of receding flood waters at the end of the rainy season or the diversion of water from rivers and streams – comprises approximately 80 to 90 percent of all water abstractions in the basin.[2] Yields from crop production in the LMB are generally low by international standards, and there is scope for increasing the scale, intensity and efficiency of production. Such changes could significantly enhance rural incomes and national macroeconomic performance. Increasing commercialisation of production, expansion and intensification of irrigation and the diversification of rice-based production systems into alternative crops with greater financial returns, are all important trends in this direction. These trends are, however, progressing at very different speeds across the various regions of the basin. Furthermore, increasing agricultural production could come at the cost of greater pressure on both land and water resources. There is the possibility of harmful feedback cycles where poorly managed agricultural expansion could undermine the long-term sustainability of the sector. Poorly managed agricultural development could have negative implications for future agricultural activities, as well as other forms of land and water use.

Unlike most of the chapters in this report, agricultural statistics were available at a basin level. Thus most of the data in the tables that follow are only for areas of Thailand and Viet Nam that lie within the basin. Because almost all of Cambodia and Lao PDR lie within the basin, national-level data have been used for these countries. In those few tables where only national level data were available for Thailand and Viet Nam, this has been indicated with the symbol * in a note below the table.

1. Economic importance of agriculture and forestry

Agriculture is the single most import economic activity in the Lower Mekong Basin. Overall, 75 percent of the region's population is estimated to be dependent upon agricultural crops, fisheries, livestock or forestry, but the picture varies considerably between countries.[3] The tables below show the contributions of the sector to GDP and exports in the four LMB countries.

Table 1. Contribution of agriculture and forestry to GDP

	Cambodia		Lao PDR		Thailand		Viet Nam*	
	1995	1999	1990	1999	1993	1997	1990	1999
Share of GDP (%)								
Crops	26.1	21.3	36.7	28.7	16.6	14.8	-	20.4
Livestock/Fisheries[a]	13.4	15.2	20.7	18.5	4.3	3.5	-	2.3
Forestry	6.6	3.9	3.2	4.9	0	0	-	0.9
Total Share of GDP	**46.1**	**40.4**	**60.6**	**52.1**	**20.9**	**18**	-	**23.6**

Note: "*" data are for the whole country rather than for just for the territory within the basin.
Sources: Lao PDR Ministry of Agriculture and Forestry 2000; Thailand National Statistics Office 2000; Viet Nam General Statistical Office 1999; IMF 2002a; IMF 2002d

Table 2. Contribution of agriculture and forestry to LMB country exports

	Cambodia		Lao PDR		Thailand*		Viet Nam*	
	1995	1999	1995	1999	1993	2000	1995	1998
Share of Total Exports (%)								
Agriculture	15	5	13	6	30	22	32	24
Forestry	69	16	39	29	0	0	3	2

Note: "*" data are for the whole country rather than for just for the territory within the basin.
Sources: Thailand National Statistics Office 1997, 2001; Viet Nam General Statistical Office 1999) IMF 2002a; IMF 2002b;

The differences between the countries reflect varying levels of industrialisation. Agriculture and forestry contribute considerably less to total economic output in Thailand and Viet Nam than in Cambodia or Lao PDR. The relative importance of agriculture decreased in all four countries over the 1990s, but to differing degrees. The change was most pronounced in Viet Nam, which industrialised rapidly during this period, and was least dramatic in Thailand's Northeast Region, where the major economic transformations had begun earlier. Also, the available figures for Viet Nam are for the country as whole, and understate the importance of agriculture in the basin region, particularly in the Mekong Delta, where a major part of the nation's rice is grown. Breakdowns for 1998 put the contribution of agriculture to regional GDP at 55 percent for the delta and 70 percent for the Central Highlands.[4] That year the 12 provinces within the delta produced rice, cash-crops, and aquaculture products that contributed 51.9 percent of total production for the country and exports worth an estimated $1.36 million.[5] Furthermore, despite the decreasing contribution of agricultural goods to Thai and Vietnamese exports, such products, particularly rice, have long been important foreign exchange earners for both countries.

[a] For Viet Nam, figures for livestock are aggregated with those for crops.

In Lao PDR, the declining relative importance of agriculture reflects the fact that growth in this sector has lagged behind that of the economy as a whole. While declining agricultural production per capita caused considerable concern over food security in the 1990s, rice self-sufficiency was achieved in 2000, after several years of stronger growth in the sector.[6] However, despite national rice self-sufficiency, there are serious rice shortages for as much as six to eight months per year in a number of provinces.[7] While agriculture and forestry comprise a high proportion of employment and GDP in Lao PDR, their contribution to national exports is lower than might be expected in a pre-industrial economy because of the large amounts of hydro-power sold to Viet Nam and Thailand.

With growth in the manufacturing and service sectors, agriculture's share of GDP has declined

Between 1995 and 1999, the importance of agriculture to the Cambodian economy decreased by approximately 15 percent (6 percentage points.) However, the sector is likely to remain the most important in the economy for the foreseeable future. Rice and livestock/fisheries each contribute about a third of agricultural output and together comprised about 28.5 percent of GDP in 1999.[8] For the same year, forestry contributed only 3.9 percent of officially recorded GDP.

For the 1999/2000 crop year, the Cambodian government estimated a rice surplus of 260,710 tonnes. This was approximately 15 percent above national requirements.[9] However, there are large discrepancies in the degree to which individual farmers are able to produce enough to meet their needs and in their ability to buy food to compensate for shortfalls on the market. Some provinces have chronic shortages, despite national sufficiency.[10] Furthermore, the overall margin of surplus is comparatively thin and the situation could easily go into deficiency if there are floods or drought. Thus, there is an ongoing need to promote food security.[11] With food security a major concern, Cambodia has not exported much rice or other food crops over the past decade. The bulk of export earnings came from forestry products in the mid-1990s, but the export share of this sector has since slipped to around 15 percent because of the growing importance of garment manufacturing, which made up the majority of exports in 1999.[12] Almost all of Cambodia's non-forestry agriculture sector exports are dry rubber.[13]

Landlessness forces rural people to migrate to urban areas to find work

It is also important to note that although the relative contribution of agriculture to the national economies of the riparian countries is decreasing, the absolute values of agricultural production have been increasing. The absolute value of agricultural output increased by 12 percent between 1995 and 1999 in Cambodia, by 22 percent in Lao PDR, 10 percent in Thailand and 19 percent in Viet Nam.[14] The trend is thus not one of contracting agricultural sectors but rather of agricultural growth lagging behind growth in the manufacturing and services sectors.

2. Land use in the Lower Mekong Basin

The Lower Mekong Basin covers approximately 61 million ha. The table below gives an overview of estimated areas devoted to different kinds of land use within the Mekong Basin areas of the riparian countries. Figures for Viet Nam are broken down between the Central Highlands and the Mekong Delta because of the dramatically differing topographies of the two regions. The data are drawn from the MRC Land-Cover Dataset.[15] This dataset is one of the most complete available but does not go beyond 1997, and thus does not capture the rapid land-use change that is believed to have taken place in Cambodia and Lao PDR since then.

Table 3. Land use in the Lower Mekong Basin in 1997

Land Cover (%)	Cambodia	Lao PDR	Thailand	Viet Nam Delta	Viet Nam Highlands
Forest	56.18	41.22	15.74	1.09	47.46
Woodland /grassland	15.00	42.07	3.47	0.34	22.65
Agriculture	23.41	14.01	79.28	83.99	29.46
Wetland/water	5.15	0.96	1.40	10.34	0.27
Other	0.26	1.74	0.12	4.24	0.16
	100.00	100.00	100.00	100.00	100.00

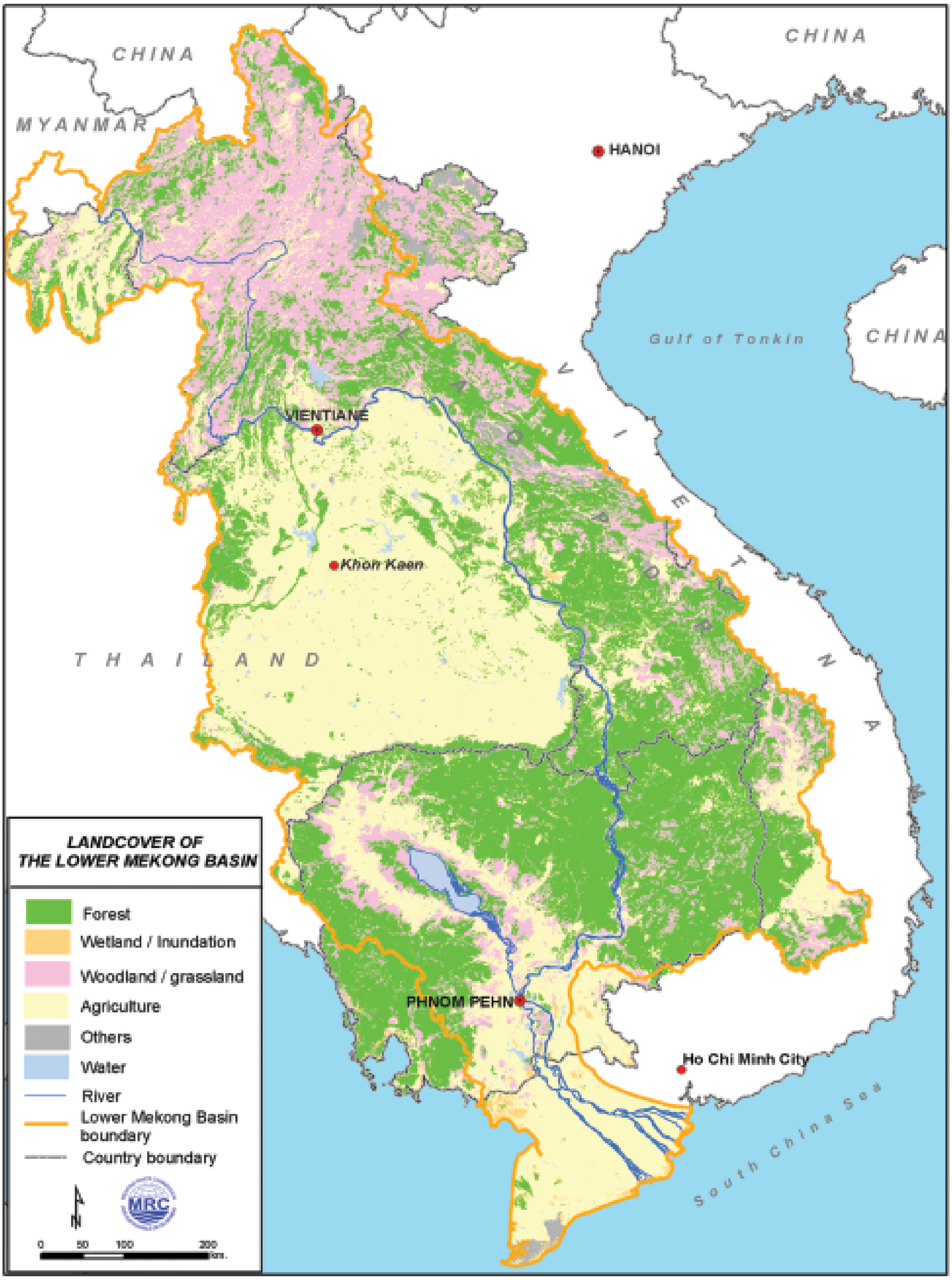
Source: MRC Land Cover Dataset 1997

Of the 25.2 million ha categorised as agricultural land, more than 10 percent, 2.73 million ha, is crop mosaic, a mixture of cropped and non-cropped areas. In lowland areas, crop mosaic may represent a mosaic of permanent agricultural land and remnant woodland. In upland areas, crop mosaic may also indicate areas under shifting cultivation. Land used for mosaic cropping accounts for 2 percent of Cambodia, 8 percent of Lao PDR, 2 percent of the LMB area of Thailand, and 10 percent of the Viet Nam Central Highlands, with none in the Mekong Delta. Agricultural land includes fallow, as well as currently- cultivated land, and thus overestimates the area of land actively used for crop growing or grazing. Comparison of the land-cover data for 1997 to previous data is problematic because of dataset inconsistencies, however, there are general indications that over the 1990s, the extent of agricultural land has been increasing at the expense of forest land.

The soil quality of land used for agriculture varies substantially across the basin. Areas of soil with few limitations to development (deep, non-gravely, with medium-high fertility) occupy nearly 20 percent of the whole basin area.[16] A preliminary land suitability assessment prepared by MRC indicated that for paddy rice, upland crops, and tree crops, 70-75 percent of the basin's land is suitable. However, the majority of this area is only marginally suitable for such cultivation.[17] Furthermore, preliminary data indicate that there is a lack of land highly suitable for upland crops and tree crops because of the paucity of deep, well-drained, fertile, non-gravely, highly stable soils on gentle slopes.

An overall representation of land use and land use suitability in the basin in 1997 is shown in Figure 1.

Figure 1. Landcover of the Lower Mekong Basin



In Cambodia, rehabilitation of the agriculture sector and full utilisation of land available for cultivation is hampered by the continued presence of unexploded landmines and other ordinance. In 1995 minefields were estimated to cover over 40 percent of arable land.[18] While considerable effort has been made to clear mines, the process has been slow and many minefields remain. This situation has led to the clearing of forest by returning farmers who are unable to safely use their own lands. Furthermore, evidence suggests that land availability in Cambodia would be insufficient to support the population even if all the remaining ordinance were cleared.[19]

The threat of mines prevents farmers from cultivating large areas of productive land

Estimates of arable land in Lao PDR vary, but there are indications that such land is not currently fully utilised, leaving room for extended cultivation in the future. The MRC Land-Use data give an agricultural land area of 2.9 million ha, but government statistics record only approximately 800,000 ha under active cultivation. [20] Over 400,000 ha is cultivated on slopes greater than 20 percent, which is not conducive to the growing of annual crops under current cultivation systems and makes erosion and other forms of environmental degradation more likely.[21] Conceptually, Lao PDR can be divided into two distinct categories of land area which support dual agricultural economies.[22] The first is the relatively flat and fertile land of the Mekong Corridor. This area is predominantly used for rice production and has recently undergone rapid market-driven economic transition, whereby farmers increasingly buy agricultural inputs through commercial channels and market a proportion of their produce. The second area consists of sloping lands that are less suitable for rice cultivation. These remote areas are characterised by subsistence agriculture and a lack of access to markets and technologies. Population pressure and inherent ecological vulnerabilities are leading to environmental degradation. As in Cambodia, these remote areas, especially those in the northeast, face problems with unexploded ordinance. Socio-economic indicators for the sloping lands and flat lands diverged sharply in the mid 1990s, with per capita annual income as low as $56 per annum in the sloping areas, as opposed to an annual average of $350-360 per annum in the Mekong corridor.[23]

In Viet Nam, there are major land-use differences between the Mekong Delta and the Central Highlands Region. The delta consists almost entirely (84 percent) of agricultural land, with the majority of this being devoted to rice growing. However, the area cultivated with perennial crops and fruit gardens covers 12 percent.[24] There is no significant forest area in the delta. The land area of the Central Highlands is 68 percent covered by forest, woodlands, and grasslands, with agricultural land covering 0.6 million ha, and crop mosaic accounting for 0.3 million ha. Upland and tree crops, along with shifting agriculture, predominate

Coffee is an important cash crop in upland areas in Lao PDR and Viet Nam in this region. Land in the Central Highlands is relatively abundant given the low population density, and the government has been encouraging the resettlement of lowlanders to the these provinces to exploit opportunities for expanding production of cash-crops such as coffee, tea and rubber.

The Korat Plateau and the rest of the Northeastern Region of Thailand, following rapid deforestation in the 1980s, are now almost 80 percent agricultural land. There are three main geographic areas – the upper and the lower sections of the Chi-Mun rivers and the smaller Mekong tributaries. The soil is generally low in fertility and highly saline.[25] Most agricultural cultivation takes place mainly in the alluvial soils in the middle and lower portions of the river valleys where there are pockets of higher productivity.

3. Agricultural methods and production

3.1 Overview

Agricultural crop growing takes place in the upland and lowland (floodplain) areas of the Mekong Basin. Forms of upland agriculture vary considerably depending upon cultural practices and local soil and topographic conditions. Major upland farming systems include shifting and semi-shifting cultivation. Crops are usually rainfed, with relatively low irrigation ratios in the upland areas. Rice is grown, as are fruit trees along with a variety of industrial cash crops. Agriculture in the uplands is typically less efficient than in the Mekong floodplains and other lowland areas, where the majority of crop production takes place. The floodplains around the Mekong are flat and nutrient rich and under extensive rice cultivation. Lowland rice farming systems include wet season rice, floating rice, flood recession rice, dry season irrigated rice, and multi-crop production systems. The various regions of the basin record between one and three harvests per year. The main harvest is the wet season crop, with smaller numbers of farmers planting in the dry season as well (with or without irrigation.) Some parts of the delta area of Viet Nam also grow a third harvest later in the year. Cropping patterns vary, although rice predominates. Dry season cropping is mostly combined with continued wet season rice, and sometimes with other crops such as corn, soybean, and vegetables.[26]

Farmers are increasingly diversifying from rice into other more profitable crops

Agriculture across the basin involves a mix of subsistence and commercialised production. In general, farming households focus first on production to meet household needs and then sell whatever surplus they have, although barter predominates in remote regions with weak market systems. Gradually, lowland households have accumulated sufficient wealth from sale of their surplus to make the transition into increasingly commercialised agriculture: production for sale and increased purchase of food for household consumption. This shift involves increased dependence on market-supplied inputs such as fertilisers and pesticides, machinery and advanced seed varieties. Commercialised agriculture has been practised for some time on the Korat Plateau and is now being pursued with vigour in Viet Nam's Mekong Delta and, to a lesser extent, in the Central Highlands. This trend is likely to accelerate as governments stress increased regional and global economic integration, and as social attitudes change. However, the shift toward commercialisation is occurring much more slowly in remote and highland regions and will probably require substantial government or donor assistance and investment. Cambodia and Lao PDR have the double challenges of ensuring food security and moving towards market-oriented, commercial agriculture, which is likely to ensure that the process of change is slow in these countries.

In Northeast Thailand and Cambodia, tobacco is a major cash crop

3.2 Irrigation

Irrigation is any process other than natural rainfall that supplies water to crops and other cultivated plants. The main crop under irrigation in the LMB is rice, and most of the data on irrigated crops refer in reality to irrigated rice. The use of irrigation is increasing in the lowland areas of the basin, not only as a means of allowing dry season and even third season rice crops, and dry season or perennial cash-crops, but also to provide extra water for wet season production.

More attention is also being paid to improving the efficiency of existing schemes through rehabilitation, water management and institutional strengthening. Despite these developments, the LMB irrigation ratio (irrigated area over cultivated area) is still low by international standards. In 1998, the ratio was estimated at 7-10 percent, as compared with 45 percent for the whole of Asia.[27] There are, however, significant differences in the extent of irrigation in the basin, with the Viet Nam Delta, for example, irrigating approximately 60 percent of crops.[28]

Only 10 percent of LMB land is irrigated compared to an average of 45 percent for Asia

There are huge variations in the scale and type of irrigation schemes in use across the basin. The largest individual scheme is the 50,000 ha Lam Pao project in Thailand, while the smallest are simple manual lift operations, irrigating less than a hectare. The most basic systems provide only supplementary water during the wet season, while more intensive schemes have the capacity to grow two to three crops per year. Major types of irrigation systems include: the use of gravity to divert rivers, lakes, or streams to provide supplementary water in the wet season, with no storage; the pumping of water from rivers in the wet or dry season, with no storage; the use of pumps or gravity to divert water from streams, rivers and runoff into reservoirs for use in dry or wet season irrigation; and the storage of receding flood waters in reservoirs for use in preparing land for cropping and wet or dry season irrigation.[29]

Irrigation systems in LMB currently face significant challenges that complicate balancing the increasing demand for irrigation water with requirements to conserve water resources. Studies show that water is lost while flowing through irrigation systems and this, in combination with over-use of irrigation water, has led to construction of reservoirs that are three to five times larger than necessary.[30] There are also problems financing irrigation schemes. These include: a lack of mechanisms for control and measurement of water use; user fees that are not high enough to encourage efficiency improvements; and a lack of financial resources to adequately maintain and manage systems.[31]

Irrigation fees are being introduced selectively, but are meeting with mixed success. In Thailand, for example, attempts to introduce an irrigation service fee have resulted in mass protests. There are also institutional problems related to the management of schemes. These include: a "top down" approach to planning and managing schemes that involves little farmer participation; a lack of legal authority for water user associations; a lack of mechanisms for transferring management responsibility to user associations; poor extension services; and a lack of coordination among concerned government agencies and user groups.[32] Although management of irrigation systems is now being handed over to farmer groups in order to increase participation, little data is available on the effectiveness of such transfers. Finally, irrigation systems tend to be designed specifically to suit rice production, which makes it difficult for farmers to diversify into non-rice crops.[33]

The table below gives details on the extent of irrigation across the LMB. The data are drawn from the MRC Irrigation Database and cover only schemes recorded by local authorities and thus omit many small, unrecorded schemes. The data refer to the potential area under irrigation if the schemes were operating to full capacity, which is not always the case (See Figure 9, Chapter 3 for a map showing the distribution of irrigation schemes in the basin).

Table 4. Irrigated areas in the Mekong River Basin, 2001

Location	Number of Schemes	Area of Wet Season Irrigation(ha)	Area of Dry Season Irrigation(ha)	Area of 3rd Season Irrigation(ha)	Irrigated Area(ha) [1]
Lao PDR*	2532	224,232	151,940	0	224,232[2]
Thailand*	8764	-	-	-	941,425
- *Royal Irrigation Dept(med/large)*	*441*	*330,056*	*72,140*	*0*	*330,056*
- *RID(other)*	*291*	-	-	-	-
- *RID(small)*	*5497*	-	-	-	-
- *Department of Energy Development Promotion*	*1072*	-	-	-	*517,205*
- *Ministry of Interior*	*1463*	-	-	-	*94,164*
Cambodia*	1012	248,842	181,506	0	392,117
Viet Nam Delta	85	1,683,094	1,417,549	351,506	1,683,094
Viet Nam Highlands	76	36,008	7,290	-	36,008
Total [3]	**12,469**	**-**	**-**	**-**	**3,276,876**

Notes: Dash (-) indicates no information. (*) – except for Viet Nam, all data are for the whole country.

1 Where there is no comprehensive wet or dry season cropping data available, the irrigated area has been taken as the common measure of the irrigation area.

2 The total irrigated area in Lao PDR has been recorded at 280,000 ha, the difference being many small schemes which have not been formally inventoried or mapped.

3 Total of schemes and areas where data is available.

Source: MRC LRIAD database 2002

Irrigation schemes in Cambodia largely rely on the use of receding flood waters as the source of irrigation water. This kind of rice production is known as recession rice and is gradually replacing lower yielding traditional floating rice. Pumping is also a major feature of Cambodian irrigation. Traditionally this was done manually, but petrol-propelled pumps are gradually becoming more common. Manual pumping for a lift of 0.5 m requires labour of about three to four work hours per day for one ha of flood recession rice. This labour requirement is approximately 40-50 percent higher than that needed for automated pumping. Planting of a second irrigated rice crop in the dry season occurs in only approximately 10 percent of the total wet season rice production area. Limited ability to control water constrains the further expansion of second season cropping.[34]

Irrigation comprises 80-90 percent of all water abstractions in the LMB

In Lao PDR, the use of irrigation expanded rapidly over the 1990s, with the government reporting an eight-fold increase in irrigated rice area during this decade.[35] However, the irrigation area is largely confined to the relatively affluent lands of the Mekong corridor, and remains a rarity in the upland areas. The increase in irrigation use in the lowlands is partly due to a move away from a few large, government-managed schemes, in favour of numerous small farmer-managed arrangements.[36] The creation of water user associations, and a related legal framework to support them, has also been important.[37]

In Northeast Thailand, where farming methods remain comparatively traditional, irrigation ratios are much lower than in other parts of the country.[38] Various large-scale irrigation projects have been constructed on the Chi and Mun Rivers, but local opposition to dam projects has made it difficult for the government to undertake further large- and medium-scale developments.[39] Furthermore, water scarcity is a major concern. Water shortages prevent full utilisation of existing irrigation works in the dry season, and there are even reports of water shortages in the rainy season.[40]

There are huge variations in scale and type of irrigations schemes in the LMB

Irrigation is extremely important in the Viet Nam Mekong Delta region, and enables the very high productivity of agriculture in this area. More than half of the total area of the delta is flooded during the rainy season.[41] Irrigation therefore plays a critical role because it allows farmers to store water for use in intensive rice cropping during the flood free period. Irrigation schemes contributed to the tripling of food production between 1975-1995 and over the last 15 years, almost all the low-yielding floating rice (estimated at half a million hectares in 1995) has been replaced by irrigated rice. The rapid rise in irrigation development in Viet Nam is the result of intensive investment in irrigation, related flood- and salinity-control works, and the market-orientated *Doi Moi* economic reforms. Government planning and management of irrigation has been decentralised, with autonomous provincial authorities now financing many irrigation activities. In the Central Highlands, irrigation is less developed than in the delta, with upland rice and coffee being the main irrigated crops.

3.3 Rice production

Rice cultivation is the most important agricultural activity in the LMB countries. As shown in the tables below, rice production has increased greatly over the past decade: by 81 percent between 1993 and 2000 in Cambodia; by 38 percent between 1990 and 1999 in Lao PDR; by 33 percent between 1994 and 2001 in Northeast Thailand; and by 27 percent between 1995 and 1999 in the delta and Central Highlands in Viet Nam. These increases are due to the use of higher yielding seed varieties, increased irrigation and larger areas under cultivation. Yields vary greatly across the LMB, depending upon location, irrigation, and season. Spring paddy in the Mekong Basin region of Viet Nam yields five tonnes per hectare, while the figure is only 1.55 for unirrigated upland rice in Lao PDR. However, over the basin as a whole, rice production remains inefficient and of comparatively little economic value to farmers, making sustainable resource management unlikely.[42] The average yield for the entire area is 2.75 tonnes/ha, whereas the average for the Asia-Pacific region in 2000 was 3.9 tonnes/ha.[43]

Rice yields are generally low in the basin due to lack of inputs such as fertilisers, pesticides and improved seed

Rice production in Cambodia has increased in efficiency since the early 1990s, due to ongoing post-war rehabilitation and infrastructure reconstruction. While total wet season cultivated area has increased during this period from less than 1.7 million ha in 1993 to 1.9 million ha in 2000, this area is still considerably less than the 2.47 million ha devoted to rice growing in the late 1960s.[44] Furthermore, yields continue to lag behind those of neighbouring Viet Nam and Thailand, mainly as a result of lower quality agricultural inputs and management systems. The dominant production system is rainfed lowland rice, which is concentrated near the Mekong, Bassac, and Tonle Sap Rivers.[45] Deepwater and floating rice is also found around the shores of the Tonle Sap River and the Great Lake, as well as the inundated areas of the Mekong and the Bassac near Viet Nam. There is also small-scale dry land rice production in hilly areas of the country.[46]

Rice is the dominant crop in Lao PDR, covering approximately 600,000 ha or 80 percent of the total cropped area.[47] There are major disparities in productivity across the country, with yield in irrigated areas above 4 tonnes/ha, compared with 1.5 tonnes/ha for rice grown in upland areas. While the harvested area for lowland rice has been on the increase, it has become smaller in the upland areas, due to the government's attempts to discourage shifting cultivation.

Over 40 percent of the basin's land area is devoted to agriculture

Over 80 percent of the cultivated area in Northeast Thailand is used for growing rice or a mix of rice and upland crops. Local varieties of drought-resistant glutinous rice are generally used, and these tend to have low yields and poor responses to fertiliser application.[48] There are three main rice cropping patterns based on generalised land types.[49] Lower paddy land is planted annually with paddy rice in the wet season and is at risk of flooding and temporary water logging. Middle paddy land is the most productive, with better water control and reduced flood risk. In upper paddy land, short duration rice is planted in only three or four years out of ten. Upland crops are cultivated at other times, and farmers face major problems with weed management. All three cropping systems use bunded planting, which involves the construction of soil embankments around rice plots to retain water.

Table 5. Cambodia rice production, 1993-2000

	1993	2000
Wet Season Rice		
Area harvested ('000 ha)	-	1,846
Production ('000 tonne)	-	3,333
Yield (tonne/ha)	-	1.81
Dry Season Rice		
Area harvested ('000 ha)	-	233
Production ('000 tonne)	-	708
Yield (tonne/ha)	-	3.04
Total Rice		
Area harvested ('000 ha)	1,685	2,079
Production ('000 tonne)	2,221	4,041
Yield (tonne/ha)	1.31	1.94

Source: Cambodia National Institute of Statistics 1994, 2000

Table 6. Lao PDR rice production, 1990-1999

	1990	1995	1999
Wet Season Rice			
Area harvested ('000 ha)	392.4	367.3	477.5
Production ('000 tonne)	1088.5	1071.3	1502
Yield (tonne/ha)	2.77	2.92	3.15
Irrigated Rice			
Area harvested ('000 ha)	11	13.6	87
Production ('000 tonne)	39.1	50.4	354
Yield (tonne/ha)	3.55	3.71	4.07
Upland Rice			
Area harvested ('000 ha)	260.2	179	153.6
Production ('000 tonne)	379.9	296.1	238
Yield (tonne/ha)	1.46	1.65	1.55
Total Rice			
Area harvested ('000 ha)	663.6	559.9	718.1
Production ('000 tonne)	1507.5	1417.8	2094
Yield (tonne/ha)	2.27	2.53	2.92

Source: Lao PDR Ministry of Agriculture and Forestry 2000

Table 7. Northeast Thailand rice production, 1990-1999

	1994	1997	2001
Major Rice			
Area harvested (‘000 ha)	4,356	4,557	4,675
Production (‘000 tonne)	7,125	7,978	9,046
Yield (tonne/ha)	1.64	1.75	1.93
Second Rice			
Area harvested (‘000 ha)	14	63	138
Production (‘000 tonne)	32	190	451
Yield (tonne/ha)	2.25	3.03	3.27
Total Rice			
Area harvested (‘000 ha)	4,370	4,620	153.6
Production (‘000 tonne)	7,158	8,168	238
Yield (tonne/ha)	1.64	1.77	1.97

Source: Thailand National Statistics Office 1997, 2001

With irrigation, some parts of the Viet Nam Delta grow three crops of rice per year

The LMB area of Viet Nam, specifically the delta region, is the core rice growing area of the country. There are three major cropping seasons in the delta: winter-spring, summer-autumn or mid-season, and wet season-long duration. Approximately 60 percent of the rice grown in this region is grown in irrigated lowlands, with the remainder under rainfed lowland cultivation.[50] Rice yields in the delta are extremely high by LMB standards and the area is nearing its carrying capacity, with high yielding rice varieties and very intensive cropping – up to three harvests per year in some places.[51] There is scope for further improving efficiency by overcoming constraints to production which include: farm sizes that are too small; a lack of roads and other physical infrastructure; and inadequate market and distribution systems.[52] There are also problems with the efficiency of post-harvest crop processing facilities that have resulted in post-harvest losses as high as 13-16 percent.[53] Furthermore, the Mekong Delta faces environmental constraints including flooding at the end of the rainy season, drought in the dry season, salinity in coastal areas, and acid sulphate soils in the Plain of Reeds and the Long Xuyen Quadrangle. Upland production in the Central Highlands is less efficient, with irrigation a rarity and yields averaging only 3 tonnes per hectare in 1999, as opposed to 4 tonnes in the delta.

Table 8. Viet Nam rice production (Mekong Delta Region), 1995-1999

	1995	1999
Spring Paddy		
Area harvested (‘000 ha)	1,036	1,450
Production (‘000 tonne)	5,349	7,252
Yield (tonne/ha)	5.16	5.00
Autumn Paddy		
Area harvested (‘000 ha)	1,398	1,934
Production (‘000 tonne)	5,296	7,201
Yield (tonne/ha)	3.79	3.72
Winter Paddy		
Area harvested (‘000 ha)	757	603
Production (‘000 tonne)	2,187	1,828
Yield (tonne/ha)	2.89	3.03
Total Rice		
Area harvested (‘000 ha)	3,191	3,987
Production (‘000 tonne)	12,832	16,281
Yield (tonne/ha)	4.02	4.08

Source: Viet Nam General Statistical Office 1999

Table 9. Central Highlands region rice production, Viet Nam, 1995-1999

	1995	1999
Spring Paddy		
Area harvested (‘000 ha)	25	33
Production (‘000 tonne)	97	155
Yield (tonne/ha)	3.85	4.63
Winter Paddy		
Area harvested (‘000 ha)	118	101
Production (‘000 tonne)	252	259
Yield (tonne/ha)	2.14	2.57
Total Rice		
Area harvested (‘000 ha)	143	134
Production (‘000 tonne)	349	414
Yield (tonne/ha)	2.44	3.08

Source: Viet Nam General Statistical Office 1999

3.4 Non-rice crops

While traditionally dwarfed in importance by rice, there are also considerable quantities of other crops produced in the LMB. Such crops include maize, fruit and vegetables, oil crops, fibre crops, and cash-crops such as coffee, tea, sugarcane and tobacco. Many of these crops can offer higher economic returns than rice. It is likely that the basin will witness increasing diversification into such products with more balanced cropping patterns throughout the year as rice farming fails to deliver desired increases in living standards.[54] In particular, the basin as a whole faces shortages of oil crops such as soybeans. These are necessary for cooking and animal protein feed, which creates profitable opportunities for those farmers willing and able to diversify.[55]

Lack of markets and marketing infrastructure inhibits crop diversification

In Cambodia, non-rice crops accounted for 8 percent of GDP in 1999.[56] Non-rice food crops were traditionally considered to be of secondary importance to rice, but have grown in popularity due to local rice deficits and the clearing of upland areas suitable for their cultivation.[57] Maize production, in particular, has increased as a result of this trend. High value commercial crops such as soy, mungbean and vegetables have also been planted over a greater area as market reforms have encouraged smallholders to adapt their planting patterns. However, the area devoted to such crops covers approximately 250,000 ha, which, as is the case for rice, is substantially less than the 310,000 ha used for producing such products in the 1960s, before war began.[58] This decline in cultivation is most likely a result of the lingering presence of minefields. Rubber tapping areas cover approximately 45,000 ha and their output comprises the main Cambodian agricultural export earner.

Table 10. Cambodia selected non-rice crops, 1999/2000*

Crop	Harvested Area (ha)	Production (tonne)	Yield (tonne/ha)
Maize	59,739	95,274	1.59
Yellow Maize	32,011	54,680	1.71
Cassava	14,003	228,512	16.32
Sweet Potato	9,322	32,516	3.49
Vegetables	31,240	181,851	5.82
Mung Bean	26,747	15,913	0.59
Peanut	10,557	9,244	0.88
Soy Bean	34,945	35,063	1.00
Sugar Cane	8,374	159,859	19.09
Sesame	16,410	7,385	0.45
Tobacco	8,292	6,358	0.77
Jute	261	264	1.01
Rubber	39,718	45,204	1.12
Castor Oil	1,515	1,365	0.90

Note: "*" data are for the whole country rather than for just for the territory within the basin.
Source: Cambodia National Institute of Statistics 2000

Maize is the most common non-rice crop in Cambodia

In Lao PDR, the maize planting area has fluctuated over the 1990s, although yields have increased substantially. Mungbean production has declined considerably because of poor local markets. As far as industrial crops are concerned, coffee and sugarcane production increased by average annual rates of 22.3 percent and 36.7 percent, respectively, between 1996 and 2000.[59] These increases have resulted more from improving yields than expanded production areas. Coffee is the major agricultural export earner, and despite increasing yields, there are serious problems with quality control, with the result that Lao PDR coffee export prices are 10 percent less than world market prices.[60] Tea production has declined by 23.5 percent per annum and cotton by 12.2 percent. This has also been in response to market conditions.[61] Vegetable production has increased rapidly, mainly driven by demand in urban centres and exports to Thailand.

Table 11. Lao PDR selected non-rice crops, 1990-2000

Item	Crop Area ('000 ha)		Production ('000 tonne)		Yield (tonne/ha)	
	1990	1999	1990	1999	1990	1999
Maize	48.1	40.7	81.77	96.052	1.7	2.36
Starchy roots	19.8	13.1	162.756	80.565	8.22	6.15
Vegetables/beans	7.9	41.1	60.672	235.914	7.68	5.74
Mungbeans	4.6	1.7	2.622	1.496	0.57	0.88
Soybeans	5.6	6.8	4.48	5.916	0.8	0.87
Peanuts	8.5	12.9	7.99	13.029	0.94	1.01
Tobacco	12.0	4.3	58.44	23.392	4.87	5.44
Cotton	6.9	4.4	4.968	4.312	0.72	0.98
Sugarcane	4.0	4.7	111.92	173.618	27.98	36.94
Coffee	17.3	42.3	5.363	17.343	0.31	0.41
Tea	0.4	0.9	1.6	0.396	4.0	0.44

Source: Lao PDR Ministry of Agriculture and Forestry 2000

Crop yields in the LMB are generally low by international standards

Diversification into various kinds of non-rice crops has taken place to a greater extent in Thailand than in the other three countries, with a wide range of such crops grown extensively.[62] However, non-rice crops still only cover approximately 20 percent of the cultivated area in the Northeast Region.[63] Vegetables, legumes, kenaf and tobacco are sometimes combined with rice in paddy lands. In unbunded fields in the uplands, cassava, kenaf, sugarcane and legumes, such as groundnuts and mungbeans, are often grown as mono-crops.[64] The major constraints on production in such upland areas are soil quality problems and the build-up of disease in continuously-cropped areas.[65] Cassava, maize and sugarcane are the most important non-rice crops, although the area devoted to cassava has reduced substantially. Although figures for the Northeast Region are unavailable, there have been major increases in the production of vegetables such as shallots and garlic.[66] Yields for most crops have seen moderate improvements since 1994, with a major (28 percent) increase for the yield of sugarcane.

Table 12. Northeastern Thailand selected non-rice crops 1990-2000

	Harvested Area ('000 ha)		Production ('000 T)		Yield (T/ha)	
Item	**1994**	**2000**	**1994**	**2000**	**1994**	**2000**
Maize	313	334	838	1041	2.67	3.12
Sorghum	3	2	4	3	1.47	1.69
Mungbean	20	22	12	15	0.62	0.68
Cassava	862	646	11680	10472	13.56	16.21
Sugarcane	205	206	9382	12098	45.79	58.71
Soybean	48	38	66	54	1.39	1.41
Groundnut	30	30	43	46	1.42	1.54
Kenaf	82	17	120	29	1.46	1.74
Cotton	9	4	12	6	1.34	1.43

Note: Figures for fruit and vegetable production for the Northeast Region were not available
Source: Thailand National Statistics Office 1997, 2000 and 2001

Whereas rice is the agricultural mainstay in Viet Nam's delta region, perennial and tree crops tend to dominate in the Central Highlands, with 269,000 ha devoted to the growing of major non-rice crops, compared to 143,000 ha for rice. The production figures below indicate that the land area devoted to major non-rice crops decreased by more than 10 percent in the Mekong Delta and increased by 33 percent in the Central Highlands between 1995 and 1999. These trends reflect the individual responses of small-holders and agribusiness operators to regional comparative advantage in the face of the relaxation of socialist market controls. Also important are government attempts to increase rice production in the delta and promote the growing of non-rice cash-crops such as coffee in upland areas by encouraging migration to the highland provinces.

Table 13. Viet Nam (Mekong Delta Region) selected non-rice crops 1995-1999

Name	Planted Area ('000 ha) 1995	Planted Area ('000 ha) 1999	Output ('000 tonne) 1995	Output ('000 tonne) 1999	Yield 1995	Yield 1999
Other Cereals	46.3	39.0	159.2	49.8	3.44	1.28
Maize	20.2	15.8	84.0	49.8	4.16	3.15
Sweet Potatoes	11.5	10.7	123.0	143.8	10.70	13.44
Cassava	10.2	9.2	79.6	84.5	7.80	9.18
Jute	3.6	0.6	6.0	1.1	1.67	1.83
Rush	5.2	2.8	38.2	16.1	7.35	5.75
Sugar Cane	98.0	102.8	5395.7	6435.5	55.06	62.60
Peanut	15.0	10.4	27.2	16.1	1.81	1.55
Soybean	11.2	9.1	22.9	20.6	2.04	2.26
Tobacco	1.0	0.7	1.9	1.2	1.90	1.71

Source: Viet Nam General Statistical Office 1999

Table 14. Viet Nam (Central Highlands Region) selected non-rice crops, 1995-1999

Name	Planted Area ('000 ha) 1995	Planted Area ('000 ha) 1999	Output ('000 tonne) 1995	Output ('000 tonne) 1999	Yield 1995	Yield 1999
Other Cereals	75.5	100.1	179.2	278.9	2.37	2.79
Maize	36.6	60.1	70	170.7	1.91	2.84
Sweet Potatoes	9.0	6.8	62.6	46.3	6.96	6.81
Cassava	29.3	32.3	262.0	278.0	8.94	8.61
Cotton	1.8	9.9	2	11.4	1.11	1.15
Sugarcane	11.3	27.9	464.2	1230.2	41.08	44.09
Peanuts	22.5	18.3	23.6	18.9	1.05	1.03
Soybeans	9.8	11.2	10.9	11.1	1.11	0.99
Tobacco	1.5	2.2	0.7	1.9	0.47	0.86

Source: Viet Nam General Statistical Office 1999

Use of fertilisers and pesticides

Use of commercially-produced fertilisers and pesticides has been growing rapidly in the LMB, particularly following the market reforms in Lao PDR, Cambodia and Viet Nam. Government attempts to promote cash crops and greater cropping intensity have also increased the use of these products.[67] On a region-by-region basis, the use of such inputs is generally correlated with higher agricultural productivity. For example, in the Mekong corridor area of Lao PDR, both fertiliser and pesticide use and rice yields are much higher than in the upland parts of the country. The same comparison can be made between the Mekong Delta and the Central Highlands areas of Viet Nam. More broadly, fertiliser use is much higher in Thailand and Viet Nam. Those countries use, respectively, 100 and 263 kg of mineral fertiliser per hectare of cropland. In Cambodia and Lao PDR, fertiliser use is only 2 and 8 kg per hectare, respectively. In Thailand's Northeast, although use of fertilisers is widespread (employed by about 86 percent of farmers) it is lower in intensity than the rest of the country, with an average application of only 47kg/ha for rice.[68]

The tables below show FAO estimates for use of various kinds of pesticides. Figures are not available for every year or for all varieties of pesticides used. There are no available data for Cambodia in this dataset.[69] Survey data from the International Rice Research Institute (IRRI) suggest that in lowland Cambodia, the percentage of wet season farmers using pesticides ranges from 8-50 percent depending upon the province, with a range of 40-100 percent for dry season farmers.[70] The same study found that the most commonly-used pesticides in the country fall under the World Health Organisation's "most hazardous" classification.

Table 15. LMB total for mineral fertiliser used ('000 Metric tonnes)

	1989	1999
Cambodia	0.3	7.9
Lao PDR	0.3	8.1
Thailand*	818.8	1801.7
Viet Nam*	563	1934.6

Note: "*" data are for the whole country rather than for just for the territory within the basin.
Source: FAO 2001

Table 16. LMB use of mineral fertiliser per ha of agricultural land (kg/ha)

	1989	1999
Cambodia	0.1	2.1
Lao PDR	0.4	8.5
Thailand*	39.8	100.1
Viet Nam*	88.2	263.2
Asia-Pacific	102.4	149.7

Note: * Includes entire country rather than only Mekong Basin Area
Source: FAO 2001

Table 17. Lao PDR pesticide use (Metric tonnes)

Item	1992	1993	1997
Carbamates Insecticides	0	18	3
Fungic/Bacterial/Seed Treatment	0	8	0
Herbicides	0	0	1
Inorganics	0	8	0
Insecticides	17	34	3
Organo-Phosphates	17	16	0
Rodenticides	4	4	0
Triazine	0	0	1
Total	**38**	**88**	**8**

Source: FAO 2002 (FAOSTAT Agriculture)

Table 18. Thailand* pesticide use (Metric tonnes)

Item	1993	1994	1995
Amides	599	989	1,502
Benzimidazoles	255	197	300
Bipiridils	267	200	244
Botanic. Produc&Biologic	0	115	0
Carbamates Herbicides	280	172	216
Carbamates Insecticides	1,095	668	1,226
Chlorinated Hydrocarbons	80	82	359
Diazines, Morpholines	12	7	6
Dinitroanilines	0	1	2
Dithiocarbamates	1,218	1,358	1,385
Fungic/Bacterial/Seed Treatment	3,990	4,885	4,827
Herbicides	9,058	9,555	11,935
Inorganics	1,601	2,162	2,060
Insecticides	5,518	5,686	6,827
Organo-Phosphates	3,444	3,794	4,462
Other Fungicides	903	1,160	1,075
Other Herbicides	2,974	3,001	3,874
Other Insecticides	808	916	626
Other Rodenticides	18	32	30
Phenoxy Hormone Products	2,317	2,293	2,637
Plant Growth Regulators	265	290	443
Pyrethroids	91	111	154
Rodenticides	18	32	30
Sulfonyl Ureas	1,122	608	524
Triazine	1,498	2,290	2,935
Triazoles, Diazoles	1	1	1
Urea derivates	1	1	1
Total	**37433**	**40606**	**47681**

***Note**: "*" data are for the whole country rather than for just for the territory within the basin.*
Source: FAO 2002 (FAOSTAT Agriculture)

Table 19. Viet Nam* pesticide use (Metric tonnes)

Item	1994	1995	1996	1997
Fungic/Bacterial/Seed Treatment	3,139	3,465	8,188	7,684
Herbicides	2,547	4,979	7,205	6,710
Insecticides	15,226	16,452	17,352	17,851
Plant Growth Regulators				667
Rodenticides				107
Total	**20,912**	**24,896**	**32,745**	**33,019**

Note: "*" data are for the whole country rather than for just for the territory within the basin.
Source: FAO 2002 (FAOSTAT Agriculture)

3.5 Upland agriculture/shifting cultivation

One of the most important agricultural systems in the LMB is the group of farming techniques know as shifting cultivation. Shifting cultivation is practiced mostly in marginal upland areas. In the LMB it occurs most often in the Viet Nam Central Highlands, the northeast of Cambodia, and the sloping land areas of Lao PDR. Because shifting agriculture occurs in remote areas and is almost entirely removed from the formal economy, it is very difficult to measure its geographic extent and productive output. However, assessment of the phenomenon is important because it provides the household consumption needs for large numbers of people, and is often deeply rooted in the culture of upland minority people. Shifting cultivation is also of consequence because it is widely considered to be a major contributor to deforestation. Estimates put the area under shifting cultivation in the basin at about 2 million ha, with 25 percent of that land classified as forest.[71]

Because of marginal soil fertility, many shifting agriculture plots are cultivated for only 1-2 years and left fallow for 10-20 years

A typical shifting cultivation system involves households in wooded or forested areas clearing and cultivating plots of land on a rotational basis. At the beginning of the cycle a plot, typically 1.5 ha per household, will be cleared using the slash and burn method.[72] Rice and various other upland crops will be planted and the plot will be worked until harvest. Because of marginal soil fertility, a second year of cultivation on the plot would result in lower yields. The household therefore leaves the plot fallow and moves on to clear a second plot for the following year. The process is repeated until the original plot has been left fallow for long enough for its fertility to be restored, generally 10-20 years.[73] Variations to this system include pioneering cultivation where plots are worked for longer periods until soil fertility is completely exhausted, and semi-shifting cultivation, which involves greater numbers of people working from fixed homesteads on flatter land.[74] Most groups combine shifting cultivation with other activities such as the gathering of non-timber forest products.[75]

Shifting cultivators are primarily from ethnic minorities

The environmental implications of shifting cultivation depend upon the intensity with which it is practised and upon the nature of the land in question. The key to whether the practice is environmentally sustainable is the length of the fallow period, which itself depends upon population density.[76] The carrying capacity of land under shifting cultivation is estimated to be 20-40 persons per km^2. In the northeast of Cambodia, for example, population density is less than 20 people per km^2, and shifting agriculture, although prevalent, is not considered to be a major environmental problem.[77] Population densities in this range allow for the required fallow periods of 10-20 years, but if there are more people in an area, land scarcity forces shorter periods, often as low as 5-7 years. Such periods do not allow for full regeneration of soil fertility, nor do they allow trees to grow tall enough to overshadow and kill off invading plants and weeds.[78] Other consequences of excessively short fallow periods include increased erosion due to the reduced capacity of the soil to retain water. Sloping lands are particularly vulnerable to developing erosion problems when fallow periods become too short. When such areas are near river tributaries, erosion may increase the load of silt washing into rivers.

Ethnic minority Thai Luu plant red corn for cattle feed

Increasingly, the carrying capacity of shifting cultivation land is being exceeded because of population growth, government sponsored or independent in-migration, and decreasing land availability due to hydro-power schemes, reclassification of forests as protected areas and the granting of logging concessions.[79] The insecure land tenure arrangements prevalent across the basin also contribute to the problem by making it easier for the land of shifting cultivators to be expropriated, which gives them less incentive to ensure its environmental preservation.[80] Such changes can start an often-observed cycle whereby increased land pressure leads to shortened fallow periods, which in turn cause a loss of soil fertility and declining crop yields, as well as increased erosion, downstream siltation, flooding and drought, all of which increase human poverty and vulnerability.[81]

Shifting cultivation is most significant as an environmental and social problem in Lao PDR. Government figures indicate that between 1982 and 1989, over 300,000 ha were cleared and planted for shifting cultivation by an estimated 280,000 families. [82] In the 1990s, government programmes to resettle upland residents and provide them with alternative livelihoods helped stabilise the practice. By 1995, the area decreased to 192,258 ha with 198,868 households and by 1998 to 148,000 ha with 156,720 households. However, most of the rehabilitated area was in the sloping lands surrounding the Mekong Corridor, while shifting cultivation continued unabated in the remoter upland areas.[83] It is estimated that 70 percent of northern households practice shifting cultivation, compared to only 12 percent for the flatter southern region.[84] There are two main types of shifting cultivation based on ethnic minority practices. The Khmu in the midlands traditionally practice rotational cultivation, while the Hmong and other highland groups have more commonly practiced the pioneering variant, with frequent moves to virgin areas.

In Thailand, shifting cultivation often occurs on lands opened up by logging. Rainfed crops are used and yields are high for the first few years because of the nutrients released by the burning or degradation of the forest cover, but soil fertility drops dramatically after a few seasons.[85] This practice is not limited to subsistence farmers, large scale cash-crop cultivation is also carried out in this fashion and local minority groups are often driven out of traditional lands by encroaching outsiders.[86]

In Viet Nam, there are about 800,000-1,000,000 people practising shifting cultivation, and about two million engaged in semi-shifting cultivation, most of them upland minorities.[87] These farmers, the majority of whom live outside the Mekong Basin in northern Viet Nam, generally operate on a subsistence basis on steep slopes. Serious soil erosion problems and endemic poverty are common. As far and the LMB portion of the country is concerned, such practices are common in the Central Highlands and rare in the intensively-farmed Mekong Delta region. The situation in the Highlands is worsening because of large-scale government-sponsored and independent in-migration, which is increasing population densities and forcing resident ethnic minorities to move into increasingly marginal forest areas.[88]

Cambodia experiences similar problems, but the situation is complicated by the fact that many post-war returnees are unable to use their family land because of minefields or conflicts over tenure and so must clear and plant upland forest areas to make a living.[89] Comprehensive mine clearance is thus required before shifting upland cultivation will end and people will return to the lowlands.

3.6 Livestock

Integrated farming is practiced to a greater extent in Northeast Thailand than in other areas of the LMB

Livestock rearing has traditionally formed an important part of farm systems, providing haulage, natural fertilisers, cash income and additional dietary protein. Dependence upon livestock is especially high for people employing subsistence production systems, with numerous groups using animals as an integral part of their livelihood strategies. Livestock, particularly large animals, are also an important provider of financial security for people in subsistence economies. Buffalo and other animals tend to be the most valuable tradable asset owned by such people and can be sold to meet emergency financial requirements or to make major investments. The loss of animals is thus identified as a major determinant of poverty. Small animals such as pigs and poultry are raised to provide farm households with a major source of animal protein.

Over recent decades, subsistence-based livestock systems have become increasingly linked to the wider economy and commercialised husbandry has become more common.[90] Intensification of production has increased and the role played by animals has changed from integrated components of farm systems (e.g. buffaloes used primarily for haulage) to discrete output units (e.g. cows grown for meat and milk.)[91] The tables below indicate that livestock production has increased substantially during the 1990s in Cambodia, Viet Nam and Lao PDR. The increases are probably due to the impact of economic reforms in Viet Nam and Lao PDR and increasing political stability in rural areas in Cambodia. Livestock production in Thailand, after an initial 20 percent increase in the early 1990s, remained reasonably constant for the rest of the decade. Breakdowns for changes in the populations of various kinds of animals reveal varying trends for the individual countries, although there has been a general decrease in the buffalo population and increased numbers of cattle, chickens, and ducks.

There is significant scope for increasing livestock production, particularly in Lao PDR where there are large amounts of potential pasture land available and the government is actively encouraging upland households to switch to animal husbandry as an alternative to shifting cultivation. However, increasing the capacity of livestock production is constrained by low quality forage and fodder, inadequate animal health services, and the low productivity of native varieties.[92] Also, traditional livestock management practices can present potential trans-boundary environmental problems in that semi-nomadic herders in remote border areas often roam between countries, and in the process, can cause animal diseases to spread across borders.

Buffaloes provide natural fertilisers, cash income and are used for tilling fields

Poultry provide cash income as well as a supplementary source of protein

Table 20. LMB livestock production index 1990-2000

	1992	1996	2000
Cambodia	120.3	134.7	157.3
Lao PDR	111.6	142.3	139.4
Thailand*	120.6	129.8	124.2
Viet Nam*	112.1	137.9	174.8

1989-1991 = 100 gross livestock products
Note: "*" data are for the whole country rather than for just for the territory within the basin.
Source: FAO 2001

Table 21. LMB average annual growth rate of livestock population 1990-2000

Animal (%)	Cambodia	Lao PDR	Thailand*	Viet Nam*
Cattle	+3.1	+1.7	+0.3	+3.3
Buffaloes	-1.2	-0.6	-9.4	+0.2
Pigs	+1.5	-2.2	+6.5	+5.1
Sheep	+1.9	N/A	-16.1	N/A
Goats	N/A	-1.2	-1.1	+5.6
Chickens	+4.7	+4.5	+4.4	+9.2
Ducks	+3.5	+16.8	+1.6	+6.4

1989-1991 = 100 gross livestock products
Note: "*" data are for the whole country rather than for just for the territory within the basin.
Source: FAO 2001

4. Agriculture and the environment

Agriculture has important environmental implications and significantly affects the quality and quantity of water and related resources in the Mekong Basin. The major mechanisms by which agriculture affects the environment are: deforestation due to the clearing of land for shifting or sedentary cultivation; irrigation; and the use of chemical fertilisers and pesticides. Also significant are the conversion of acid-sulphate soils to agricultural use and human interference in the balance of ecosystems. All of these environmental influences affect resource use and sustainability and put constraints on agricultural activity.

4.1 Environmental impacts of deforestation

If not properly managed, agricultural development could undermine land use sustainability

The typical effects of deforestation are soil erosion, soil compacting and gullying, reduced water regulation capacity and increased flooding, and increased sediment in streams, rivers, and wetlands.[93] Deforestation is of particular concern in vulnerable watershed areas – land on steep or very steep slopes at high elevations in the headwater areas of the river system. Such land is particularly prone to erosion. The problem is exacerbated in steep areas of Lao PDR and Northeast Thailand because contour agriculture is not practised, which increases the severity of erosion problems caused by agricultural activity. A recent MRC study found that deforested critical watershed areas covered 3.5 percent of Cambodia, 20 percent of Lao PDR, and 7.5 percent of basin Viet Nam, with data for Thailand being unavailable.[94] The impact of this situation in terms of erosion and runoff is difficult to precisely estimate because essential data on runoff and retention rates under different kinds of vegetation cover are not available.[95] While erosion and resultant sedimentation certainly remain major problems, MRC water testing data indicate that levels of suspended solids are currently decreasing across the basin.[96] The reduction of sediment loads could be the result of the development of large numbers of small irrigation schemes that collect sediment in their reservoirs.

4.2 Environmental impacts of irrigation

As the greatest user of water in the basin, irrigation schemes have implications for water levels and water quality in the Mekong River and its tributaries. It is estimated that in Cambodia, irrigated agriculture accounts for around 94 percent of total abstractions, with a figure of 82 percent for Lao PDR, 91 percent for Thailand, and 86 percent for Viet Nam.[97] With demand for water rapidly increasing, there are strains on the supply of water for agricultural use. In many communities, water supply is insufficient for 2-5 months of the year, and reservoirs are often not full enough to meet irrigation demands, especially in Thailand.[98] In the dry season month of April, irrigated agriculture in the Vietnamese section of the delta now extracts 53 percent of the available flow in that section of the river.[99] Water deficits are particularly noticeable in the Isarn region of Thailand. Low water levels also contribute to other environmental problems such as soil acidity and the increasing intrusion of sea water in the Mekong Delta. These problems are likely to increase if water abstractions upstream lead to less water downstream to flush away contaminants.[100] With the riparian countries all endeavouring to increase rice production, and hence extending irrigation systems, there is likely to be growing water scarcity and water-use conflicts between the agricultural, industrial, and domestic sectors. Diversification of production into crops that use less water than rice could be one solution to the problem.

Much of the LMB suffers from both chronic flooding and drought

The establishment of irrigation reservoirs can cause changes to the river's flow regime, which have important environmental implications. Reservoirs can reduce severe flooding and shorten the duration of flooding, which generally assist wet season cultivation in the flood plain. They also can delay the onset of floods, which is especially beneficial in the lower parts of the river. The associated reduction in the flood plain area does, however, adversely affect fish production and thus fish catches. This, in turn, has serious consequences for the millions dependent on the fishery for subsistence and livelihoods. Also, the ability of reservoirs to reduce the flood peak under extreme conditions is uncertain. Emergency releases from reservoirs can quickly cause flood flows equal to or greater than natural river flows and cause major damage to cropping (and to life and property) in areas where reduced flooding during normal years creates a sense of complacency. Irrigation reservoirs are managed primarily to meet the demands of irrigation, and are normally kept as full as possible to guarantee dry season requirements. Greater understanding of inflows could improve their potential for flood control.

In the Viet Nam Delta, inundation of seawater threatens agricultural production

Excessive irrigation in the dry season and irrigation with poor drainage can, in combination with certain soil and water conditions, cause salinity problems. Salt can accumulate in the sub-soil and at the surface, and cause immediate damage to agriculture and fish production and productivity, as well as long-term soil deterioration. Salinity problems in the Korat Plateau in Northeast Thailand stem from the irrigation of saline soils and rock-salt exploitation.[101] Sodium chloride concentrations in this area range from 2,000-10,000 mg/L.[102] Similar problems occur in the Vientiane Plain.

In the Viet Nam Delta, salinity is caused by the intrusion of seawater. This is a concern to farmers near the mouth of the river, where about 750,000 ha is affected by saline water during the dry season. [103] Efforts to control salinity intrusion by blocking seawater lead to other problems. Water stagnates and may result in fish-killing algae blooms, and water

Dykes and other infrastructure protect delta farm land from salt water intrusion polluted with human waste, pesticides and other substances is not flushed into the sea.[104] Also the use of river water to flush away intruding seawater reduces the availability of water for irrigation. At the end of the dry season, total flow in the coastal part of the delta is about 2000 m^3, which would be sufficient for irrigation purposes, except that approximately 1500 m^3 are required to wash away the saline water intruding from the sea.[105] However, recent MRC water quality testing shows that salinity levels have been decreasing across the basin, particularly in Northeast Thailand.[106] The reasons for this are still unclear, but could include a general shift from small-holder to commercialised salt extraction that may be more efficient and result in lower levels of salt run-off.

4.3 Environmental impacts of pesticide and fertiliser use

Pesticide and fertiliser use is another important means by which agricultural activity may impact the resources of the basin. While overall the rate of chemical application in the basin is comparatively low, there are problems with improper handling and the use of banned pesticides. Farmers in Thailand and Viet Nam are generally aware of the potential dangers of pesticides, but such awareness is lower in Lao PDR and Cambodia, where these products have only recently begun to be used on a large scale.[107] Persistent pesticides are banned in the riparian countries, but it is clear that residual and illegally imported stocks continue to be used because residues of DTT, Dieldrin, and similar chemicals have been found in fish across the basin.[108] However, investigation into the build-up of pesticide residues in the bodies of such fish has revealed that contaminant levels are well below the maximum safety levels specified by the World Health Organisation.[109] Pesticides can also cause environmental problems through build-up in the soil, toxicity to humans and the development of resistance on the part of pests. The latter has been held responsible for localised outbreaks of pests such as brown plant hopper.[110] There is currently little available data to indicate the extent of such problems. The relationship between pesticide use and fisheries is further discussed in Chapter Seven on fisheries.

Pesticides banned elsewhere in the world are readily available in some areas of the LMB

Because of high intensities of fertiliser use, the Korat Plateau in Thailand and the Mekong Delta are areas of ongoing concern for ground and surface water contamination.[111] In the delta there is concern over excessive fertiliser use affecting water quality and damaging integrated aquaculture operations. MRC water quality surveys have revealed an increase in levels of nutrients in the water.[112] There is a need for further systematic investigation of this issue, but it appears that in general, the use of nitrogen, phosphate and potassium fertilisers is not at levels likely to cause significant damage to ecosystems.[113]

4.4 Acid sulphate soils

The conversion of acid-sulphate soils to agricultural use, especially in the Mekong Delta, is creating more agricultural land, but acid runoff is damaging other subsystems downstream such as the culturing of fish in rice fields.[114] Acid sulphate soils occur in the mangroves and grasslands of the delta, covering some 1.6 million ha, or 40 percent of its soils, mainly in the Plain of Reeds, the Long Xuyen Quadrangle, and the Ca Mau Peninsula.[115] These soils are also characterised by high levels of potentially toxic aluminium and poor phosphorous availability. The issue is mostly localised to these areas and does not extend into the Cambodian area of the delta. In the dry season, the acid sulphate water rises to the surface and is discharged into the canals at the onset of the rains. While the acidity causes soil and water quality problems and can result in lower crop yields and fish populations, farmers are able to mitigate the harm it causes by diluting it with irrigation water and fertilisers. However, these responses have second order effects such as increased water consumption and fertiliser nutrient build-up.

4.5 Agriculture and biodiversity

Agricultural practices also have implications for bio-diversity and the balances between species in ecosystems. Such changes can in turn impinge upon agricultural productivity in harmful feedback loops. For example, Golden Apple Snails (*Pomacea* sp.) from South America have been introduced in Cambodia, Thailand, and Viet Nam for breeding as a supplementary food source, but have escaped captivity and proliferated rapidly in agricultural areas. [116] In Thailand and Viet Nam they have already become a major rice pest, as they have in other parts of Asia and there is a danger of similar problems emerging in Cambodia. Also problematic are rapid increases in populations of crop-destroying pests such as rats, following the efforts of rural people to eliminate snakes, which are natural predators of rats. There is thus an ongoing need to monitor the complex linkages between agriculture and the environment – particularly the ways in which agricultural activity causes environmental damage and the ways in which environmental degradation in turn constrains agricultural production.

5. Institutional factors affecting agriculture

5.1 National agricultural strategies and policies

All four LMB countries see the promotion of agriculture as a critical component of rural and national development. Improving the agriculture sector is considered a key means by which LMB countries can improve national food security and increase export earnings.[117] Until recently, government policy and institutional support for the sector has focused most closely on increasing rice production through more efficient farming methods, improved inputs, and increased dry season irrigation.[118] In recent years, more attention has been paid to the diversification of crops, improvement of physical and market infrastructure, and sustainable management of environmental resources. Emphasis is also being placed on the strengthening and expansion of agricultural extension services. Such services are generally inadequate in the riparian countries. There are not enough extension workers, and they are often insufficiently trained and lacking the required technical knowledge. This situation hampers attempts to encourage diversification of crops and the re-training of people who migrate to areas where unfamiliar production systems are used.

The Cambodia 2001-2005 Socio-Economic Development Plan focuses on poverty alleviation and recognises that poverty rates are highest among rural families involved in the agriculture sector.[119] Rural development and agricultural development are therefore accorded high priorities. The target for agricultural GDP growth for the period is 3.5 percent per annum. The government intends to provide a supportive policy framework for agriculture, including the provision of core economic and social infrastructure and services that allow farmers to make their own investments and production decisions.[120] Major initiatives and components include: 1) accelerated and sustainable irrigation development, including increased farmer participation through strengthening of Water Users Associations; 2) development of highly productive and diversified farming systems through improvement of technological and financial inputs and management techniques; 3) land administration reform to cover measures for alleviating land conflicts and unregulated land encroachments, accelerated rural land titling and providing land for the landless; 4) tackling market failures and infrastructure problems that impose high transport and distribution costs and inefficient dissemination of price signals; 5) gaining greater access to international markets for agricultural products; 6) strengthening of extension services and of relevant public institutions; 7) expansion of livestock production, with emphasis on animal health services, nutrition and range management; and 8) promotion of community-based integrated agroforestry systems. [121]

In its "Strategic Vision for the Agriculture Sector," the Lao PDR government lays out a dual strategy to deal with the dual rural economies along the Mekong Corridor and on sloping lands. The approach to agriculture in the comparatively prosperous corridor area is to encourage acceleration of the market driven forces for change already underway.[122] This will involve agricultural intensification and diversification: increasing productivity, improving value-added processing and expanding marketing and sales. Initiatives to be undertaken will include: the strengthening of rural credit facilities using market determined interest rates; government and private sector sponsored market research; market information systems and regional marketing links; developing internationally-accepted product grades and standards; and rehabilitating, expanding and intensifying dry season irrigation schemes with participatory community based management.[123] There has also been a shift from focusing on supply to expansion of demand through the liberalisation of international trade policy and removal of inter-provincial trade and transport restrictions.[124]

In the more economically backward sloping land areas, the government has identified the key constraints to development as: 1) lack of markets and market information flows; 2) inadequate access to transport links; 3) low incidence of rural savings and investment; 4) absence of productivity-enhancing technology flows; 5) slow implementation of formal land tenure arrangements; and 6) insufficient community-based irrigation infrastructure to optimise water resource productivity within the agricultural sector.[125] The government's general intention is to tackle the problems of lack of access to various important resources and shift away from low-input/low-output farming systems (e.g. shifting cultivation) that are incapable of helping the growing populations on sloping land break out of cycles of poverty. Key strategies include: opening community market access through feeder road upgrading and expansion and market information delivery; improving rural credit systems through institutional, legal and financial support for private and public banks serving this market; improved land use planning, incorporating farmer participation and consideration of relevant bio-physical and socio-economic parameters; regularising land tenure; and introducing new crops and technologies through improved, farmer-driven extension.[126]

The crux of Thai agricultural policy is raising rural incomes through crop diversification and improved agricultural practices, especially for products with good export potential.[127] Water management is a high priority, especially in terms of improving the efficiency of the many existing water management projects, and promoting basin-wide coordination of water resources. Essential steps toward the achievement of these goals include: improving irrigation management efficiency, promoting the development of small-scale irrigation projects, and strengthening farmers groups and Water Users Associations.[128] Significant progress has been made toward the last of these objectives, with the Thai government authorising legal recognition of the associations and transferring some water management responsibilities to them.[129] More generally, the government intends to support projects with immediate returns and income generating potential, and to increase links between smallholders and agribusiness. There have been numerous successful agricultural development and extension programmes in the Northeastern Region and Thai agricultural extension programmes are well resourced and well coordinated, compared to those in the other LMB countries.[130]

Viet Nam's agricultural policies must be seen against the context of the country's ongoing transition from a command economy to a market-based system. As with the other LMB countries, the overriding national goals involve increasing food security and export earnings through expanded rice, industrial crop and non-rice food production. However the policy focus is mostly on the reform of relevant legislation so as to support market-driven development. Key areas for reform include land registration, the rural financial sector, and more generally the transformation of the government's role from ownership of agricultural production to supporting farmers through extension, research, irrigation and water management, flood control, and infrastructure improvement.[131] Of particular relevance to the natural resources of the Mekong Basin are plans to expand irrigation, improve existing schemes, and expand the delta water management systems to deal with acid-sulphate soils and salt intrusion.[132]

Agricultural policies for the delta and highlands regions are very different. In the delta, the government is committed to protecting most rice land, but proposes to convert up to 500,000 ha of low-productivity land from rice production to other cash crops.[133] Public research efforts have been focused on improving various rice-based farming systems, including: rice and fish integrated with fruit trees; rice and shrimp in saline areas; rice and fish in deepwater areas, and rice with cash crops in floating rice areas.[134] The policy for the Central Highlands is strong support for non-rice cash-crops such as coffee, tea and rubber. Expansion of these crops is one of the reasons that the government has resettled lowlanders into the Central Highlands, so they provide a labour force to exploit the available land. More generally, the focus of the 2001-2005 socio-economic plan for Viet Nam is strongly biased towards increased industrialisation. This includes a programme of rural industrialisation to reduce the dependence of rural people on agriculture. As a result, the GDP share of agriculture is projected to drop by 10 percent by 2020.

In some upland areas, shifting cultivation is degrading watersheds

5.2 Land tenure issues

In all four LMB countries there are problems of unclear or insecure tenure over land and other natural resources in rural areas. These are having serious social, environmental, and economic consequences. Most land in the LMB technically belongs to the state, but there are mechanisms in each country for group or private tenure.[135] However, the lack of clarity and transparency of these mechanisms, and the degree to which they overlap with other traditional or state decreed laws and rights causes ambiguity and conflict. One major problem is a general lack of land-title for rural small holders. In Thailand in 1992, for example, 40 percent of Thai farmers were estimated not to have title over their land.[136] It was therefore relatively easy for big developers to annex smallholders' land, creating a situation of insecurity that gave farmers little incentive to invest in the sustainable environmental management of their land. Lack of title also means that land cannot be used as collateral for loans, cutting farmers off from financing and stunting the development of rural credit markets.

Titling problems are particularly pronounced in forest areas and areas designated unclassified or unused, which are usually utilised for shifting cultivation or grazing. In such areas, overlapping local claims are difficult to verify and are often at odds with the results of government-driven allocation processes.[137] Also problematic are attempts to reclassify forest land, especially the endowing of protected status, which overrules the traditional land use rights of forest residents, forcing them to move elsewhere to make their living and increasing land-use intensity in the areas in which they end up.[138]

5.3 Agricultural market issues

One of the biggest challenges for agricultural development in the LMB is the development of efficient and responsive markets and market infrastructures for agricultural inputs and produce. Unless farmers know what crops to grow and are able to market their surpluses, they have little incentive to produce them and unless they produce surpluses, they are likely to remain poor. Some would suggest, therefore, that improving the efficiency of agricultural marketing a key factor in rural poverty alleviation.

Key components of efficient agricultural markets include: affordable and accessible rural credit; high quality agricultural inputs such as seeds, fertilisers, pesticides, machines, and related technology; effective marketing and market information for farmers; rural transportation systems; national distribution networks; and international trade polices and relationships.

Rural credit is most necessary for the purchase of inputs for livestock and dry season crops and is thus an important requirement in moving from low value-added rice production to more lucrative agricultural pursuits. Of the four LMB countries, only Thailand has an extensive formal rural credit system, the Bank of Agriculture and Agricultural Co-operatives.[139] However, rates of credit utilisation have been relatively low, with only a minority of farmers in debt, and most of these being wealthier farmers who could afford to take the risks inherent in borrowing money.[140] In Cambodia, NGOs and international donors have been attempting to build rural credit networks. While they have had some degree of success, the system covers only a limited portion of the country and is criticised for charging interest rates as high as 60 percent per annum.[141] In Viet Nam, rural credit is provided predominantly by the Viet Nam Bank for Agriculture. However, loan procedural difficulties and limited government funds have resulted in difficulties in meeting the demand for credit, and the interest rates offered by private lenders are often extremely high. There is also a lack of medium and long-term credit facilities. Similar problems can be seen in Lao PDR. National savings are low (only 4 percent of GDP, the lowest for the ASEAN group) and there is no viable nation-wide rural financial system.[142] Informal lending predominates, with village revolving funds and household-to-household loans being common. Such arrangements are often in kind, rather than moneterised, especially in the remoter sloping land areas. There are a few formal credit organisations operating in the Mekong Corridor area, and the Lao PDR government intends to support the development and extension of this sector by allowing the market to set interest rates above inflation rates and establishing a corps of Mobile Credit Officers to "bring the banks to the farmers."[143]

Throughout the basin, livestock are becoming an increasingly important part of agricultural production

In terms of marketing and market information, the most important factors include "identification of potential markets, knowledge about potential crops for those markets, suitable crop production plans, availability of pre- and post-harvest technologies, and marketing mechanisms and arrangements."[144] In general, such facilities are underdeveloped across the basin, making it harder for farmers to make the best decisions on what crops produce, and whether the prices they receive could be better. The solution to these problems is generally held to be more effective on-farm extension programs, but such moves are often hampered by a lack of experienced management staff at the field level, and limited flexibility in government operations and budgeting support.[145] Another marketing-related issue is the development of mechanisms such as product grades to ensure that crop qualities meet the standards of local, national and international markets.

Rural infrastructure is important because it determines the ease with which products are able to move from the farm gate to the final consumer market, and is hence a major determinant of their final cost and competitiveness. Infrastructure problems exist across the basin area, but are most pronounced in Lao PDR, where the 1992/3 census found that approximately 20 percent of the population lived in areas not accessible by truck and over half were more than 10 km from the nearest market.[146] While it is difficult to estimate the costs of such a situation to rural communities, they are sure to be considerable. In response, the Lao PDR government, along with the other LMB countries, has made the upgrading of farm-to-market road networks a high development priority in rural areas.

6. Conclusion

Agriculture provides the livelihood of 75 percent of the population of the Lower Mekong Basin and is a key driver of national development in each of the riparian countries. The sector is also a major source of pressure on the natural resources of the region. Understanding and monitoring the links between agricultural activities, land and water use, and environmental change are critical to any attempts to ensure the sustainable development of the LMB.

- Agricultural activities are the mainstays of the Cambodian and Lao PDR economies and major providers of employment and export earnings for Thailand and Viet Nam.

- Rice growing dominates the sector, although diversification into fruits and vegetables and upland and tree crops is occurring.

- Lowland rice fed by rains and floods predominates, with irrigation common in some regions, particularly in the Mekong Delta, but rare in other regions.

- Irrigation is expanding and intensifying across the four countries, but is faced with institutional and natural resource-related constraints.

- These are great variations in productivity, with rice yields in upland Lao PDR about 1.55 tonnes/ha, compared to approximately 5 tonnes/ha for the Viet Nam Mekong Delta. Productivity is linked to the quality of agricultural inputs including land, irrigation, seed, fertilisers and pesticides, as well as supporting services such as finance and distribution networks.

- The upland regions of the basin, with less favourable environmental and market conditions, tend to have lower productivity levels and higher incidences of rural poverty than the more prosperous lowland and floodplain regions.

- Shifting cultivation is a very common upland farming system, which although environmentally sustainable under low population densities, appears to be exceeding carrying capacity and causing environmental degradation in many areas.

- Deforestation, caused by the clearing of land for shifting and sedentary cultivation, along with logging and other human activities, is leading to deteriorating watershed quality with increased erosion and sediment runoff. These problems are particularly marked in the upland areas of critical watersheds.

- Activities that increase agricultural production can also cause damage to the environment. Irrigation developments can increase salinity and cause other forms of water quality deterioration, as well as creating obvious pressures on water quantity. There are reports of water shortages in the Korat Plateau and salinity problems in the Mekong Delta. There are also concerns about pesticides and fertilisers causing contamination of ground and surface water.

- Environmental deterioration in turn can potentially affect agriculture by limiting crop yields when soil quality worsens, increasing the severity of floods and droughts, and increasing problems with pests and disease.

- All four governments place a high priority on agricultural development, generally promoting intensification of production through irrigation and technology improvements and diversification into products with higher returns than rice, while endeavouring to strengthen the supporting policy, legislation, and institutional environments.

- Institutional problems remain, including weaknesses in extension services, inadequate land tenure systems and market failures and inefficiencies, particularly in terms of markets for credit, market information and physical market infrastructure.

- The combination of rural poverty, economic reform and expansion, and national development initiatives is placing increasing pressure on the agriculture sector and hence upon land and water resources. If not managed properly, agricultural expansion could cause environmental changes that undermine the sustainability of the sector, as well as other sectors that depend upon the land and water of the Mekong Basin

Endnotes

[1] MRC 2001
[2] FAO 1997; 1999a; 1999b; 1999c
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Forestry 9

The forestry sector is of great importance to the future of land and water resources in the LMB, as well as to the social and economic development of the riparian countries. Forests are heavily exploited in parts of the LMB, and this has important implications for the quality of land and water resources. Forestry activity takes place on two levels: commercial logging, and the gathering of wood and other forest products by individual smallholders. On the commercial level, forestry is of considerable economic value and forms an important component of GDP and export earnings for Lao PDR and Cambodia. However, this industry faces problems related to illegal over-exploitation of resources. In terms of smallholder activity, exploitation of forest resources is a major source of livelihood for people who live in or around forests. It is estimated that 17 percent of the people living in the basin draw a significant proportion of their livelihood from forest resources, particularly in terms of gathering food, non-timber forest products and fuelwood.[1]

Forest resource use is causing loss of forest cover, with MRC data suggesting an annual basin-wide deforestation rate of 0.53 percent between 1993 and 1997. Although the causes of deforestation cannot be directly determined from the data available, it appears that logging is a driving force behind forest degradation, and that degraded forest lands are often cleared and converted to agricultural use. Human activity in the forestry and agriculture sectors is thus reducing the stock of forest resources in the LMB. While 0.53 percent per annum may not seem a large figure, this rate will have profound implications if it remains steady or accelerates in the longer term. If this rate of deforestation remains constant, the LMB will have only about 20 percent forest cover left in less than 100 years from now, as opposed to the more than 35 percent that it currently possesses. The environmental impacts of deforestation on such a scale are complex and uncertain, but could involve greater erosion and soil degradation, with increased run off of silt and sediment into the river system and a resulting decline in the quality of water resources.

Logging in watersheds can have serious consequences

Forestry management has become a highly controversial issue in the Lower Mekong Basin and adjacent areas. Controversies centre on three main issues. The first concerns the exploitation of forests and forest products, including non-timber forest products. Important questions include: Who should be permitted to use forests? For what purposes should forests be used and at what rates? A second issue is prevention of the illegal exploitation of forests and their resources, including the illegal alienation of forest lands, illegal logging and illegal trade in wildlife. The environmental consequences of forest loss, the third important issue, includes potential impacts on hydrological processes, water quality and soil loss. It is not appropriate to discuss all these issues in this report but more detailed discussions may be found elsewhere in publications by the Siam Society and Smith.[2]

Unlike most of the chapters in this report, forestry statistics were available at a basin level. Thus most of the data in the tables that follow are only for areas of Thailand and Viet Nam that lie within the basin. Because almost all of Cambodia and Lao PDR lie within the basin, national-level data have been used for these countries. In those few tables where only national level data were available for Thailand and Viet Nam, this has been indicated with the symbol * in a note below the table.

1. Forestry sector activities

1.1 Overview of the forestry sector

Forestry across the LMB is characterised by active logging, often carried out across borders, ineffective logging bans and application of regulations, and a reforestation process that is too slow to keep up with forest cutting and biased toward mono-culture.[3] The forestry sector covers commercial logging, private and commercial gathering of fuelwood, and the harvesting of non-timber forest products (NTFP.) The sector contributes 5 percent of the GDP for Lao PDR, 4 percent for Cambodia, 1 percent for Viet Nam, and below 1 percent for Thailand. However, these figures understate the importance of forest resources in the economic and social lives of LMB people because of the large numbers who draw their livelihoods partially or fully from the forests. Forests are also of enormous indirect value by virtue of the role they play in protecting watersheds from erosion and other forms of degradation.

Uncontrolled and illegal logging continues in much of the basin

The tables below give Food and Agriculture Organization (FAO) estimates of the quantity of various forest resources exploited in the LMB countries, including concession and non-concession (illegal and smallholder) activity. Figures for Thailand and Viet Nam are only available at the national rather than the basin level.

Table 1. Cambodia forestry sector output 1990-2000 (m^3)

Item	1990	1995	2000
Industrial roundwood	567,000	1,040,000	809,000
Other industrial roundwood	457,000	630,000	630,000
Plywood	2,300	29,000	27,000
Roundwood	11,795,231	12,026,632	10,928,409
Sawlogs+veneer logs	110,000	410,000	179,000
Sawnwood	71,000	140,000	3,000
Veneer sheets	0	29,000	45,000
Wood-based panels	2,300	58,000	72,000
Wood charcoal	25,036	36,275	31,042
Wood fuel	11,228,231	10,986,632	10,119,409

Source: FAO 2002a

Table 2. Lao PDR forestry sector output 1990-2000 (m^3)

Item	1990	1995	2000
Industrial roundwood	455,000	994,000	866,000
Other indust. roundwd	105,000	119,000	132,000
Plywood	10,000	8,500	125,000
Roundwood	6,082,031	6,724,394	6,737,960
Sawlogs+veneer logs	350,000	875,000	734,000
Sawnwood	100,000	465,000	350,000
Wood-based panels	10,000	8,500	125,000
Wood charcoal	12,892	14,717	16,772
Wood fuel	5,627,031	5,730,394	5,871,960

Source: FAO 2002a

Table 3. Thailand* forestry sector output 1990-2000 (m^3)

Item	1990	1995	2000
Chips and particles	0	0	1,449,000
Fibreboard	131,000	181,000	194,000
Fibreboard, Compressed	82,000	0	0
Hardboard	0	70,000	102,000
Industrial roundwood	3,093,000	2,775,000	2,894,000
Insulating board	49,000	30,000	0
MDF	0	81,000	92,000
Other indust. roundwd	2,601,000	2,742,000	2,848,000
Particle board	60,000	216,000	1,039,000
Plywood	122,000	278,000	91,000
Roundwood	24,899,980	23,500,478	23,446,514
Sawlogs+veneer logs	492,000	33,000	46,000
Sawnwood	1,170,000	425,900	294,000
Veneer sheets	136,000	8,000	3,000
Wood-based panels	449,000	683,000	1,327,000
Wood charcoal	1,064,983	1,122,083	1,202,869
Wood fuel	21,806,980	20,725,478	20,552,514

Note: "*" data are for the whole country rather than for just for the territory within the basin.
Source: FAO 2002a

Table 4. Viet Nam* forestry sector output 1990-2000 (m^3)

Item	1990	1995	2000
Industrial roundwood	4,669,000	4,425,000	4,556,000
Other Industrial Roundwood	1,813,000	2,009,000	2,140,000
Particle board	2,000	2,000	2,000
Plywood	37,000	37,000	37,000
Roundwood	31,203,428	31,218,304	31,241,548
Sawlogs+veneer logs	2,856,000	2,416,000	2,416,000
Sawnwood	896,000	721,000	721,000
Wood-based panels	39,000	39,000	39,000
Wood charcoal	109,512	126,659	108,258
Wood fuel	26,534,428	26,793,304	26,685,548

Note: "*" data are for the whole country rather than for just for the territory within the basin.
Source: FAO 2002a

1.2 Commercial logging

In terms of commercially-produced lumber and timber, the region as a whole consumes most of the wood it produces, but there are significant intra-regional flows, with Cambodia and Lao PDR producing a surplus and Thailand and Viet Nam importing to meet their needs.[4] Demand in the latter two countries is driven primarily by construction needs that cannot be satisfied due to domestic logging bans. Thailand has banned commercial logging entirely, following annual deforestation rates as high as 4-5 percent in the 1980s and a series of floods and landslides that caused public scandal in 1989.[5] As result, unsatisfied timber and lumber demand in Thailand has increased pressure on forest resources in Cambodia and Lao PDR. This situation is unlikely to abate in the near future, with wood demand in Thailand estimated to be increasing at the rate of 5 percent per year.[6]

Tables 5 and 6 below show the relative importance of forestry exports and provide estimates of the quantity of roundwood logs traded between the LMB countries in 1999. Much of this trade is conducted illegally, in defiance of government established quotas, bans and concession rules. It is thus difficult to accurately ascertain the quantities of wood involved and estimates must be taken as indicative only. Legal logging within government quota restrictions is not considered to present a major problem in terms of environmental sustainability, although there are issues with inefficient logging practices and poor planning causing greater forest cover loss and environmental degradation than is necessary given the quantities being harvested.[7] For example, a considerable proportion of the wood harvested in Lao PDR is lost due to poor management practices.[8]

Illegal logging, which appears extensive in Cambodia and Lao PDR, presents a greater environmental concern in terms of sustainability and deforestation, although again, it is difficult to ascertain the quantities of timber involved. There are particular problems with concession operators adjacent to protected areas logging within the protected areas and merging the illegally-acquired logs with their legitimate harvest to avoid detection. Furthermore, the concession granting process is often not transparent and enforcement is weak, leading to over-cutting of valuable trees at an unsustainable rate.[9] The enforcement of regulation and implementation of policy is made difficult by a lack of resources for forestry agencies.[10]

Table 5. Contribution of forestry to LMB country exports (%)

	Cambodia		Lao PDR		Thailand*		Viet Nam*	
	1995	1999	1995	1999	1993	2000	1995	1998
Share of total exports								
Forestry	69	16	39	29	0	0	3	2

Note: "*" data are for the whole country rather than for just for the territory within the basin.
***Source*:** Thailand National Statistics Office 1997, 2001; Viet Nam General Statistical Office 1999; IMF 2002a; IMF 2002b

Table 6. Lower Mekong Basin industrial roundwood trade 1999

		Importers					
	Country	Cambodia	Lao PDR	Thailand*	Viet Nam*	Other	Total
Exporters	**Cambodia**	X	Little	1500	800	700	3000
	Lao PDR	-	X	300	100	100	500
	Thailand	-	-	X	-	500	500
	Viet Nam	-	-	-	X	500	500
	Other	-	-	3200	500	X	3700
	Total	-	Little	5000	1400	1800	8200

Note: Units (1000s M^3 rwe per year) * data are for the whole country rather than for just for the territory within the basin.
Source: updated from Castren 1999, cited in MRC 2000, p 18.

1.3 Fuelwood collection

The majority of people in the basin use wood or charcoal for cooking and boiling water

While commercial logging attracts the most attention as a source of pressure on LMB forest resources, fuelwood collection is also an important driver of demand for wood. In 1995, for example, Cambodia is estimated to have supplied 95 percent of its energy requirements for cooking and boiling water with fuelwood. In Lao PDR, 80 percent of cooking energy requirements are provided by fuelwood, and a substantial proportion of wood felled is for fuel, with a similar situation in Thailand and Viet Nam.[11] The cutting of mangroves for charcoal production is also common in some regions. Because most fuelwood is consumed by the collecting household rather than entering the formal economy, it is difficult to ascertain the quantities collected.[12] In Cambodia, for example, various estimates of fuelwood production for the mid 1990s run between 6-11 million m^3.[13] For Lao PDR, the government estimates that about 12.7 million m^3 is gathered annually, although FAO figures are about half this level.[14] One estimate for Viet Nam suggests that if converted to its area equivalent, the quantity of fuelwood gathered would account for six times as much harvesting as commercial logging.[15] However these figures, while significant, do not translate directly to pressure on forest resources because a significant proportion of the wood collected comes from scattered trees in non-forest areas, or consists of branches that are cut off standing trees.

1.4 Non-timber forest products (NTFPs)

Another important component of the forestry industry is NTFP harvesting. The NTFP category encompasses a wide range of forest resources, including wildlife, wild fruits, medicinal plants, resins, gums, precious woods, rattan and bamboo. Demand for these products is growing throughout the LMB and in China. This is leading to increased income-earning opportunities for forest dwellers, but is also creating the danger of unsustainable resource use.[16] While such products are not included in official forest valuations, they comprise important primary and secondary sources of income for large numbers of people, as well as sources of food and cash-income for farmers during poor harvest years. In Thailand, for example, an estimated 5 million people derive their primary income from NTFPs.[17] Given that the cutting of lumber for sale is either illegal or requires a government concession in the riparian countries, NTFPs provide smallholders with a means of generating income from forest resources in a way that timber cannot. The yields from the harvesting and cultivation of NTFPs in upland conditions are often such that their economic value per hectare is greater than for rice cultivation, which means that NTFP harvesting can be a more attractive option for forest dwellers than shifting cultivation.[18] As such, NTFPs enhance the value of intact forests to local people and discourage deforestation.[19] Gathering these products is also superior to commercial forestry as a provider of employment. On average, ten hectares of NTFPs require thirty labourers to work them, which is ten times the number needed for a similar area of lumber production.[20] NTFPs are very important in the Central Highlands of Viet Nam, and across the country as a whole. In the early 1990s, they provided subsistence livelihoods and cash-income for an estimated 20 million people (across all of Viet Nam), as well as valuable export earnings.[21] The critical importance of such products compounds the negative social consequences of deforestation because loss of forests deprives large numbers of people with access to resources upon which they depend.

2. Forest cover and deforestation

2.1 Trends in LMB forest cover

This section presents details about forest cover and deforestation in the Lower Mekong Basin (LMB) between 1993 and 1997, which have been derived from MRC's Forest and Land Cover Data Set, compiled between 1993 and 1999.[22] This data set, which is based on visual interpretations of Landsat satellite images, combined with limited ground truthing, is one of the most complete available.[23] However, it does not go beyond 1997, and thus fails to capture any land-use changes that may have taken place in the LMB since then. For more information on the availability and reliability of forest cover data, please refer to the box below titled “Forest cover data availability: issues and problems”.

The term forest is used here as defined by the Forest Cover Monitoring Project: “An area is considered as forest if the tree cover (crown cover) is at least 20 percent and if tree height can be assumed to be about 10 meters or more. If the tree cover is equal or more than 20 percent, but tree height ranges only between 5 and 10 meters, an assignment to the class ‘forest regrowth’ appeared to be appropriate...”[24] All figures given here for individual countries only refer to those parts of the countries that are located within the LMB. Map 1 presents forest cover in the Lower Mekong Basin in 1997.

The most densely-forested country in 1997 was Cambodia, with almost two thirds of its area covered by forest, while the most sparsely-forested country was Thailand, with less than one sixth forested. Almost all of the forested land in the LMB area of Viet Nam is in the Central Highlands region, and forest cover was more extensive in southern and central Lao PDR than in the northern part of the country. In assessing forest cover figures across the four countries, one can see that there is a strong negative correlation between population density and forest cover. Lao PDR and Cambodia have population densities of 21 and 49 persons per km^2 and have 41 percent and 58 percent forest cover respectively, while the basin portions of Thailand and Viet Nam with 128 and 224 persons per km^2 have 16 percent and 24 percent, respectively.[25]

Non-timber forest products include wildlife, wild fruits and vegetables, medicinal plants, resins, gums, precious woods, rattan and bamboo

Table 7, below, details changes in forest cover in the basin areas of the four countries between 1993 and 1997. The forest cover in all four countries, and hence in the LMB as a whole, has decreased during the period observed from an overall 36.7 percent in 1993 to 35.9 percent in 1997.

Table 7. Forest cover in the LMB in 1993 and 1997

Area	Forest cover 1993		Forest cover 1997		Total size	
	ha	%	ha	%	ha	%
Cambodia	9,274,703	59.4	9,092,093	58.2	15,618,908	100
Lao PDR	8,746,487	42.2	8,544,584	41.3	20,712,008	100
Thailand	3,038,772	16.1	2,990,087	15.9	18,827,978	100
Viet Nam	1,664,005	24.7	1,615,670	24.0	6,745,651	100
LMB	**22,723,966**	**36.7**	**22,242,433**	**35.9**	**61,904,545**	**100**

Table 8, below, presents a breakdown by classes of forest cover, and shows that the largest losses have occurred in areas classified as "open/distributed forest", followed by "regrowth forest" and "closed forest".

Table 8. Distribution of forest cover types in the LMB in 1993 and 1997

Type	Forest cover 1993		Forest cover 1997	
	ha	% of 1993 total	ha	% of 1993 total
Forest, closed	2,945,301	13.0	2,897,159	12.7
Forest, open/disturbed	15,010,897	66.1	14,662,059	64.5
Forest, mosaic with non-forest types	3,527,399	15.5	3,521,009	15.5
Forest regrowth	762,940	3.3	685,276	3.0
Other forest types	477,429	2.1	476,930	2.1
Total	**22,723,966**	**100.0**	**22,242,433**	**97.9**

Note: % values refer to Total in 1993. For detailed definitions of Forest Classes see FCMP 1997

Deforestation is compared with reforestation and regrowth in Table 9. In all four countries, deforestation and reforestation/regrowth have been taking place simultaneously, with the latter partly compensating for the former. The *Net Forest Cover Loss* of Table 8 equals *Deforestation* minus *Reforestation & Regrowth*. Lao PDR has suffered the largest net forest cover loss in absolute terms, while Viet Nam has lost the greatest percentage of its forest cover. The LMB as a whole has lost close to 500,000 ha, or slightly over 2 percent of its forest cover within only four years.

Table 9. Deforestation and reforestation & regrowth 1993 – 1997

Area	Deforestation		Reforest. & regrowth		Net forest cover loss	
	ha	%	ha	%	ha	%
Cambodia	194,800	2.1	12,190	0.1	182,610	2.0
Lao PDR	212,263	2.4	10,360	0.1	201,903	2.3
Thailand	49,982	1.6	1,297	0.0	48,685	1.6
Viet Nam	77,427	4.6	29,092	1.7	48,335	2.9
LMB	**534,472**	**2.3**	**52,939**	**0.2**	**481,533**	**2.1**

Note: % values refer to Forest Cover 1993 of the respective Area in Table 7.

There have been significant differences in the ratio of deforestation versus reforestation and regrowth in the individual countries. Reforestation programmes, while legally required of many logging concessionaires and generally accorded a high priority by LMB governments, have had varied success. On the whole they lag behind deforestation by a substantial margin. Viet Nam has had the most success in this area and has compensated for over one third of the deforestation it has experienced through reforestation and regrowth. This is most likely related to the government's recent reforestation efforts: almost 90 percent of the total reforestation and regrowth found in Viet Nam during the period observed was made up of forest plantations.[26] Reforestation rates in the other three countries are much lower, and in all four countries are far from sufficient to stabilise forest area.There is also cause for concern about the nature of reforestation efforts. There is a general bias towards mono-culture, resulting in decreasing bio-diversity. Furthermore, survival rates for planted trees are low due to poor planning, use of inappropriate species and insufficient institutional support.[27]

For easier comparison, the *Net Forest Cover Loss* of Table 9 can be expressed in the form of annual deforestation rates shown in Table 10. For example, the rate given for the LMB means that the region as a whole has annually lost an average 0.53 percent of its forest cover during the period observed.

Table 10. Annual deforestation rates 1993 – 1997

Area	Deforestation rate %
Cambodia	0.50
Lao PDR	0.58
Thailand	0.40
Viet Nam	0.73
LMB	**0.53**

Figure 1. Lower Mekong Basin – Forests 1997

As Map 1, above, shows, deforestation has not been evenly dispersed across the entire LMB. Rather, there have been quite distinct "hot spots" of deforestation, found mainly around existing population centres (see clusters of deforestation around and near Chiang Rai, Luang Namtha, Attapeu, Kon Tum, Buon Ma Thuot, Ban Lung, Kampong Thom) and in the vicinity of roads. Further, deforestation is found in particular along the Thai-Cambodian and the Lao-Chinese borders. Also note that the two densest clusters of deforestation (Attapeu and Ban Lung) are both linked by road to nearby more-populated neighbouring countries, thus having potential access to their markets for timber and agricultural produce.

The current rate of logging in the LMB is at an unsustainable level

It appears from this geographical distribution that deforestation does not take place randomly, but at least to some extent follows predictable patterns. To a certain degree, deforestation further appears to be an international (cross–border) problem. This indicates that reducing deforestation may require regionally-integrated approaches, the implementation of which may in a number of cases be beyond the capacity of any single government.

Forest cover data availability: issues and problems

Reliable data on forest cover, and even more so on its changes, are difficult to obtain. For example, data sampled from a limited number of publicly-accessible sources show an enormous variety of forest cover figures. For Cambodia (whole country), one academic source[28] offers "Scientific Data Products" which, when evaluated, yield forest cover figures of 27.3 percent (1985)[a] and 47.6 percent (1992)[b]. Had this been the case, Cambodia would have enjoyed an annual reforestation rate of 8.25 percent. For the Lao PDR (whole country), forest cover figures range from 47 percent (in 1994)[29], 47.2 percent (in 1992)[30], 54.4 percent (in 1989)[31], 54.4 percent (in 2000)[32, 33, 34], 55.5 percent (in 1989)[35], 56.7 percent (in 1990)[36] to over 80 percent (in 2000)[c]. One source attempts to clarify: "A massive 85 percent of Laos is forested, with 47 percent classed as forests in the 1989 inventory and 38 percent as unstocked and bamboo forests…"[37] Such diversity of figures makes reliable determination of deforestation rates nearly impossible. Even worse than their numerical uncertainty is the fact that most available figures and their source data are fuzzy in a geographical sense, i.e. they do not allow the identification of deforestation "hot spots", and thus do not support prioritisation of intervention measures.

What causes such enormous diversity? Likely causes are incompatible data generation methods, lack of background knowledge on the analyst's part, lack of funds or time, politically-motivated interference with study methods and results, and the classic dilemma of public goods. *Incompatible data* *generation methods* result in different studies not being comparable. This happens, for example, when studies use different definitions of what constitutes a forest or work with different base maps. *Lack of background knowledge on the analyst's part* often leads to misinterpretations of natural phenomena. For example, the impacts of the seasonal monsoon climate on the appearance of different vegetation types on remotely sensed images are often completely neglected in studies performed by researchers with little local or forestry-related experience. This may result in grossly biased estimations of forest cover figures. *Lack of funds or time* results in the use of inappropriate data generation methods, with speedy delivery of products of whatever quality being given priority over accuracy and reliability. *Outside interference with study methods and results* sometimes involves the deliberate alteration of forest cover figures to make them suit a particular agenda. Data generated by national institutions may be subject to this type of bias. In the *dilemma of public goods*, all those who would benefit from the provision of such goods find it costly to contribute and would prefer others to pay for the goods instead. This is certainly the case with data on forest cover: due to the high cost of their generation, many organisations resort to recycling of existing – and often outdated – data instead of investing in the generation of new data. It is obvious that in such a situation, accuracy and reliability suffer.

Unreliable figures, whatever their cause, are likely to result in poor decision-making. Setting political as well as geographical priorities is difficult without reliable information about the location and magnitude of deforestation problems. In fact, the MRC's Forest and Land Cover Data Set is so far the only source of reliable information at the basin-wide level, which has been generated with an appropriate methodology,[d] and has been subject to independent accuracy testing. [38]

However, even this data set is already out of date. It was last updated in 1997, so there is no reliable information about the deforestation that has occurred since then. Given the importance of forests for the health of the LMB, an update is urgently required if access to reliable information about the status and trends of the LMB's forests is deemed important for making appropriate decisions. Past experience has shown that such an update will come at a cost.[e] One possible solution to make monitoring of deforestation easier and less expensive could be the application of statistically-sound sampling procedures instead of traditional mapping approaches, which would map the whole basin.

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[a] assuming all clouds and their shadows in the GIS data set conceal forest, without this assumption 23.5 %

[b] assuming all clouds and their shadows in the GIS data set conceal forest, without this assumption 40.9 %

[c] calculated from Forest map on http://www.fao.org/forestry/fo/country index.jsp?lang_id=1&geo_id=39

[d] Interdependent interpretation of satellite image time series, see Forest Cover Monitoring Project MRC/GTZ. 1998 [1].

[e] The Forest Cover Monitoring Project, which created the MRC's Forest and Land Cover Data Set, had a budget of $ 3.2 million over 6 years.

2.2 Forces driving deforestation

Possible causes of deforestation include commercial logging, fuelwood collection, shifting cultivation, and the encroachment of sedentary agriculture. Secondary causes include forest fires and infrastructure development. However, the specific forces driving deforestation in the LMB cannot be directly identified from the source data. What can be done is identifying into which land cover types the areas affected by deforestation are transformed (see Table 11), and from this, draw at least some partial conclusions. During the period observed, deforestation has resulted in degraded vegetation types on about one quarter (23.2 percent) of the area it affected. On more than half of the affected area (53.7 percent), forest has been replaced by shifting cultivation or upland agriculture, and on another 17.8 percent, by permanent agriculture. Hence, on altogether more than 70 percent of the area affected, forest has given way to some form of agriculture.[f] One might therefore assume a growing population's increasing demand for food is the main cause of deforestation.

Swiddon agriculture is often the only option for marginalised, ethnic minorities

However, there are strong indications that other agents precede the ultimate conversion from forest to agriculture. As Table 12 shows, those forests that have been converted to shifting cultivation or upland agriculture were mostly (80.4 percent) already degraded beforehand.

Table 11. Land cover types after deforestation

Area	Degraded tree & shrub vegetation		Shifting cultiv. or upland agriculture		Permanent agriculture		Other types		Total	
	ha	%	ha	%	ha	%	ha	%	ha	%
Cambodia	55,332	28.4	92,827	47.7	39,341	20.2	7,300	3.7	194,800	100
Lao PDR	55,305	26	132,175	62.3	24,574	11.6	209	0.1	212,263	100
Thailand	4,505	9	28,769	57.6	14,150	28.3	2,558	5.1	49,982	100
Viet Nam	9,016	11.6	33,072	42.7	17,142	22.2	18,197	23.5	77,427	100
LMB	**124,158**	**23.2**	**286,843**	**53.7**	**95,207**	**17.8**	**28,264**	**5.3**	**534,472**	**100**

Note: % values refer to the sum of all types for each country.

Although again the forces driving this degradation cannot be directly identified from the source data, it is very likely that much of it was caused by logging, simply because other degrading agents have a much smaller impact on the details visible on satellite images (i.e. would hardly lead to the classification of an area as being degraded). This is fully in line with findings elsewhere in the literature, for example, with the observation that "in many tropical regions logging paves the way for agricultural expansion by providing the necessary roads and capital".[39]

[f] A distinction of shifting cultivation and other more permanent forms of upland agriculture was not possible in most cases from satellite images only. Therefore they have been combined into the class *Shifting Cultivation or Upland Agriculture* used here.

Table 12. Forest types in 1993 converted to shifting cultivation/upland agriculture 1993 – 1997

Area	Degraded forest		Other forest		Total	
	ha	%	ha	%	ha	%
Cambodia	74,236	80.0	18,591	20.0	92,827	100
Lao PDR	117,737	89.1	14,438	10.9	132,175	100
Thailand	12,969	45.1	15,800	54.9	28,769	100
Viet Nam	25,661	77.6	7,411	22.4	33,072	100
LMB	**230,603**	**80.4**	**56,240**	**19.6**	**286,843**	**100**

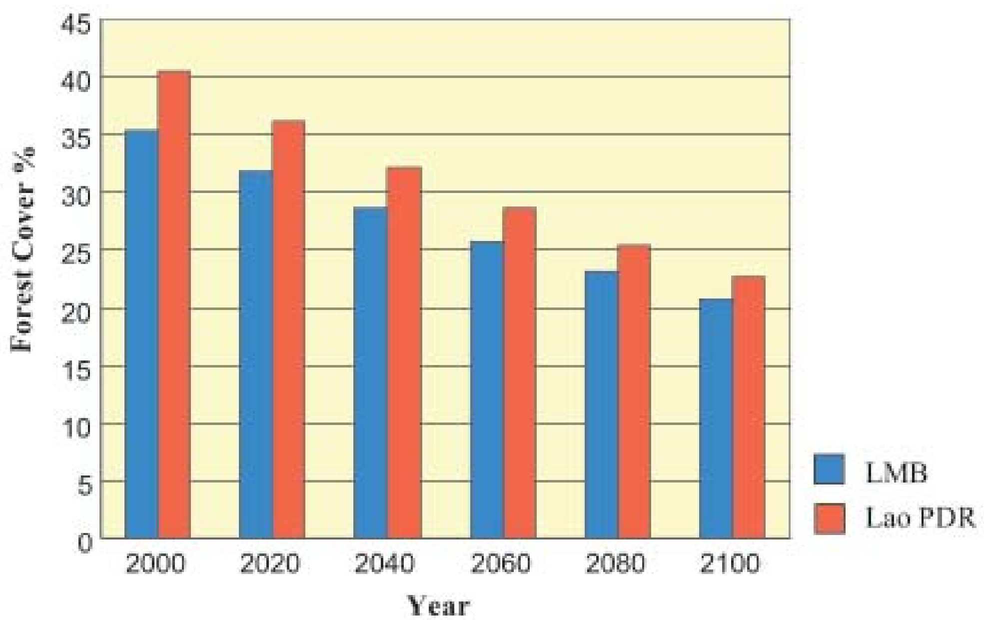
2.3 Possible future scenarios for deforestation

While the 0.53 percent average annual LMB deforestation indicated in Table 9 does not seem a great deal at first glance, this figure gets an entirely different meaning when used to predict how much of the forest cover of the LMB would be lost during the next century, assuming deforestation continues at the same annual rate.

Under this assumption, the LMB would have only about 20 percent forest cover left in less than 100 years from now. Even worse, Lao PDR, the country whose forests now cover a significant proportion of the mountainous headwater areas of major tributaries of the Mekong River, would experience a reduction of its forest cover from today's level of over 40 percent to only slightly more than 20 percent. The effects that deforestation of this magnitude could have on the steadiness of water flow from headwater areas, and on floods in the entire Mekong River system, could be considerable.

The assumption regarding the deforestation rate made above is rather conservative. For example, it does not take into consideration the fact that the LMB population is likely to grow further and that hence the demand for forest products and for agricultural land will increase, thus leading to even more forest degradation and ultimately more deforestation than predicted in Figure 1.

Figure 2. Development of forest cover at annual deforestation rates of 0.53 percent (LMB) and 0.58 percent (Lao PDR)



3. Environmental consequences of deforestation

The most direct environmental consequence of deforestation is the loss of the forest biota in the deforested area. Because forests are almost always more biologically diverse than the systems with which they are replaced, this usually results in a local loss of biodiversity, and potentially a reduction in global species diversity. While many of the larger more conspicuous forest species (the "charismatic megafauna"such as tigers and rhinos which are often associated with calls for biodiversity conservation), tend to have large distributions, many of the small, less spectacular species do not. Insects and small herbaceous plants are far more limited in distribution and it is these species that are most frequently lost when forest is cleared.

An issue of great concern in the LMB and the region as a whole has been the consequences of forest clearance on hydrology and related processes such as flooding, soil erosion and mass soil movement. Much of the literature to 1990 on this issue was reviewed by Bruijnzeel.[40] The outcomes are not simple and depend greatly on how the forest is removed, the soil type, slope and rainfall patterns of the area from which the forest is removed, and the subsequent fate of the area.

The way the forest is removed, and even the seasonal timing of the removal, influence the amount of soil disturbance and soil compaction. For example, use of heavy equipment tends to compact soil so that commercial logging operations using bulldozers will cause more compaction than other forms of logging or clearance due to swidden agricultural practices. Similarly compaction occurs more in wet than dry soils so forest clearance during the wet seasons is likely to cause greater compaction and dry season clearing.[41] Compaction and soil disturbance can have important consequences for erosion and water infiltration.

When mature forest is cleared, the hydrological consequences depend on the subsequent use of the land. For example, there are a number of studies showing that young, regenerating forest has higher transpiration rates than mature forest so the consequence may be decreased runoff and stream flow. On the other hand if the forest is replaced with grassland or paved areas, runoff may increase and streamflows will be higher, although the seasonal pattern may alter with wet season flows increasing at the expense of dry season flows.

All these hydrological impacts have been documented from controlled studies on relatively small catchments. Attempts to demonstrate that they occur on the scale of large river basins have so far not been successful. In tropical regions such attempts have been made for catchments in Thailand, on the island of Taiwan and the Amazon.[42] A suggested reason for the failure to detect the effects is that the spatial and temporal variability of rainfall in large tropical catchments is too great and masks the impact of catchment vegetation change.

Increasing run off in logged areas can result in erosion, turbidity and sedimentation

4. Social consequences of deforestation

Rapid population growth in upland areas means that shifting agriculture can no longer be practiced sustainably

Deforestation is also a major concern on both a social and economic level. Across the basin, large numbers of people draw upon forestry resources for a high proportion of their subsistence and income needs. In Lao PDR, for example, over 85 percent of the population depend upon forests for at least part of their livelihood.[43] Such people face numerous problems when forests are destroyed.[44] The food security provided by NTFPs is lost, creating a greater need to generate cash income to buy food on the market. Malnourishment often results, and is compounded by, the loss of good quality drinking water. Fuelwood gathering becomes more difficult and takes more time away from other activities. The loss of livelihoods causes many males to migrate in search of work, which can lead to family disintegration, greater workloads for women and a general lowering of female status as a result of the second marriages migrating men may make.[45] The agricultural encroachment that follows deforestation often causes the loss of traditional land use rights and traditional conservation mechanisms. Ethnic minority groups tend to suffer these effects most severely and often find themselves pushed into increasingly marginal areas in the face of conflicts with governments or logging companies.

5. Conclusion

- The forestry sector is of major economic, social, and environmental importance in the Lower Mekong Basin. Forest resources are exploited by commercial and smallholder operations for timber, fuelwood, and non-timber forest products.

- The commercial logging sector is characterised by active logging, often carried out on a cross-border basis. The demand for wood in Thailand (where logging has been banned since 1989) and Viet Nam, is a major factor driving logging in Cambodia and Lao PDR.

- Commercial forestry activity is often carried out on an unsustainable scale, with government regulatory controls sometimes unable to prevent overexploitation. There is a need for greater resources for the management of forestry concessions and the enforcement of regulations.

- Large numbers of smallholders also live in and around forests and draw all or part of their living from the collection of fuelwood and non-timber forest products for household consumption and sometimes sale for small amounts of cash.

- Forest resources are being used faster than natural or plantation regrowth can replenish them. Data shows that the average rate of deforestation across the LMB between 1993 and 1997 was 0.53 percent per annum.

- The available evidence suggests that logging is the most important activity causing the degradation of forested lands, and that degraded forests are commonly converted to agricultural use, causing loss of forest cover.

- Forest losses have important environmental consequences as they can cause erosion and watershed degradation. These changes may reduce water regulation capacities, which in turn could result in higher incidences of flooding, and declines in water quality and even quantity. The loss of bio-diversity is another important consequence of deforestation.

- The environmental changes that forest losses contribute to can have significant negative implications for human activities such as agriculture and fisheries, with reduced land and water quality constraining crop yields, and feeding into harmful cycles of poverty and overexploitation of the environment.

- Loss of forest cover is also a major concern on a social level because forest dwellers and others often lose their livelihoods when forests are logged and this, in turn, contributes to social problems.

Endnotes

1 MRC 2000, Executive Summary
2 Siam Society 1989; Smith 2001
3 MRC 1997, pp. 5-7
4 MRC 2000, p. 17
5 FCMP 1999b, p. 6
6 MRC 1997, p. 5-9
7 MRC 2000, p. 32; MRC 1997, pp. 5-8
8 MRC 2000, p. 32; MRC 1997, pp. 5-8
9 MRC 1997, pp. 5-9; MRC 2000, p. 31; Azimi *et al.* 2000, p. 12
10 MRC 2000, pp. 31-33
11 MRC 1997, pp. 5-7
12 MRC 1997, pp. 5-7
13 Azimi *et al.* 2000, p. 10; FAO 2002
14 Lao PDR Ministry of Agriculture and Forestry 1999, p. 19; FAO 2002
15 Azimi *et al.* 2000, p. 15
16 MRC 2000, p. 19
17 MRC 2000, p. 19
18 Durst *et al.* 1994, p. 157
19 MRC 2000, pp. 15-16
20 Durst *et al.* 1994, p. 157
21 Durst *et al.* 1994, p. 156; Azimi *et al*. 2000, pp. 14-15
22 FCMP 1999a; FCMP 1999b
23 FCMP 1997
24 FCMP 1997
25 MRC 2000, pp. 15-16
26 FCMP 1999a
27 MRC 1997, p. 5-9, 5-10
28 Michigan State University. 2000.
29 Lao PDR Ministry of Agriculture and Forestry 1999
30 FAO. 2000
31 FAO. 2000
32 FAO. 2000
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34 FAO. 2002
35 FAO. 2000
36 FAO. 2001
37 Nordic Institute of Asian Studies 2000, p. 20
38 Malyvanh and Feldkotter 1999
39 Kaimowitz 2000
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43 Azimi *et al.* 2000, p. 13
44 MRC 2000, pp. 23-24
45 MRC 2000, pp. 23-24

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Hydropower 10

The hydroelectric potential of the Mekong and its tributaries is largely undeveloped. In the 1960s, the Committee for Coordination of the Investigation of the Lower Mekong Basin (known as the Mekong Committee) carried out extensive research and planned more than 12 hydroelectric projects on the Mekong mainstream, but few of these were actually built, due to decades of war and civil unrest. Although peace has come to the region, so far only 5 percent (some 1,600 MW) of the lower basin's hydroelectric potential of approximately 30, 000 MW have been developed, and these few projects are only on the tributaries. The only dams on the Mekong's mainstream are two in the upper basin in the People's Republic of China.

When the Mekong River Commission replaced the Mekong Committee in 1995, the focus changed. MRC was established as a river basin management organisation, with as much emphasis placed on sharing resources equitably and sustaining the environment as on developing resources.

In 2001, MRC's Council and Joint Committee approved a new Hydropower Development Strategy. This treats hydro potential as one of many renewable natural resources and considers both the benefits and the adverse consequences of hydroelectric development.

The Strategy was developed through extensive research and consultation with a wide range of stakeholders that included National Mekong Committees, lines agencies, international organisations and civil society groups. It is based on five principles which MRC's Council endorsed at its annual meeting in 1998: (1) information exchange; (2) international cooperation on sustainable development of hydropower projects; (3) integrated overall planning of the mainstream and sub-basins (up to the pre-investment stage); (4) cumulative environmental and socio-economic aspects as well as public participation; and (5) encouragement of the private sector to join in developing hydropower potential with proper consideration of the environment and the well-being of the people.

The Khone falls in Lao PDR near the Cambodian border

The objectives of the Strategy are grouped into three strategic areas: consideration of integrated water use and environmental and socio-economic factors; efficient hydropower generation and distribution mechanisms; and information system and capacity building.

The chapter which follows discusses: the importance of electric power; the potential for hydro development in the Mekong Basin; projected growth in the demand for electric power in the LMB; the status of hydropower development in the LMB and factors which influence hydropower development; positive and negative impacts of hydropower development; and, China's plans for hydro projects in the upper basin.

1. Importance of electric power and common sources

Electric power is required both for economic development and for domestic use. As economies develop and people's living standards improve, their requirements for electric power increase. In the Lower Mekong Basin, the combination of rapid economic development and improvement of people's living standards has greatly increased the demand for electric power.

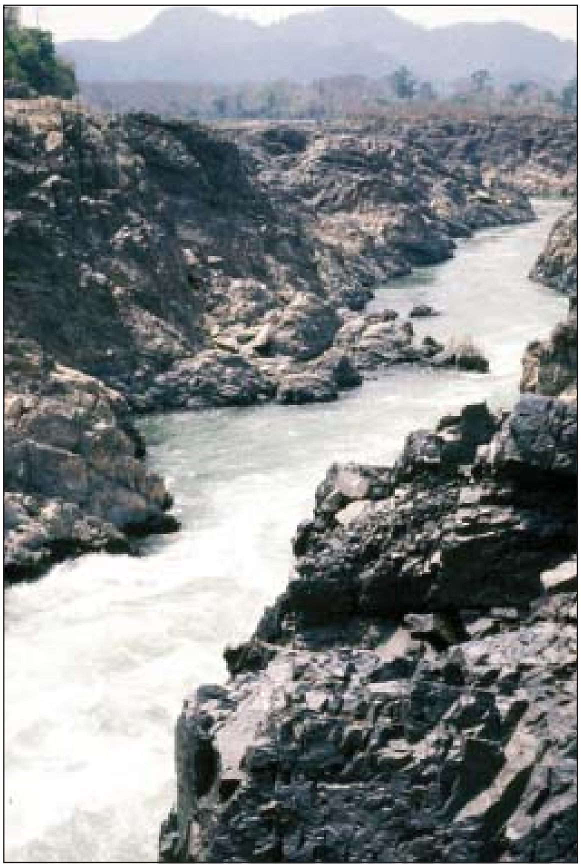
Worldwide a variety of power sources are used. These include fossil fuels (coal, petroleum, natural gas), nuclear power, renewable energies (hydro, geo-thermal, wind, solar power) and other generating systems such as fuel cells. According to estimates made in 1999 by the US government's Energy Information Administration, globally about 63 percent of power is generated from fossil fuels, 19 percent from hydro, 17 percent from nuclear power and 1 percent from other sources (EIA 1999).

The world's deposits of fossil fuels are limited and the price of fossil fuels fluctuates greatly. There are also concerns that using fossil fuels emits CO^2, which contributes to global warming and adds other environmentally-damaging substances to the atmosphere (SO^x, NO^x, micro dust, etc.). In order to reduce dependency on fossil fuels and mitigate the adverse impacts on the environment, efforts are being made worldwide to develop other means of generating electricity. In recent years, interest in using nuclear power has declined because of concerns about safety. Although alternative power sources such as fuel cells, solar and wind power are used to a limited extent, these alternatives are currently either too expensive or their capacity is too limited to meet more than a small fraction of the demand for electric power.

Of energy sources other than fossil and nuclear fuels, only hydro is currently a major source of electric power. Although worldwide, hydropower is limited by the availability of suitable sites, in the Mekong River Basin, the potential for hydro development is considerable. Since known energy sources other than hydro are limited in the Mekong Basin, especially in Lao PDR and Cambodia, the development of hydropower could be of considerable benefit. Provided projects do not cause serious environmental or social consequences (as discussed later in this chapter), they could meet both local needs for power and earn income from sales to more-industralised neighbouring countries.

2. The potential for hydropower development in the Mekong basin

The total potential for feasible hydropower projects in the four Lower Mekong Basin countries is approximately 30,000 megawatts (MW). Of this, 13,000 MW are on the Mekong's mainstream, and the remaining potential is in the tributaries (13,000 MW on tributaries in Lao PDR, 2,200 MW on tributaries in Cambodia and 2,000 MW on tributaries in Viet Nam). As stated above, only 5 percent (some 1,600 MW) of the Lower Mekong's hydro potential have been developed, and all projects are on the tributaries, not on the mainstream. There is also considerable hydro potential in the Upper Mekong Basin. In Yunnan Province of the People's Republic of China, total hydro potential is an estimated 23,000 MW, and two projects, totalling 2,850 MW, have already begun operating. The hydro projects currently built in the Mekong Basin are shown in Figure 1 and their capacity is listed in Table 1.



Rapids on the Mekong River just below the Chinese border

Concern about the development of hydro projects in the basin has grown in recent years. For example, in Thailand, the Pak Mun project has been criticised for significantly reducing the fishery in the Moon River and causing other problems. Unannounced releases of water from the Yali Falls Dam on the Se San River in Viet Nam have caused loss of life and property downstream in Cambodia, and civil society groups in Cambodia have criticised Viet Nam's plans to develop more hydro projects on the Se San.

In signing the 1995 Agreement that established the Mekong River Commission, member countries all agreed that before any hydro project can be built on the mainstream of the Mekong, all four members must agree. Although MRC members are only required to notify each other of their intention to build a project on a tributary, the 1995 Agreement obligates members to ensure that no harmful effects will occur downstream in neighbouring countries.

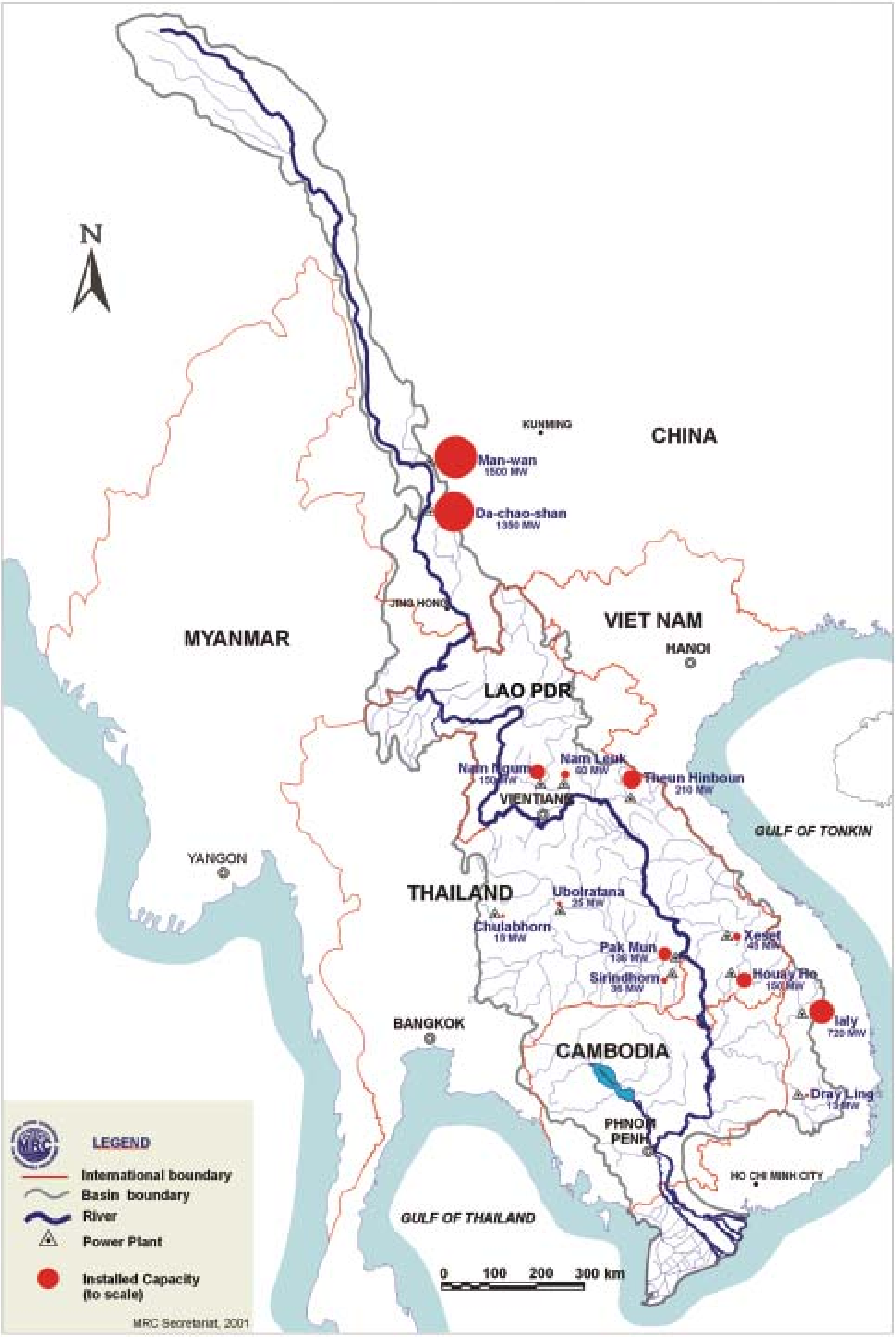
Increasingly, MRC has been called upon to facilitate dialogue among governments and other stakeholders to ensure that transboundary impacts are considered.

Table 1. List of completed hydropower projects (10 MW<)

Country	Name	Location	Capacity (MW)	Output (GWh/year)	Commissioning
China	Manwan	M	1,500	7,870	1993
	Dachaoshan	M	1,350	5,930	2001
Lao PDR	Nam Ngum	TR	150	900	1971-85
	Xeset	TR	45	150	1991
	Theun Hinboun	TR	210	1,645	1998
	Houay Ho	TR	150	600	1999
	Nam Leuk	TR	60	184	2000
Thailand	Sirindhorn	TR	36	115	1968
	Chulabhorn	TR	15	62	1971
	Ubolratana	TR	25	75	1966
	Pak Mun	TR	136	462	1997
Viet Nam	Dray Ling	TR	13	70	1995
	Yaly	TR	720	3,642	2000

***Note**:* TR = tributary and M = mainstream
***Source**:* MRC 2001

Figure 1. Completed hydropower projects in the Mekong Basin (10MW<)



3. Demand

In Tables 2 and 3, actual electricity consumption and peak load over the last 10 years are presented for the four countries of the Lower Mekong Basin.

Table 2. Actual electricity consumption (1990-2000)

Year	Cambodia		Lao PDR		Thailand		Viet Nam	
	Energy Sales (GWh)	Annual Growth Rate(%)	Energy Demand (GWh)	Annual Growth Rate(%)	Energy Demand (GWh)	Annual Growth Rate(%)	Energy Demand (GWh)	Annual Growth Rate(%)
1990			273		43,189		8,678	
1991			311	13.9	49,225	14.0	9,152	5.5
1992			356	14.5	56,006	13.8	9,654	5.5
1993			373	4.8	62,180	11.0	10,665	10.5
1994			394	5.6	69,651	12.0	12,284	15.2
1995	121		480	21.8	78,880	13.3	14,636	19.1
1996	200	65.3	543	13.1	85,924	8.9	16,946	15.8
1997	254	27.0	604	11.2	92,725	7.9	19,151	13.0
1998	304	19.7	688	13.9	92,134	-0.6	21,665	13.1
1999	313	3.0	772	12.2	90,414	-1.9	23,739	9.6
2000	381	21.7	865	12.0	96,781	7.0	26,722	12.6

Notes: The above data for Cambodia are for energy sales and only for the government's agency, Electricité du Cambodge. All data are for countries as a whole.
Source: ADB 2001

Table 3. Actual peak load (1990-2000)

Year	Cambodia		Lao PDR		Thailand		Viet Nam	
	Peak Load (MW)	Annual Growth Rate	Peak Load (MW)	Annual Growth Rate(%)	Peak Load (MW)	Annual Growth Rate(%)	Peak Load (MW)	Annual Growth Rate(%)
1990			48		7,094		1,660	
1991			55	14.6	8,045	13.4	1,850	11.4
1992			63	14.5	8,877	10.3	2,005	8.4
1993			64	1.6	9,730	9.6	2,143	6.9
1994			71	10.9	10,709	10.1	2,408	12.4
1995			85	19.7	12,268	14.6	2,796	16.1
1996			95	11.8	13,311	8.5	3,177	13.6
1997			108	13.7	14,506	9.0	3,595	13.2
1998			126	16.7	14,180	-2.2	3,875	7.8
1999			146	15.9	13,712	-3.3	4,329	11.7
2000	114		167	14.4	14,918	8.8	4,890	13.0

Note: data are for countries as a whole.
Source: ADB 2001

These tables show that in the four countries, growth in demand was considerable (an average of some 10 percent per year during the 1990s). The exception to this was Thailand in 1998 and 1999, where the Asian Financial Crisis drastically slowed the economy. Data on Cambodia indicate only power that is currently supplied, and not actual demand. It is thought that the demand for electric power in the LMB will continue to grow rapidly. Demand forecasts for each country are provided in Tables 4 and 5.

Table 4. Energy demand forecast (GWh per year)

Year	2000	2005	2010	2020
Cambodia	586	1300	2,500	5,700
Lao PDR	865	1,500	2,500	4,400
Thailand	96,781	135,000	184,000	328,000
Viet Nam	26,722	44,000	72,000	169,000
Total demand	124,954	181,800	261,000	507,100

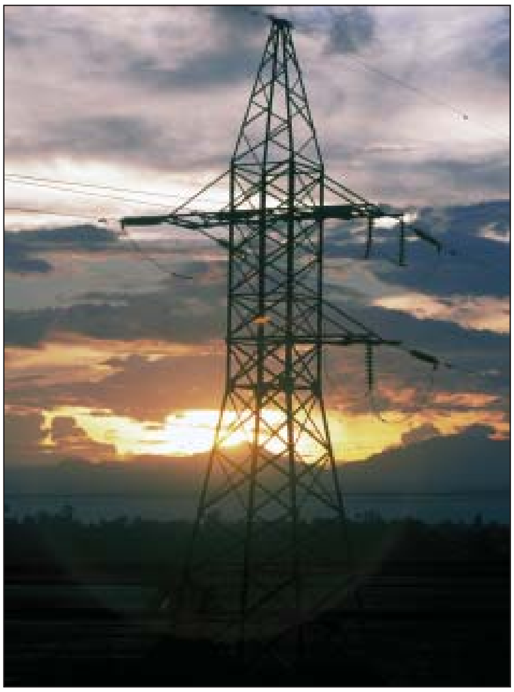
***Source*:** ADB 2001

Table 5. Peak demand forecast (MW)

Year	2000	2005	2010	2020
Cambodia	114	280	530	1,100
Lao PDR	167	280	440	780
Thailand	14,918	21,000	28,000	51,000
Viet Nam	4,890	7,800	12,000	28,000
Total demand	20,089	29,360	40,970	80,880

Note*:* data are for countries as a whole.
Source*:* ADB 2001

It is estimated that over the next 20 years, demand for electric power in the whole Mekong Region will increase by an average of about 7 percent per year. Thus in 20 years, the total generating capacity in the region will about four times greater than what is available today.



Demand for electricity is growing at about 7% per year

4. Status of hydropower development

Hydropower dam on the Nam Ngum River, one of the Mekong's tributaries in Lao PDR

Over the next ten years, according to projections made by the Asian Development Bank in 2001, MRC member countries will need to develop about 20,000 MW of new generating capacity. After this period, generating capacity will have to be developed at an even higher pace. Most of the power generation developments currently planned for Thailand and Viet Nam are thermal and gas turbine projects (fuelled primarily by natural gas and coal). There are plans as well for the development of hydropower, but mainly in Lao PDR (on tributaries of the Mekong) and in Viet Nam (mostly outside the Mekong Basin).

Since hydropower potential in the Mekong Basin is largely undeveloped, hydropower may become an increasingly important source of electricity in the future. However, for now, plans involve only a small part of the potential, concern only the tributaries and are likely to take a long time to be implemented. No plans are currently being considered for damming the mainstream in the lower basin. One small project is under consideration for the mainstream in Lao PDR but this will not involve damming the river. The Thaknoh hydropower project, which is currently at the pre-feasibility stage, is a small run-of-the-river project. As such, it would use the river's natural flow to generate power and not require damming the river.

There are a number of reasons why it is difficult to develop hydro projects. These include:

4.1 Difficulties in finding funds

Hydropower projects are generally characterised by high initial investment and a long payback period. These conditions have made it difficult for developing countries to fund hydro projects from domestic sources and instead, they have usually obtained funds from international lending agencies such as the World Bank and the Asian Development Bank. In recent years, however, because investment costs are so high and hydro projects can have adverse impacts on the environment and on local people, international funding agencies have been much less willing to fund projects. As result, developing countries have had to turn to the private sector for funding.

The pay-back period for a hydro project is typically two or three times longer than that for a thermal project

In Lao PDR, all the large-scale hydro projects currently being planned will be developed by independent power producers (IPPs). These IPPs are consortia made up primarily of private investors and it is the responsibility of the IPPs to secure the funds needed to develop projects. Here again there are problems. As governments privatise, the electric utilities that buy power from producers will require producers to bid against each other on a regular basis. Without long-term guarantees from utilities to buy their power at a profitable fixed price, it will be difficult for IPPs to raise the substantial funds needed to develop hydro projects.

4. 2 Undeveloped power market

Most of the hydropower potential in the Lower Mekong Basin is in Lao PDR and Cambodia, but both of these countries do not have a large enough domestic market (demand) to warrant developing large-scale projects. For the foreseeable future, domestic demand could be satisfied with the development of small-scale projects.

It is expected that in future a regional power network will be developed connecting all the national power systems in the Greater Mekong Sub-region. Under these conditions there will likely be a market for the Mekong Basin's hydro potential. But this is a long-term goal, and at this time, it is difficult for a number of technical and political reasons to create an integrated power system. In the short term, only isolated hydro projects, intended largely for export to a single country, are likely to be developed. Even in these cases, developers must demonstrate that their projects are competitive with projects using fossil fuels – something that will be difficult to do for the reasons just given.

4.3 Environmental and social impacts

Development of the Lower Mekong Basin's hydro potential is also likely to take some time because extensive investigations are needed prior to construction to ensure that dams will not have serious adverse effects on the environment and/or human welfare. Prior to the development of hydro projects, investigations of the actual environmental situation and assessments of negative as well as positive impacts have to be undertaken and carefully evaluated in order to judge whether a project will be acceptable or not. Unfortunately, the benefits and negative impacts of hydro projects cannot be measured on a common scale. Too often emphasis is placed on the economic benefits or on certain negative impacts, without a balanced appraisal of both. Also, due to differences in standards between countries, it is difficult to judge the transboundary impacts that projects may have.

Dams and reservoirs alter the ecology and biodiversity of a river system

In considering whether to proceed with hydro development, the following negative and positive impacts need to be considered:

4.3.1 Negative impacts of hydro projects

- adverse impacts on the ecosystem (aquatic life, animals, birds, vegetation)
- blocking of the flow of sediment
- negative impacts due to changing a river's flow pattern
- negative social impacts (resettlement, loss of livelihood)
- loss of scenic landscapes (tourism potential)
- negative impacts on water quality due to storage of water (eutrophication, lower temperatures for discharged water)
- negative impacts on other users of water (navigation, fisheries)
- problems during the construction period (noise, vibration, dust, traffic problems)

Only five percent of the basin's hydroelectric potential has thus far been developed

4.3.2 Positive impacts of hydro projects

- harnessing of a renewable natural resource
- reducing of the negative impacts that power generation has on the global environment (for example, reducing the use of fossil fuels will lessen air and water pollution)
- increasing the river's flow in the dry season, and reducing peak flow during the flood season
- increasing the availability of electrical power will stimulate economic development and improve people's living standards
- revenues will be earned from the sale of power

5. Hydropower development in the People's Republic of China

In Yunnan Province on the upper stream of the Mekong, China is implementing hydro projects on the mainstream without official consultation with the countries downstream. China currently has plans to construct six dams/power stations, in addition to the two that are already operating. These projects are: the Manwan dam/hydropower station with a reservoir capacity of 920 million m^3 and an installed generation capacity of 1,500 MW; and the Dachaoshan dam/hydropower station with a reservoir capacity of 880 million m^3 and an installed generation capacity of 1,350 MW. The six hydro projects planned on the Mekong River for Yunnan Province in China are presented in Table 6 and the location of the projects is shown on the map in Figure 2.

Table 6. List of planned and completed hydropower projects on the Mekong in China

Name of Project	Installed Capacity (MW)	Annual Generation (GWh)	Total storage C. (million m^3)	Catchment Area (km^2)	Average Flow (m^3/s)	Commiss -ioning
Gongguoqiao	**750**	4,670	**510**	97,300	985	
Xiaowan	**4,200**	18,540	**15,130**	113,300	1,220	2010-12
Manwan	**1,500**	7,870	**920**	114,500	1,230	1993
Dachaoshan	**1,350**	7,090	**880**	121,000	1,230	2001
Nuozhadu	**5,500**	22,670	**24,670**	144,700	1,750	2013-16
Jinghong	**1,500**	8,470	**1,040**	149,100	1,840	2012-13
Ganlanba	**150**	1,010		151,800	1,880	
Mengsong	**600**	3,740		160,000	2,020	
Total	**15,550**	74,060				

Source: Committee of Science and Technology 1993; ADB 2001.

China plans to complete three more hydro projects between 2010 and 2020. These are the Xiaowan project, with a reservoir capacity of 15,130 million m^3 and an installed generation capacity of 4,200 MW; the Jinghong project with a reservoir capacity of 1,040 million m^3 and an installed generation capacity of 1,500 MW; and the Nuozhadu project with a reservoir capacity of 24,670 million m^3 and an installed generation capacity of 5,500 MW. On January 20, 2002 China announced the commencement of construction on the Xiaowan project.

Now that the first two dams, Dachaoshan and Manwan, have been constructed and are operating, some downstream impacts such as changing of the river's flow pattern, blocking of sediment and impacts on the environment have occurred. The reduction in suspended sediment concentrations resulting from sediment trapping in Manwan Dam is already apparent as far downstream as Pakse in southern Lao PDR. The next two projects, Xiaowan and Nuozhadu, will have much larger reservoirs and could also change the river's flow on a seasonal basis.

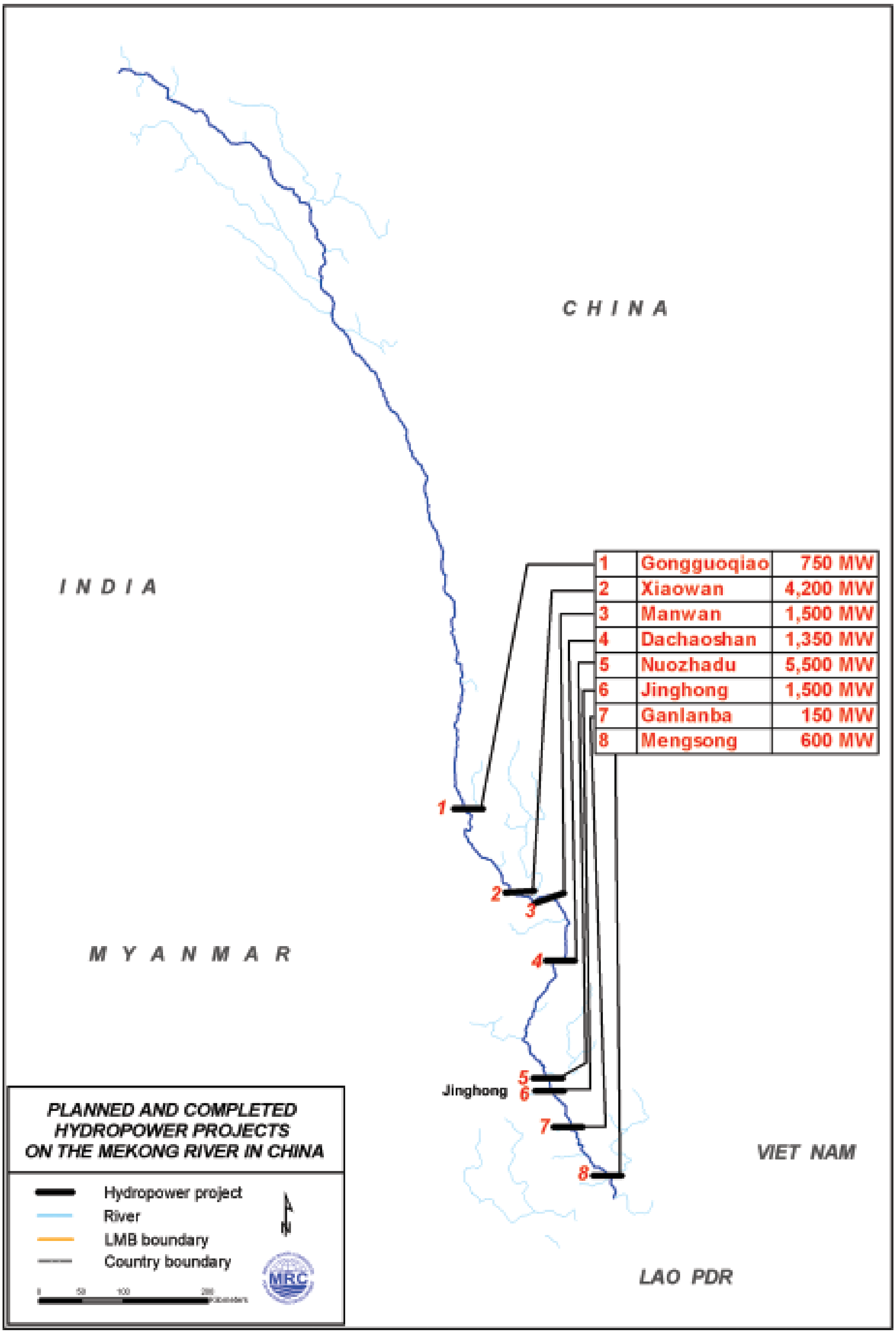
Dachaoshan Dam in China is the second of two large dams built on the Mekong mainstream in China. China is planning to build 6 more dams on the mainstream

To maximise the positive impacts and minimise the negative impacts from dams, they should be planned and operated in consultation with all countries in a river basin. Ideally such a scheme for consultation and rules for dam operation will be established by 2008-2009 – before the commencement of ponding in the Xiaowan reservoir.

Sharing data among countries on a common river system is crucial. The kinds of data that are required by countries downstream from planned hydropower projects include: information on real-time and scheduled dam operation (operation data for the power station, inflows, water level of the reservoir, discharges from the spillway, discharges to maintain river flow, utilisation of water for irrigation and domestic use). In order to exchange data on these subjects a system must be developed collaboratively among the countries concerned.

On 1 April 2002, China signed an agreement with MRC to provide data on river levels at two stations located on the Upper Mekong in China. Though the information provided by China is still limited, this agreement is an important first step in establishing cooperation between China and countries downstream.

Figure 2. Planned and completed hydropower projects on the Mekong in China



6. Implementation of hydropower development

From an economic point of view and for the benefit of the global environment, hydropower has much to offer in the Mekong Basin, provided that adverse social and environmental impacts are considered and mitigated. Ideally, in evaluating the benefits and consequences of hydro development, and in deciding how to manage the river's flow, all of the Mekong Basin's countries, including China, should be involved.

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Trade and transport 11

In the Lower Mekong Basin, water transport has traditionally been the principal means of travel for much of the population. Locating their communities on or near waterways has provided communities not only with an abundance of fish and fertile sediments for agriculture, it has also enabled them to trade with neighbouring communities up and down the river.

More than one third of the people living along the Mekong in Cambodia and Lao PDR live ten kilometres or more from a year-round road

Not only is waterway transport important for people living near rivers and streams in the basin, it is also becoming increasingly important for international trade. Although the 15 m high Khone Falls on the border between Lao PDR and Cambodia prevents boats from passing, above and below the falls, boats are used to transport both people and goods for hundreds of kilometres. As the economies of the LMB countries grow, not only will river trade between them increase, but shipping beyond the Lower Basin will grow as well.

Waterway transport has much to offer local communities living along the river, governments and those involved in large-scale trade and transportation. River transport can move people and cargo at costs that are lower than road and air transport and river facilities are less expensive to build and maintain than road and rail networks. If proper precautions are taken to protect the environment, river transport can be more environmentally-friendly than other forms of transport, both in terms of less intrusive infrastructure and with regards to fuel economy, which in turn results in less air pollution.

Although the advantages of river transport are numerous, government polices, plans, and spending priorities continue to promote road, rail and air transport over inland water transport (IWT). This is as true in the Lower Mekong Basin, as it is elsewhere in the world.

River transport can move cargo and people for lower costs than road or air transport

The chapter that follows discusses the following topics:

- passenger and cargo traffic on the waterways of the Lower Mekong Basin
- the contribution of river transport to poverty alleviation
- modal shares of inland waterway transport versus those of competitive transport modes
- navigational channels and inland ports
- the extent of IWT vessel fleets
- government transport policies related to IWT development
- conditions for increased international navigation
- environmental protection measures for IWT

Because data on inland waterway transport were extremely limited in the Lower Mekong Basin, this chapter is largely based on a study conducted by the MRC in April and May 2002. During this study a researcher visited all four lower basin countries to gather transport-related data. Although gathering this data was a challenge because in some countries IWT records are kept by individual ports and not necessarily passed on to the national government, sufficient data were collected to cover the above-listed topics.

Four main factors influence the extent to which the Mekong and its tributaries are used for transportation purposes. These are:

- economic and trade growth
- the availability of choices in type of transport and the strength of competition from other types of transport (most notably from road transport)
- physical restrictions, such as limitations on vessel draft, imposed by the maximum depth of water available in the dry season or (in the case of parts of the delta affected by tides) at low tide
- the non-physical (or institutional) barriers to international navigation

1. Importance of inland waterway transport to the remote communities in the Lower Mekong Basin

Throughout the Lower Mekong Basin, the Mekong and its tributaries provide poor communities with the means of getting to markets, health clinics and education services located in district or provincial centres. This is particularly true during the monsoon season when roads become impassable for months at a time. While the dependence of riverside communities[a] on inland waterway transport is gradually declining as a result of the on-going construction of new roads in the Lower Mekong Basin, more than one-third of populations living along the Mekong in Cambodia and on its tributaries in Lao PDR live further than 10-11 km from a year-round road (see Figures 1 and 2). For such communities, the river is the only means of transport.

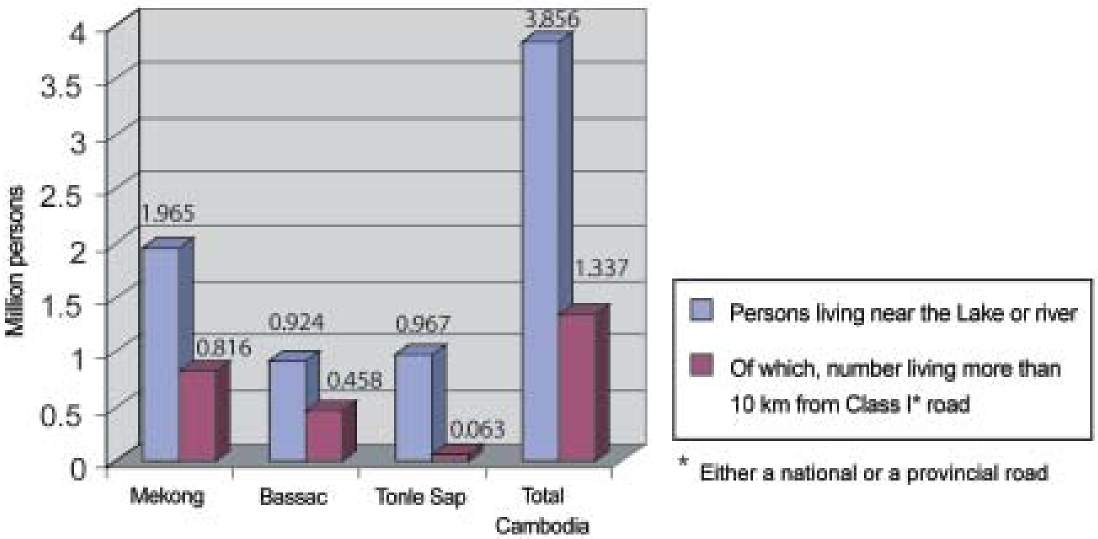
During the monsoon season, when roads become impassable, water ways are the only means transportation for millions of people

[a] For the purposes of this review, "riverside communities" are defined as those within 10-11 km of the Mekong River or one of its tributaries.

In Cambodia, only those living near a national or provincial road are likely to have year-round road transport because roads of lesser importance are rarely built for year-round use. Dependence on inland waterway transport in Cambodia is greatest along the mainstream of the Mekong River, rather than along its tributaries. This is because there are long stretches of the river, such as between Stung Treng and Kratie, which are relatively remote from national or provincial roads. Altogether, some 970 villages along the Mekong River and its tributaries, housing some 1.36 million Cambodians, are totally dependent on inland waterways for transportation.

By contrast in Lao PDR, with the possible exception of some stretches between Kenthao and Luang Prabang, the Mekong River runs close to all-season roads for its entire length.[b] For communities located along the Mekong's tributaries in Lao PDR, access is considerably more restricted, especially where (as is the case with the Nam Ou and the Se Kong), these tributaries pass through remote, mountainous terrain. The number of villages in Lao PDR estimated to be wholly dependent on inland waterways for navigation for most of the year is estimated at 915, with a population of about 320,000.

Figure 1: All-season road access for river populations in Cambodia



Sources: UN World Food Programme and Mekong River Commission, GIS data bases; Cambodia National Population Census 1998 and Cambodian Socio-Economic Survey, 1999

While road access data for the Mekong Delta region in Viet Nam were not available for this review, modal share data demonstrate the dependence of communities on IWT in the 12 main provinces of this region. Annually about 73 percent of the region's cargo tonnage and about 27 percent of its passengers travel by water.[c] In addition, the relatively short average distances for passenger trips on inland waterways in the delta (only 15 km), suggest that waterways are satisfying a crucial need of local communities for intra-district transportation. While it is likely that road building projects already underway will result in fewer passengers using the waterways, cargo transport is unlikely to decline. Cargo transport is dominated by rice exports and other trade in agricultural commodities. These use high-capacity bulk transport and transfer facilities of a type that cannot be provided by road operators.

[b] World Food Programme. 2001. Poverty Indicators. National Statistics Centre and State Planning Committee, Lao PDR, in collaboration with World Food Programme, Vientiane.

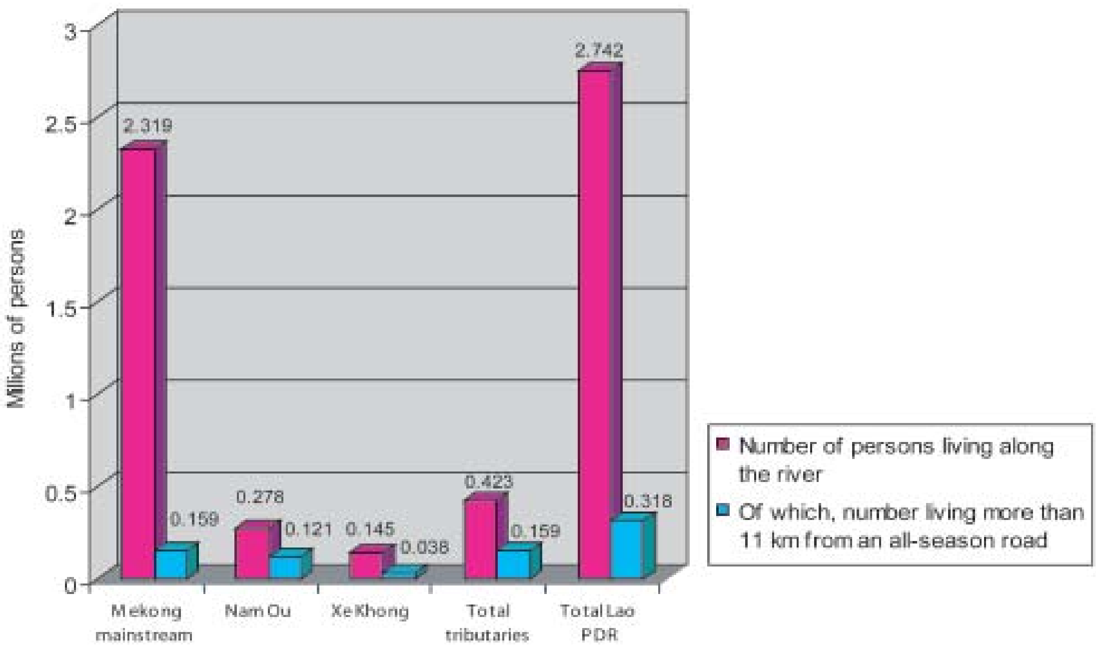
[c] Viet Nam National Statistical Yearbook, 2000 and information supplied by Viet Nam Inland Waterway Administration (Southern Branch) during MRC mission to Ho Chi Minh City, April 2002.

Of all member countries, Thailand alone has the benefit of a dense network of paved all-season roads running both parallel, and at right angles, to the Mekong River.

It should be emphasised that although the communities which benefit most from river transport are those which have no, or very limited, year-round access to other modes of transport, for many others, which do have better road access, boats still provide by far the cheapest means of transport. Thus, even poor communities with relatively good road access, are still likely to depend on the river to satisfy their basic transport needs.

In the Mekong Delta in Viet Nam about 73 percent of the region's cargo is transported by waterways

Figure 2: All-season road access for river populations in Lao PDR



Sources: UN World Food Programme (Lao PDR), GIS data base; Agricultural Census, Lao PDR, 1998

2. Contribution of river transport to poverty alleviation

Available evidence suggests that the poorest communities in the Mekong Basin are rarely located along the Mekong River and its tributaries. In Cambodia, for example, the poorest communities (those with more than 40 percent of the population below the poverty line) live some distance from the river.[d] Generally speaking, the communities along the Mekong River and its tributaries have less than 40 percent of their households below the poverty line (on average 25-40 percent).[e] The exceptions are the communities bordering the Tonle Sap River and Lake.

Another way of looking at this evidence is that the communities bordering the Mekong and its tributaries have already benefited economically from the river's attributes, whether they be related to water for irrigation, to fishery resources or to transport uses. As a result, they are considerably less poor than they would have been had they been remote from the river. While it is practically impossible to separate the benefits provided by these attributes, there is little doubt that the year-round transport capability provided by the river has contributed substantially to the economic well-being of its communities.

In the very few instances where riverside communities appear not to be realising the full economic benefits from use of the river for transportation (as appears to be the case with communities located along the Tonle Sap River and Lake), measures to improve benefits range from infrastructure improvements to reducing the burden of taxes and charges on boat operation.

In 2001, river trade between China and Lao PDR totalled $350 million.

[d] UNWFP *et al.* (February 2001), page 47.

[e] UN World Food Programme in cooperation with the Ministry of Planning, Cambodia and UNDP, *Identifying Poor Areas in Cambodia,* February 2001. In this study, "poor households" have been defined as those with consumption expenditure below the 54,050 Riel per month estimated as necessary to purchase a 2100 calorie food basket per day and to meet other minimal expenditures.

3. Trade benefits of river transportation

In 2001, trade valued at an estimated $4,700 million was transported in the LMB on the Mekong River and its associated waterways. This comprised trade between: Thailand and Lao PDR amounting to $350 million; between Thailand and China (Yunnan Province) worth $88 million; trade into and out of Cambodia, worth $235 million; and trade into and out of the Mekong Delta in Viet Nam (excluding trade with Cambodia) worth $4,000 million.[f]

As the only land-locked Lower Mekong Basin country, Lao PDR has realised substantial benefits from the use of the Mekong River as the principal conduit for its international trade flows. In 2001, the value of the export, import and transit trade flowing through that country's river customs checkpoints opposite Thailand is estimated to have amounted to $348.52 million, or 44 percent, of a total trade value of $795.49 million (see Figure 3).

During the wet season, about 1.3 million Cambodians living along the Mekong are totally dependent on the river and its tributaries for transport

River customs checkpoints account for an even greater share of the value of Lao PDR's exports – about 64 percent – since export flows tend to be dominated by logs, timber products and other agricultural commodities (such as coffee). All of these are well adapted to transport by river, but some can cause substantial damage to pavements if transported by road.

Four river customs checkpoints – Kenthao (opposite Loei Province of Thailand), Pakxan (opposite Beung Karn, Thailand), Thakhek (opposite Nakhon Phanom, Thailand), and Savannakhet (opposite Mukdahan, Thailand) account for more than 90 percent of the value and volume of all trade through Lao river checkpoints. However, in future, the continuing rapid growth of truck traffic over the Friendship Bridge (averaging 16 percent per annum over the past five years), coupled with the impending construction of a new bridge across the Mekong River at Mukdahan, is likely to cut sharply the value and volume of foreign trade passing through these river checkpoints.

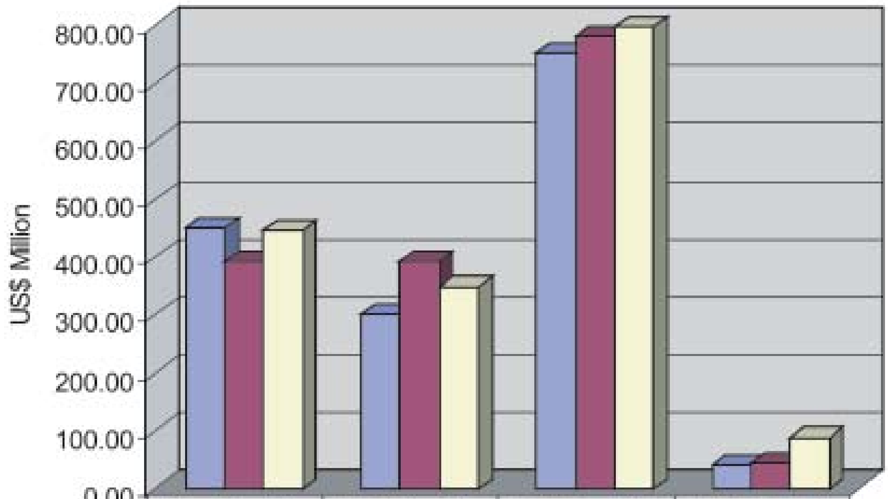
Although the advantages of river transport are numerous, LMB governments, like those worldwide, continue to favour road, rail and air transport

[f] Estimates by the author on the basis of CIF value data supplied by customs departments (Cambodia, Lao PDR,Thailand) and national statistical publications (Viet Nam).

Since for much of its passage through the two countries, the Mekong River forms the border between Thailand and Lao PDR, the value of the foreign trade moved on the river between these two countries is as much a measure of value to Thailand as it is to Lao PDR. In addition, in recent years, Thailand has been benefiting from use of the river to transport a growing proportion of its bilateral trade with Yunnan Province in China. This has been mostly through the Lower Mekong Basin ports of Chiang Saen and Chiang Khong. In a single year the value of this trade more than doubled, from \$43.21 million in 2000 to \$87.85 million in 2001.[g] It is likely that implementation by the Upper Mekong countries of the April 2000 Agreement on Commercial Navigation has had a major influence on this expansion of trade, which serves to demonstrate the speed and extent of trade benefits flowing to countries willing to make the necessary institutional adjustments to remove trade barriers.

Transport is constrained along much of the river because of limited depth in the dry season

Figure 3: Estimated value of trade (export, import and transit) passing through river and land border checkpoints of Lao PDR and Thailand, 1999-2001



	Thailand/Lao PDR (Road)	Thailand/Lao PDR (IWT)	Thailand/Lao PDR (Total)	Thailand/China (all IWT)
1999	448.84	301.90	750.75	40.30
2000	390.66	390.24	780.90	43.21
2001	446.97	348.52	795.49	87.85

Source: Customs Departments, Lao PDR and Thailand April –May 2002

[g] From data supplied by the Thai Customs Department, June 2002.

In the Mekong Delta in Viet Nam, 90 percent of exported rice and 60 percent of exported fruits and vegetables are transported to ports by inland waterways

In Viet Nam, some 90 percent of the export tonnage of rice and some 60 percent of the export tonnage of fruit and vegetables (fresh and processed) originates in the Mekong Delta and is transported by inland waterway vessels at least as far as Ho Chi Minh City and the main export ports on the Mekong and Bassac Rivers. The tonnage and value of export rice transported in 1999 on the waterways of the Mekong Delta was estimated at approximately 4.06 million tonnes and $1,800 million.[h] Corresponding estimates of the volume and value of fresh and processed fruit and vegetable exports in the same year were 63,000 and $63 million respectively. Thus, the combined value of agricultural exports moved by inland waterway vessels in the Mekong Delta can be estimated at nearly $2,000 million annually. If this figure was augmented by the value of other export commodities and by the value of the sizeable import volumes moving into the region, it is not inconceivable that the total value of the trade being moved annually on the waterways of the Mekong Delta could amount to $4,000 million, or nearly 20 percent of the country's overall foreign trade value.

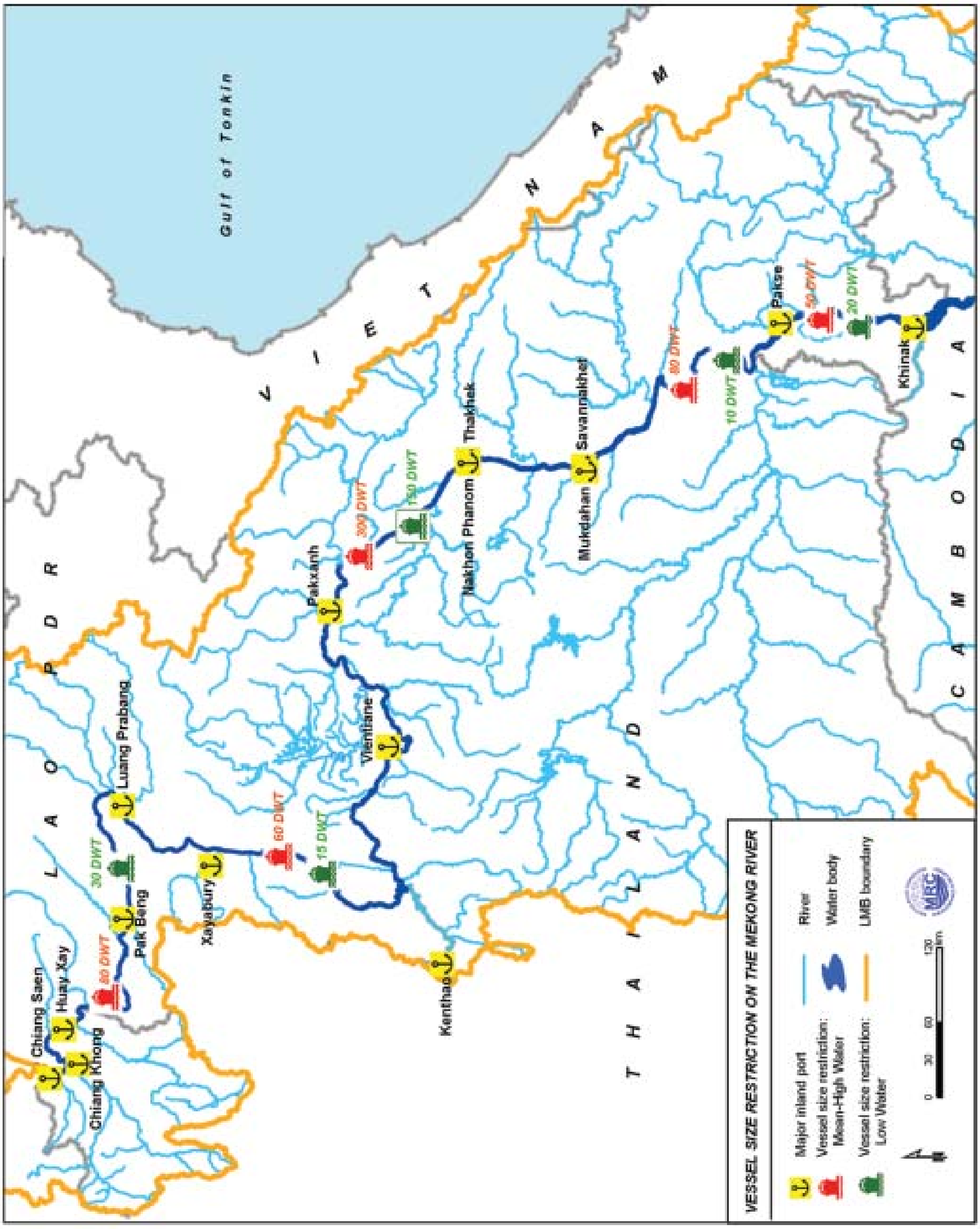
4. River navigation conditions

Unlike some of the world's great waterways, the flow and depth of the Mekong is essentially unregulated. This means that the passage of vessels along much of the river is constrained by the limited depth of water available in the main navigation channels during the dry season, and in the estuaries during low tide. Infrastructure for navigation along the river is otherwise limited to dredging at a very few locations, bank protection, the provision of landing and cargo handling facilities at inland ports, and the installation of navigational aids.

All sections of the Mekong River and its associated waterways are navigable during the high water season (i.e. for about eight months of the year), with the exception of a 14-km section, just north of the border between Cambodia and Lao PDR, which contains the impassable barrier of the Khone Falls. Of the remaining sections, one (of 261 km between Savannakhet and Pakse) is only navigable during the low water season by vessels smaller than 10 dead weight tonnes (DWT), and several other sections are navigable at low water with lesser (but still severe) restrictions on vessel size.

[h] Estimates by the author based on export volume and value data taken from the Viet Nam National Statistical Yearbook, 2000.

Figure 4. Vessel size restriction on the Mekong River - Lao PDR and Thailand



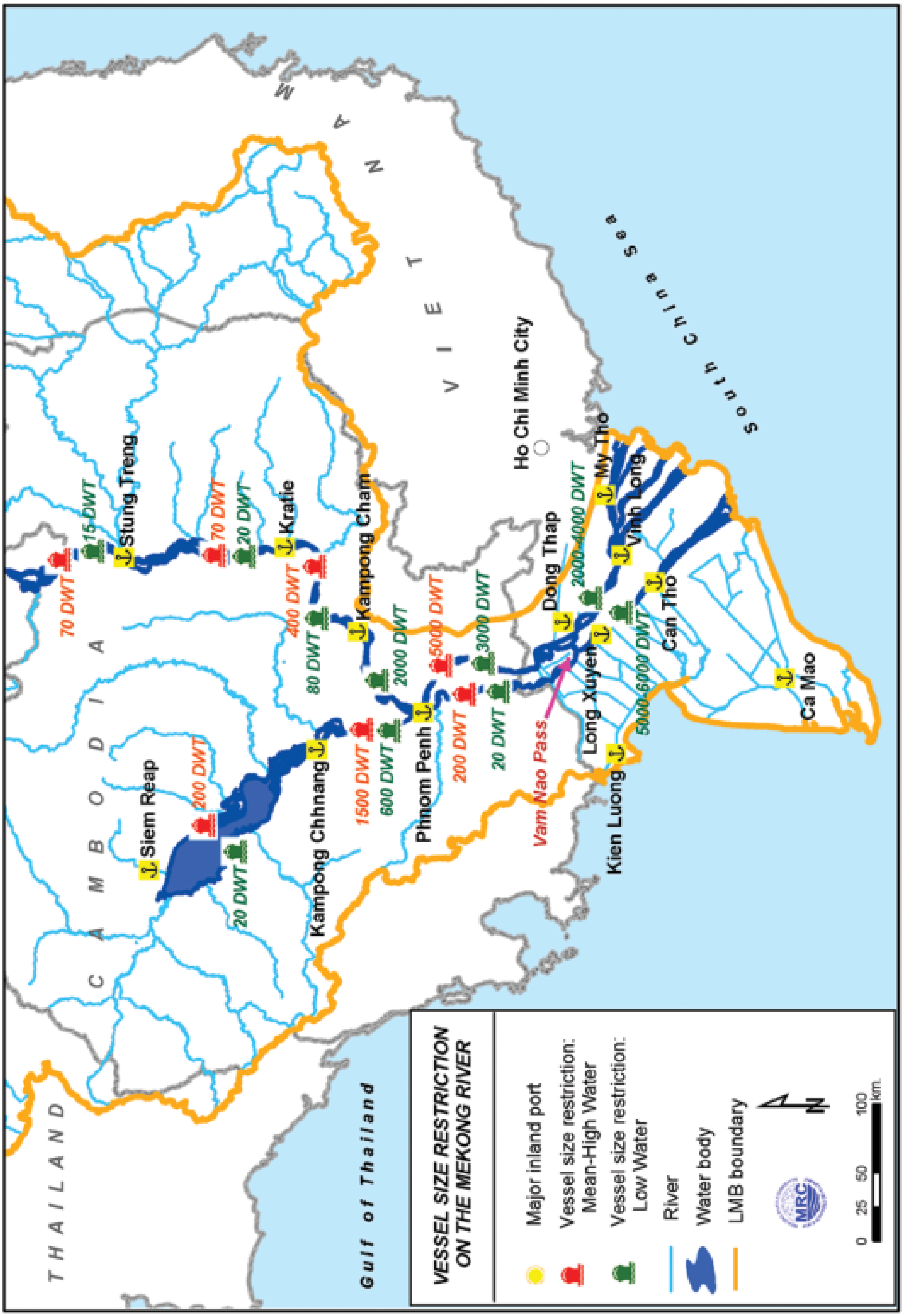


Figure 5. Vessel size restriction on the Mekong River - Cambodia and Viet Nam

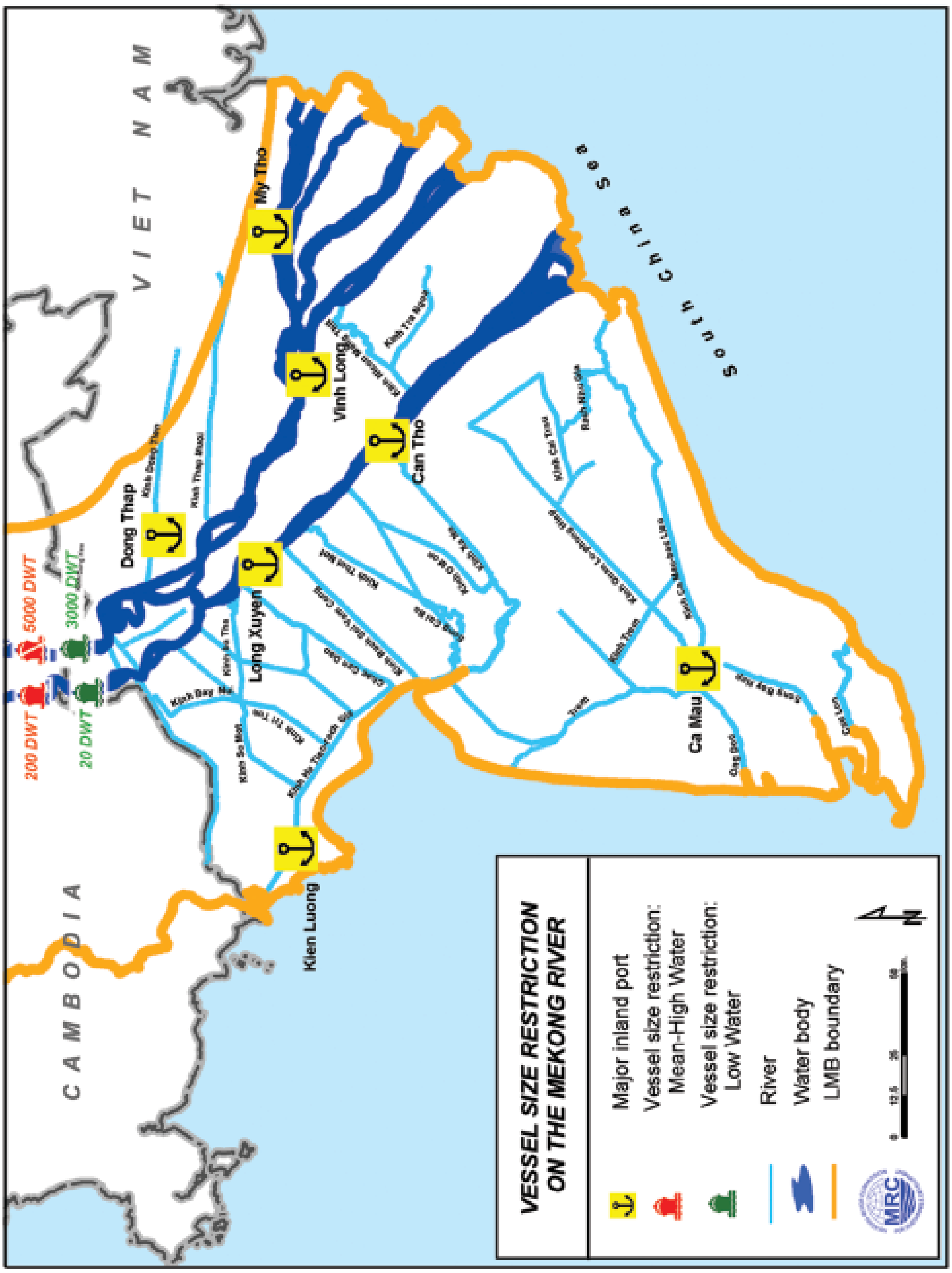


Figure 6. Vessel size restriction on the Mekong River - Viet Nam Delta

5. Inland ports and intermodal connections

Port facilities along the Mekong and its tributaries range from crude, makeshift landings formed by boats moored side by side against the river bank, to concrete ferry ramps (as in Lao PDR and Thailand), to purpose-built concrete quay structures equipped with modern cargo handling technology. Port infrastructure is at its most sophisticated level in the Mekong Delta in Viet Nam, where five maritime bulk-handling ports (three on the Mekong River and two on the Bassac River) share with the ports of Ho Chi Minh City the task of consolidating and dispatching 90 percent of Viet Nam's annual exports of rice. Among these ports is Can Tho (located on the Bassac River about 80 km upstream of the estuary), which has been designated for expansion and improvement under the World Bank's "Viet Nam Inland Waterways and Port Modernization Project". As part of this project, Can Tho Port is being equipped with high capacity cargo handling equipment, including mobile cranes for the lifting of containers.

Twenty-three of the 25 major ports in the Lower Mekong Basin (four in Thailand, eight in Lao PDR, six in Cambodia and seven in Viet Nam) are connected to main (either national or provincial) roads. The only exceptions are two ports located between Vientiane and Luang Prabang. However, the density of the main road networks in the vicinity of ports varies widely. It is densest in Thailand, and least dense in Lao PDR and Cambodia. In the Mekong Delta in Viet Nam, the low-lying and swampy nature of the terrain has, until recently, imposed a barrier to the expansion and improvement of the main road network. This has been recognised as a major impediment to the development of rural and industrial communities in the delta. Thus, a World Bank-funded project is now underway to remove this impediment by upgrading segments of Highway 1, as well as national and provincial roads in the delta provinces.[i] This project may be expected to contribute significantly to improving the intermodal linkages of several delta ports, including Can Tho.

The World Bank is assisting with the improvement of Can Tho Port in Viet Nam

[i] PO42927 Mekong Transport and Flood Protection Project (approved on 20 December 2000, for completion by 30 June 2006).

6. Growth and composition of inland waterway vessel fleets

Much of the available data on the growth and composition of the inland water transport vessel fleets of the LMB member countries were incomplete, inconsistent and unreliable. In Cambodia, in particular, the lack of any central control over boat licensing, meant it was not possible to identify in national statistics the fleets of small boats registered and licensed in the provinces.[j] Notwithstanding the data deficiencies, it was possible to develop a limited picture of fleet growth and composition in the four LMB member countries.

At the end of 2000, the IWT fleet of Lao PDR totalled 1098 boats, of which 405 (37 percent) were cargo or multi-purpose boats and 693 (63 percent) were passenger-carrying boats. Over the past five years, there has been little change in the size of the overall fleet. More than two-thirds of the cargo-carrying fleet was comprised of boats with a deadweight tonnage of 10 or less, reflecting a requirement for the operation of small boats during the dry season, especially for the stretch of the river between Vientiane and Luang Prabang. About half of the passenger boats had less than 16 seats, but those with 16-50 seats accounted for nearly one third of the passenger-carrying fleet.

The IWT fleet in the Thai portion of the Lower Mekong Basin has been stable for the past five years, numbering 110 vessels (55 passenger, 35 cargo and 20 multi-purpose passenger and cargo vessels). The majority of vessels are of less than 30 DWT, but several large flat-topped barges of 200-300 DWT operate as vehicle-carrying ferries from Beung Karn, Nakhon Phanom and Mukdahan ports to Laotian ports across the river. The relatively small size of the Thai fleet reflects the negligible use of the river for domestic transport.

According to a study conducted in 2002, 37 percent of river traffic were cargo vessels and 63 percent carried passengers

In Cambodia, the number of centrally-registered vessels as of 30 November 2001, totalled 593, including 127 dry cargo boats, 226 combined passenger/cargo and express boats, 24 tankers, 93 tugboats, 90 barges and pontoons, 8 ferries and 25 service boats. It is understood that there has been little or no growth in this fleet over the past five years. No breakdown of this fleet by deadweight tonnage was available.

As of 30 April 2002, the registered inland waterway fleet of the Mekong Delta in Viet Nam numbered 57,791 vessels. This fleet was reported to have nearly doubled in size since 1997.[k] More than three-quarters of the fleet comprised motorised or non-motorised barges of between 200-1500 DWT. Passenger vessels (licensed to carry 20-150 passengers), numbered 7,519 units, or 13 percent of the registered fleet. Not included in the fleet data provided by the Viet Nam Inland Waterways Administration were some 350,000 small "country" boats, mostly of 10-20 DWT, which operate on the waterways of the Mekong Delta under private ownership. Details of this "country boat" fleet could not be reported as registration processes are decentralised and it is understood that only 45 percent of the fleet is, in fact, registered.

[j] In Cambodia, all boats except those with an engine power rating of more than 90 HP are inspected, registered and taxed by the provinces in which they are based. Only the latter group is inspected, registered and taxed by the Ministry of Publics Works and Transport in Phnom Penh.

[k] Source, Viet Nam Inland Waterways Administration (Southern Division), during MRC mission, April 2002.

Figure 7. Modal Linkages in the Lower Mekong Basin

7. IWT traffic and modal share analysis

The LMB line agencies largely lack comprehensive and up-to-date records of passenger and cargo traffic plying the river and its associated waterways. As a result, estimates of traffic volumes had to be made from a variety of different sources. In some member countries (notably in Lao PDR and Cambodia), much of the authority for vessel licensing and port operation has been decentralised to provincial offices, and with it, the responsibility for record-keeping. In most cases, records are manually maintained and provincial staff are under no obligation to submit returns on a regular basis to line agency head offices.

In the case of Cambodia, not only was there an absence of reliable and consistent data on IWT passenger and cargo flows, but information on traffic flows for some other transport modes was also practically non-existent. For example, data on road traffic flows were unavailable, because traffic counts have not been undertaken on the main roads since 1996. For the purposes of this study, road traffic was estimated from vehicle crossing data supplied by the three main ferry operators in Cambodia, at Prek Kdam, Tonlebet and Neak Luong. While this data covered long distance traffic on Highways 1,5, and 7, it did not cover traffic on Highway 4, which is likely to be substantial. Nor did it cover short-distance traffic on the major highways, which does not use the ferries. For these reasons, the estimates of road traffic flows are likely to understate significantly the actual volumes of passenger traffic moving on the main road system.[1]

Estimates of passenger and cargo traffic volumes and modal shares for all transport modes operating in the LMB indicate that only in the case of the Mekong Delta in Viet Nam has IWT achieved dominance over other transport modes, and then only for cargo transport (Table 2). Recently, however, IWT passenger and freight volumes in Lao PDR have begun to increase, albeit from a low base. The declining trend in IWT passenger volumes for all countries, except in Lao PDR, reflects the impact of an expansion of the region's main road networks. A negative impact on passenger volumes carried by inland waterway vessels in Lao PDR must also be expected, both as a result of the ongoing improvement of the main road network, and of the impending construction of a new bridge across the river between Mukdahan (Thailand) and Savannakhet (the second largest city in Lao PDR).

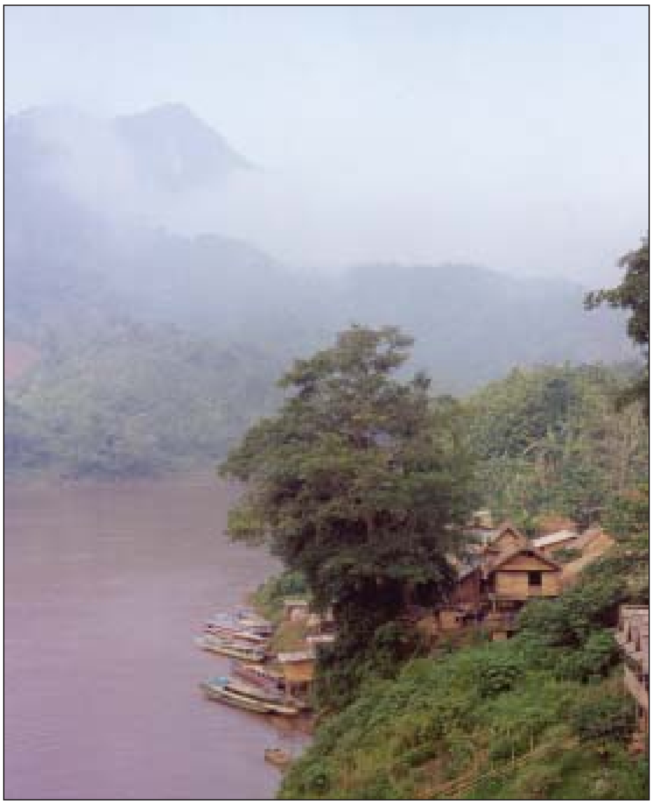
River transport facilities are less expensive to build and maintain than road and rail facilities

Despite road network improvements in the vicinity of the major ports of the Mekong Delta in Viet Nam, it is unlikely that the IWT mode will lose its dominance of cargo transportation in that region, due mainly to the advantages of IWT for bulk cargo movement.

[1] However, if this omission could be rectified, it would have little practical effect on IWT mode shares, which are already very low (at about 1.1 percent of traffic carried by all modes in Cambodia during the reference year of 2001).

Of the four LMB member countries, only Thailand does not make significant use of the river and its associated waterways for domestic transport. This may be attributed to the high density of the network of all-season roads linking all major and minor population centres along the river in Thailand. The presence of flexible, convenient and relatively fast road transport alternatives throughout the basin area in Thailand has meant that IWT is now used only where such alternatives are unavailable, such as for cross-river (and cross-border) traffic at locations not yet connected by a road bridge. Data collected from Thai customs and immigration offices in the LMB show that road vehicles crossing the Friendship Bridge between Nong Khai (Thailand) and Tarnaleng (Lao PDR) now account for 88 percent of all passenger traffic, and 55 percent of all cargo traffic, between Thailand and the PDR. The share of road transport in this cross-border traffic will inevitably increase as soon as the planned bridge connecting Mukdahan with Savannakhet is available for service in about 2005.

Cargo traffic between Simao (Yunnan Province of China) and the Thai ports of Chiang Saen and Chiang Khong has recently been growing at a very rapid rate (40 percent per year), but the tonnages carried still represent a very small share of the total volume of trade between Yunnan Province and Thailand. The bulk of this traffic is distributed by shipping services through Chinese coastal ports and from there by rail and road to Kunming. Thus, there is a major opportunity for water transport to use its cost advantage to increase its share substantially.



Remote communities in Lao PDR depend on water transport

Table 1 : Traffic flows, by mode, in the Lower Mekong Basin

Traffic category/ Country	Volumes						Shares (%)				
	IWT		Road	Rail	Air	Total	IWT	Road	Rail	Air	Total
	Vol.	Av. annual growth %*									
Passenger traffic											
Mill. passengers -2001											
Lao PDR, domestic	1.8	9.1	19.1	-	0.5	21.4	8.4	89.3	-	2.3	100.0
Th.-Lao PDR –Th.	0.2		1.6			1.8	11.1	88.9			100.0
Cambodia	0.3		23.6	0.2	0.2	24.3	1.1	97.1	0.9	0.9	100.0
Viet Nam (Mekong Delta)	86.0	-1.9	230.0			316.0	27.0	73.0	-	-	100.0
TOTAL – LMB	88.3		274.3	0.2	0.7	363.5	24.4	75.4	-	0.2	100.0
Mill. pass.-km -2001											
Lao PDR, domestic	72.8	11.2	1423.7	-	178.3	1674.8	4.3	85.1	-	10.6	100.0
Th.-Lao PDR –Th.	0.5		3.3			3.8	13.2	86.8			100.0
Cambodia	54.3		2365.3	32.4	48.7	2500.7	2.2	94.6	1.3	1.9	100.0
Viet Nam (Mekong Delta)	1292.1	-1.5	6049.0	-		7341.1	17.6	82.4	-	-	100.0
TOTAL - LMB	1419.2		9838.0	32.4	227.0	11520.4	12.4	85.3	0.3	2.0	100.0
Cargo traffic											
Mill. metric tonnes *-2001*											
Thailand-China-Thailand	0.4	40.1				0.4					
Lao PDR, domestic	0.7	6.9	1.5	-	-	2.2	31.8	68.2	-	-	100.0
Th.-Lao PDR -Th.	1.5		1.8	-	-	3.3	45.5	54.5	-	-	100.0
Cambodia	0.5	-6.4	2.1	0.4	-	3.0	16.7	70.0	13.3	-	100.0
Viet Nam (Mekong Delta)	21.8	7.4	8.0	-	-	29.8	73.2	26.8	-	-	100.0
TOTAL – LMB	24.9		13.4	0.4	-	38.7	64.3	34.6	1.1	-	100.0
Mill. tonne.-km -2001											
Thailand-China-Thailand	200.0	40.1				200.0					
Lao PDR, domestic	58.9	16.8	162.2	-	0.6	221.7	26.6	73.1	-	0.3	100.0
Th.-Lao PDR –Th.	2.9		3.6	-	-	6.5	44.6	55.4	-	-	100.0
Cambodia	53.2	-6.7	488.0	108.3	-	649.5	8.2	75.1	16.7	-	100.0
Viet Nam (Mekong Delta)	2316.5	7.5	652.0	-	-	2968.5	78.0	22.0	-	-	100.0
TOTAL - LMB	2631.5		1305.8	108.3	0.6	4046.2	65.0	32.3	2.7	-	100.0

Note: Data for Lao PDR domestic traffic are for the Year 2000. Average annual rates of growth were computed for IWT traffic over the past five years.

Sources: MRC missions to member countries, April-May 2002; National statistical yearbooks for 2001

8. Government transport policies and IWT development

A study undertaken in 1982 for the Congressional Budget Office of the US Congress concluded that inland barge transport was at least three and a half times more energy efficient than truck transport, and 1.7 times more energy efficient than rail transport.[m] These conclusions were reinforced by other studies undertaken in the United States of America during the 1970s and 1980s, which found even greater margins of advantage for inland waterway transport in terms of energy consumption.[n]

While the relative energy efficiency and other cost advantages of inland waterway transport have yet to be fully investigated and confirmed for the Lower Mekong Basin, there is no reason to expect that IWT in this region would not enjoy the same, or even greater, advantages over land transport as those recorded in the United States. However, there is evidence that the economic advantages of IWT may not be properly reflected in the comparative commercial charges of IWT and road transport operators in some areas of the Lower Mekong Basin. In fact, information provided by the Ministry of Communication, Transport, Post and Construction in Lao PDR suggests that in some cases, charges made by IWT operators are three times the applicable road transport charges for the same traffic.

To some extent, this may be due to distortions in government charges which fail to recover the full cost of providing road infrastructure from truck operators, while also penalising boat operators who are obliged in all LMB countries to contribute to road development funds, through their payments of fuel tax.[o] Boat operators in some LMB countries, notably in Lao PDR, may also be prevented from realising maximum commercial advantages from their operations because during the low water season, they must operate small boats with a payload capacity smaller than that of a ten-wheel truck (but without a commensurate reduction in operating costs).

What is reasonably clear, is that in all LMB member countries, government transport expenditure priorities consistently fail to recognise the environmental and economic advantages of the IWT mode. A comparison of government capital and operating expenditures on inland waterways and roads during the most recent five-year period for which data were available, shows that in three of the four LMB countries, inland waterways attract less than 1.5 percent of all expenditure on both modes. This comparison is shown in Table 2.

With World Bank funding, two major canal routes in Viet Nam are being dredged to a depth of three metres, allowing operation of barges of 500 DWT

[m] Congressional Budget Office, US Congress, *Energy Use in Freight Transportation*, Washington DC, February 1982, page 10.

[n] Mooz, W.E., *The Effect of Fuel Price Increases on Energy Intensiveness of Freight Transport,* Rand Corporation , Santa Monica, CA, December 1971 and Eastman S.E., *Fuel Efficiency in Freight Transportation,* The American Waterway Operators Inc., Arlington, VA, June 1980.

[o] In Lao PDR, for example, government tax revenue represents 28 percent of the pump price of diesel fuel in Vientiane (about 2,635 Kip or about US 30 cents per litre), including a direct “road fund” contribution of 40 Kip per litre. *[Information obtained during an MRC mission to Vientiane in April 2002]*

Table 2: Five-year capital and operating expenditure allocations by governments

Country	Inland waterways		Roads		Total (two modes)	
	5-year expenditure (US$ million)	***Share(%)***	5-year expenditure (US$ million)	*Share(%)*	5-year expenditure (US$ million)	*Share(%)*
Cambodia	0.411	***1.2***	34.024	98.8	34.435	100.0
Lao PDR	0.314	***0.3***	121.425	99.7	121.739	100.0
Viet Nam	33.233	***1.3***	2,584.333	98.7	2,617.566	100.0

Notes: Cambodia data are for the five-year period 1997-2001; Lao PDR data are for the five-year period 1996-2000 (fiscal years commencing 01 October); and Viet Nam data are for the five-year period, 1995-1999, but purport to include only capital expenditures.

Sources: National Statistical Yearbook, Viet Nam, 2000; MRC missions to LMB member countries, April-May 2002

Data for Thailand were not included in this table, because it is understood that the section of the Mekong River for which Thailand has responsibility, attracts only a small share of national expenditure on inland waterway development and maintenance. Therefore, the inclusion of national data is unlikely to be representative of expenditure allocations at the LMB level.

Nevertheless, it might be reasonable to conclude that the Mekong River in Thailand attracts a share of expenditures that is significantly less than 1 percent of the total amount expended on roads and inland waterways combined. It is important to note that if it were possible to include in Table 2 expenditures allocated to other modes, such as railways and air transport, the inland waterway expenditure shares would be even lower than indicated in the table.

Data indicate that not only are expenditure allocations disproportionate to the economic “worth” of IWT, but also that they are disproportionate to IWT’s share in the national transport figures of all LMB member countries (Table 2). For example, the river and its associated waterways are estimated to carry 73 percent of all cargo tonnage in the Mekong Delta Region of Viet Nam, 45 percent of all cargo tonnage between Thailand and Lao PDR, 31 percent of all cargo tonnage within Lao PDR and 17 percent of all cargo tonnage within Cambodia.

Unless LMB governments commit a higher level of funding for essential river works, especially for dredging of some dangerous spots, bank protection, port improvement, installation of aids to navigation, and establishing navigation training, it will be difficult for the IWT sector to maintain its significant role in cargo transport. Similarly, a more realistic funding approach, which in reality requires nothing more than a re-ordering of mode funding priorities, will be necessary for the IWT sector to establish a significant role in passenger transport (especially in tourist transport).

9. Support by international agencies for transport network improvement in the LMB

The two main international development funding agencies are implementing major transport infrastructure improvement projects which will have a significant impact on the development of an integrated transport network within the Lower Mekong Basin.

The Asian Development Bank, through its Greater Mekong Subregion Programme[p], is funding the improvement of two international highway links:

- Highway 9, forming part of the GMS East-West Corridor linking Northeast Thailand through Lao PDR to Danang Port in Viet Nam (this project involves the improvement of 78 km in Lao PDR and 83 km in Viet Nam, for an estimated cost of $67 million)

- The highway linking Phnom Penh in Cambodia with Ho Chi Minh City in Viet Nam (involving the improvement of 105 km in Cambodia and 80 km in Viet Nam, for an estimated cost of $125 million)

Coupled with ADB support for rural road improvement projects in Lao PDR and Cambodia, as well for construction of the R3 missing road link in the GMS Northern Economic Corridor (Kunming-Chiang Rai), these projects will improve the road linkages of inland ports, throughout the LMB.[q]

The World Bank is implementing a number of projects, which may also be expected to enhance the intermodal linkages of the inland waterway system in the Lower Mekong Basin. They include:

- The *Viet Nam Inland Waterway and Port Rehabilitation Project*, involving dredging of two major canal routes, expansion of vertical clearances under five bridges, port improvements at Can Tho and Ca Mau, installation of navigational aids throughout the Mekong Delta, and evaluation of alternatives for deepening the Bassac River Estuary. This project is being implemented over the period April 1997-June 2003, at a cost of about $85 million.

ADB and the World Bank are enhancing the intermodal linkages in the LMB

[p] for more information on ADB/GMS, see Chapter 15 on Cooperation.

[q] The R3 missing link between Boten on the China/Lao PDR border and Huayxay on the Mekong River in Lao PDR, forms part of what is known as the GMS Northern Economic Corridor.

- The *Mekong Transport and Flood Protection Project* in Viet Nam, involves, among other things, the upgrade of 180 km of Highway 1 between Can Tho and Ca Mau and another 182 km of national and provincial roads throughout the Mekong Delta. The estimated cost of this project is $144 million, and it is being implemented over the period December 2000-June 2006. Significantly, the upgrading of Highway 1 will include strengthening of highway bridges to accept 30 tonne gross vehicle weights, which will be necessary to permit the passage of container-carrying semi-trailer vehicles.

- Two projects in Lao PDR , the *Third Highway Improvement Project* and the *Provincial Infrastructure Project*, aimed respectively at reconstruction of 230 km of Highway 13 between Savannakhet and Pakse, and the provision of year-round road access to villages in the remote northern provinces of Oudomxay and Phongsaly. These projects are being implemented by December 2003 and November 2006, respectively, at costs estimated, respectively, at $69 million and $28 million.

- A *Road Rehabilitation Project* in Cambodia, involving upgrading of 89.3 km of National Road 6 and of 21.5 km of National Road 3, as well as rehabilitation of urban streets in Phnom Penh and Sihanoukville and institutional strengthening and capacity building. This project is being implemented over a five-year period, between 1999 and 2004, at an estimated cost at $48 million.

The World Bank's Viet Nam Inland Waterway and Port Improvement Project can be expected to result in substantial improvements to navigation in the Mekong Delta.

The two major canal routes, Ho Chi Minh City to Kien Luong and Ho Chi Minh City to Ca Mau are being dredged to a minimum three metre depth, allowing the operation of 500 DWT barges (up from 200 DWT currently).

The ports of Can Tho and Ca Mau are being provided with modern, high capacity cargo handling equipment, including that for handling containers.

If institutional impediments are removed, Phnom Penh Port could capture a large share of cargo bound to eastern Asia

The Bassac Estuary is subject to a high rate of siltation and a tidal variation of 2.5-3 metres. At low water depth (3.6 metres), vessels of only 3,000 DWT can pass through the estuary, but the extra 3 metres of the high tide allows vessels of 6,000 -7,000 DWT to enter. However, the government of Viet Nam is committed to improving access to the port of Can Tho and wants to allow vessels of between 10,000 and 20,000 DWT to enter the Bassac River. This is likely to involve the construction of a channel to by-pass the estuary, which cannot provide stable conditions for navigation. Subject to its satisfactory financial and economic justification, there is a strong possibility that the World Bank will take a leading role in the development of this project. Significantly, one of the major benefits of the project will be to allow sea-going vessels to proceed as far as Phnom Penh using the Bassac River (and the Vam Nao Canal to the Mekong River). This, coupled with other measures, will result in the removal of all physical and non-physical obstructions on this transit route.

10. Potential for operational linkage of IWT with other transport modes

The increasing demand for transportation of heavy commodities such as logs and construction materials is beginning to pose major problems for road maintenance, especially in Lao PDR and Cambodia. With limited road infrastructure, both countries can ill afford to have their road surfaces severely damaged by overloaded trucks. However, such threats translate into opportunities for IWT, since boats are able to take over the linehaul transport of heavy commodities from trucks without the necessity of upgrading either the capacity of boat fleets or of existing port infrastructure.

In Lao PDR, one such opportunity could involve the integration of road and inland waterway transport in the movement of cement traffic, amounting to more than 350,000 tonnes per year. Two plants recently constructed under joint Chinese/Lao ownership at Vang Vien, about 150 km north of Vientiane, have the capacity to produce up to 375,000 tonnes of cement annually, equivalent to the entire national demand for cement. However, as a result of the poor condition of the national highway network (and consequently extended truck cycle times), the company operating these plants has been unable to secure sufficient trucks to transport cement. A solution to this problem could involve trucking the cement about 80 km to a port on the Mekong River, and then completing distribution to Vientiane, Luang Prabang and Savannakhet by boats, each with a minimum capacity of 50 DWT. The economics of this type of integrated transport operation would be enhanced by the possibility of back-hauling limestone from Savannakhet (a major source of supply for the cement plants).[r]

11. Potential for increased international navigation

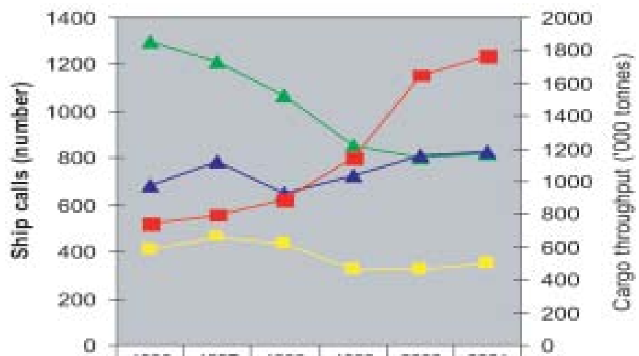
The adoption in 2001 of a harmonised system of aids to navigation on the Mekong River and its associated waterways, developed jointly by the United Nations Economic and Social Commission (ESCAP) and the Mekong River Commission, will remove at least one significant barrier to international navigation within both the Upper and Lower Mekong Rivers.

There appear to be few, if any, difficulties of an institutional nature impeding international navigation between China and Thailand (affecting the ports of Chiang Saen and Chiang Khong in the LMB), nor, for that matter, between Thailand or Lao PDR, since existing transit agreements between these countries have been in force for many years. Between Lao PDR and Cambodia, navigation is prevented by the physical obstacle of the Khone Falls. However, between Cambodia and Viet Nam, international navigation continues to be restricted by a delay in realising an agreement on protocol terms.

Apart from institutional impediments, there should be no reason why the port of Phnom Penh should not capture a major share of international cargo traffic originating from, or bound for, countries to the northeast of Cambodia, especially China, Japan, the Philippines and the Republic of Korea as well as to and from Singapore and Viet Nam. If such traffic is to be distributed instead through Sihanoukville Port, a distance penalty of 490 km will be incurred. Currently, the direct river journey takes about the same time as a journey to Sihanoukville, but this is due to a prohibition on navigation of the river by night, as well as to delays associated with border crossing formalities. Elimination of these river transit delays would result in a time saving of at least 12 hours for the direct river journey over the Sihanoukville option.

[r] From information supplied by the Ministry of Commerce, Lao PDR, during the MRC mission to Vientiane during April 2002.

Figure 8: Comparative traffic growth of Phnom Penh and Sihanoukville ports



	1996	1997	1998	1999	2000	2001
Ship calls, Phnom Penh	1296	1213	1069	850	803	820
Ship calls, Sihanoukville	686	784	650	726	814	825
Cargo throughput, Phnom Penh	584.7	658.4	619.6	458.7	468	503.3
Cargo throughput, Sihanoukville	741.3	794.3	884.9	1140.9	1641.8	1763.6

Sources: Phnom Penh Autonomous Port and Sihanoukville Port Authority

Yet, as may be observed in Figure 4, the robust traffic growth of Sihanoukville over the past five years (+3.8 percent per year for ship calls and +18.9 percent per year for cargo throughput) is in stark contrast with the declining traffic growth registered by Phnom Penh over the same period (–8.7 percent for ship calls and –3.0 percent for cargo throughput). It is possible that these widely divergent growth outcomes may have been due in part to Sihanoukville Port capturing some of the trade flows which, in the absence of transit delays (and possibly, punitive transit charges) on the river route, might have been directed to Phnom Penh Port.

A key element in the reduction of border crossing delays on the river route is the bilateral agreement on waterway transport between Cambodia and Viet Nam, signed in December 1998. This agreement is significant in that it, and its associated protocol, limit to two the number of places at which vessels are required to stop for completion of customs and other border-crossing formalities – Vung Tau in Viet Nam and Phnom Penh Port in Cambodia. Another agreement dealing with Transit of Goods between Cambodia and Viet Nam, was signed in September 2000. Previously there were four such stopping places, including the official border checkpoints of Vinh Xoung in Viet Nam and Kaom Samnor in Cambodia. Unfortunately, owing to delays in the resolution of differences between the two governments regarding the list of prohibited transit goods, the agreement has yet to be put into full operation. Its early implementation is becoming a matter of concern, since some new international traffic opportunities – including a tourist passenger boat service between Siem Reap and Ho Chi Minh City – are being delayed by the absence of an enforceable agreement between the two countries.

Vietnamese customs officers on drug patrol in the Mekong Delta

More effective use of the Mekong river system as an international transit route will materialise when both countries can benefit. One of the factors influencing such development will be the strong possibility that international shippers will make greater use of the economic trade potential made possible by the triangle of Ho Chi Minh City, Phnom Penh and Can Tho Ports.

12. Navigation and the environment

12.1 Environmental Impacts of inland water navigation

Of the four governments of the Lower Mekong Basin, Thailand appears have the strongest regulations to deter boat and port operators from discharging fuel or other liquid or solid waste matter into waterways or onto adjoining land. In Thailand, the Harbour Department has authority under its enabling legislation to issue fines for those who spill foreign matter into waterways. However, a number of ports along the Thai side of the Mekong are not owned and managed by the Harbour Department, but instead by provincial government authorities. Thus the Harbour Department does not have the power to prosecute all the infringements that could occur.

While there have been no reports of major spills, research[s] indicates that no agency has the possibility of rapidly mobilising the trained personnel and specialised equipment needed to clean up after a spill. Only in Thailand and Viet Nam do the relevant line agencies have the necessary personnel and equipment, but they are located in Bangkok and Ho Chi Minh City, some 600-700 km and some 150 km, respectively, from the main waterways of the Lower Mekong Basin.

Provision of specialised port facilities would reduce the risks posed by ships and barges carrying petroleum and other potentially-dangerous cargo

In Viet Nam, all new projects involving dredging or development of infrastructure, in and beside waterways, are now required to undergo an environmental impact assessment (EIA). In Thailand, EIAs are required for port development projects designed to handle vessels of greater than 500 DWT, which would seem to exempt most, if not all, port development projects likely to proceed along the Mekong River in Thailand. In Cambodia and Lao PDR, there appears as yet to be no requirement for EIAs to be completed for inland waterway projects.

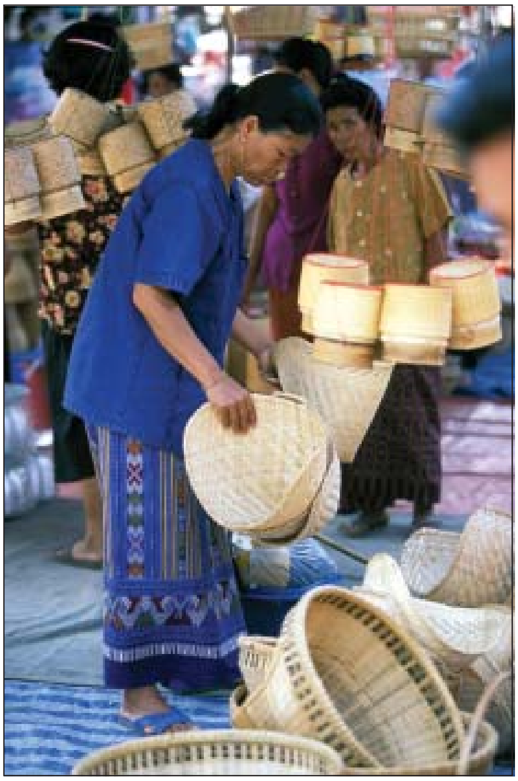
Better monitoring, coordination and control of navigation activities can contribute significantly to a better environment by reducing shipping accidents and regulating the movement of dangerous and toxic substances. For example, the provision of specialised port facilities would eliminate the risks involved in the beach landings of petroleum tanker barges where no such specialised facilities exist. In addition, the introduction of common rules and regulations will reduce the frequency of collisions, and with it the pollution risk.

[s] MRC missions to member countries, April – May 2002.

12.2 Some environmental and socio-economic benefits of water transportation

The considerable environmental and social benefits which can be derived from the use of inland water transportation, as opposed to other forms of transportation (e.g. road transport) can be summarised as follows:

- IWT transportation operates in a waterway environment that has few junctions which tends to reduce both the number and severity of accidents.
- The environment of the waterway system often places more distance between vessels and the surrounding population and property than is the case with either truck or rail transport.
- Inland waterways, unlike road and rail networks, require lower initial investment and lower on-going costs for maintenance.
- Because of their much greater capacity, IWT with large barges, requires far fewer units than either rail or truck transport to move an equivalent amount of cargo. Barges thus have proportionately fewer accidents and burn less fuel in carrying the same volume of cargo.
- For remote communities near waterways, IWT is usually less expensive and less environmentally damaging than extension of roads to these areas.



In remote areas, waterway transport helps producers get their goods to market

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Domestic water and sanitation 12

If volume were the only consideration, use of the Mekong Basin's water for domestic purposes and sanitation would be of small importance. Its demands represent no more than 5 or 6 percent[1] of all ground and surface water used for any purpose in the basin, and water used for all purposes is only 10 percent of the water flowing from the river's mouth (Table 1).[2]

Table 1 Freshwater withdrawal for domestic use and sanitation

Country and year	**Domestic use sector % of total water usage**
Cambodia (1987)	5
Lao PDR (1987)	8
Thailand (1990)	5
Viet Nam (1990/1992)	4

Note: Data are for the whole country
Sources*:* World Resources Institute 2000; Gleick 2000

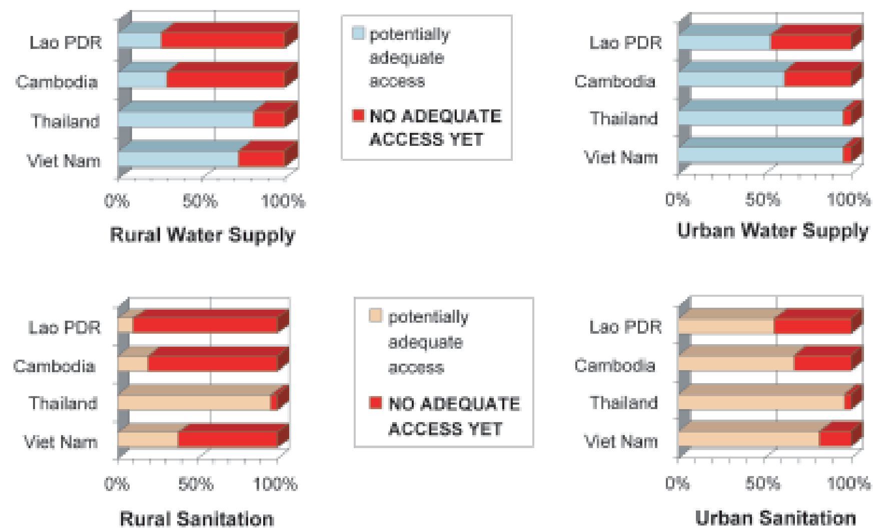
From other perspectives, however, domestic water and sanitation are of very high importance indeed. First, water quality and hygiene have a significant impact on human health and productivity. Second, access to domestic water, to sufficient quantities of it and to supplies that are reliable year-round, need to be assured to meet everyday basic human needs.

In rural areas, women and children often walk long distances to obtain drinking water

Domestic water and sanitation are clearly essentials for the health and productivity of all 55 million people living in the Lower Mekong Basin. But as Figure 1 indicates, a very high proportion of people in the basin lack adequate access to safe water and sanitation. This is particularly so in Cambodia, Lao PDR and Viet Nam, which all have largely rural, relatively dispersed populations in their areas of the basin. And water for domestic use is not always evenly distributed geographically, seasonally or equitably – factors which in turn can have severe impacts on development in general, and on poverty reduction in particular.

In rural areas, the poor are the most vulnerable to inadequate supplies of domestic water. It is their children who are the most likely to contract water-and-sanitation-related diseases, especially diarrhoea. In addition to health risks, in rural areas poor people often have to walk some distance to supply their families with water. Women and children, who are the family members most likely to carry water, may spend hours of their day doing so. This is a loss not only of time that could be spent on more productive activities, but if the water source is far from home, personal safety may become an additional issue.

Figure 1. Access to domestic water and sanitation in the LMB countries



Notes: Figures shown are countrywide, in the absence of more specific data for that part of each country falling within the LMB. Scales are based on approximate percent of populations served

Source: UNICEF 2002

In urban areas of the basin, a much higher percentage of people have water piped into their homes and are able to flush sewage away, but the poorest urban dwellers, whose numbers are increasing the most rapidly due to migration from rural areas, often lack such conveniences. Governments cannot keep up with the demand for water and sanitation services as more and more people settle in urban areas. Problems are arising as well in urban areas because the water and sanitation systems built decades ago are reaching the end of their lifespans and are beginning to break down. As a result, service levels are low, significant amounts of water are lost and water becomes contaminated as it flows through leaking pipes.

The poorest urban dwellers, who are often recent migrants from rural areas, usually lack adequate domestic water and sanitation

As LMB populations grow and coalesce in urban areas, providing water and sanitation services will become an even-greater challenge. Populations are likely to demand better quality water and greater quantities of it, and compete with other users of water such as agriculture and industry.

Thus although in a largely water-rich area such as the Lower Mekong Basin, domestic water may not at first seem as important as other water uses, it is, in fact, one of the most crucial uses for water, and likely to become more so in the near future as provision becomes even more challenging.

The provision of domestic water and sanitation services must be included in development plans throughout the LMB. The success of social and economic development depends on adequate access to these services, which will remain an essential indicator of progress.

In the chapter that follows, national policy will be overviewed, along with threats to water quality, as an example of a number of basin-wide issues. Available data on water and sanitation coverage and water-related disease statistics will also be presented, as will the need for more appropriate indicators of progress than just the extent of coverage. Finally, some overall conclusions are drawn.

1. The scope of domestic water and sanitation

Domestic water use within the LMB typically includes household use (drinking water, cooking, bathing, washing of clothes etc.), small-scale gardening and, where facilities are available, the flushing away of sewage. In urban areas, the water and sanitation systems established to meet domestic needs also serve businesses, government and public services such as educational institutions and hospitals. However, the water used for industry, power generation, irrigation, livestock and aquaculture is usually excluded from the domestic water sector.

Clean water can easily become contaminated during use if good hygiene is not practiced

The water sources used for domestic purposes and sanitation include not only surface water, but also groundwater, springs and rainwater. While cities and many towns in the basin have systems that pipe water to people's homes, most rural dwellers get their water from boreholes, wells, springs, streams, rivers, ponds and rainwater, and these supplies are often communal. In cities, human waste is flushed into sewerage systems, septic tanks or cesspits, or, in low-income areas, discharged in whatever way is available. In rural areas, people use latrines or pits dug into the ground or discharging into ponds or water courses, or people relieve themselves in the open.

2. Domestic water and sanitation (DWS) policy within the Lower Mekong Basin

Providing adequate access to domestic water and sanitation has been identified as one of the most important challenges facing the four riparian states. This is well reflected in national policies, strategies and plans, as well as those of donor and lending agencies. This is particularly so in Cambodia, Lao PDR and Viet Nam, and is in line with international priorities and commitments. Amongst other things, current policy seeks to shift the emphasis from a focus solely on physical coverage as a measure of success to include a number of other aspects now considered crucial. Among these are the need to develop water supply, sanitation, hygiene awareness and behavioural change in parallel, and increase emphasis on factors which ensure long-term sustainability.

Box 1. LMB commitments to International Development Targets for Water Supply and Sanitation

- By 2015 to reduce by one-half the proportion of people without access to hygienic sanitation facilities.
- By 2015 to reduce by one-half the proportion of people without sustainable access to adequate quantities of affordable and safe water.
- By 2025 to provide water, sanitation and hygiene for all.

***Source**:* WHO/UNICEF/WSSCC 2001.

During the 1990s, it became increasingly clear worldwide that attempts to expand water supply were not having the desired impact. Firstly the facilities were not always used, maintained, or providing the health and other benefits that were intended. Secondly, the rate of new construction was not keeping up with growing populations.

Box 2. The Dublin Principles

The following principles have been adopted by governments within the basin as well as internationally.

Principle No. 1 - Fresh water is a finite and vulnerable resource, essential to sustain life, development and the environment.

Principle No. 2 - Water development and management should be based on a participatory approach, involving users, planners and policy-makers at all levels.

Principle No. 3 - Women play a central part in the provision, management and safeguarding of water.

Principle No. 4 - Water has an economic value in all its competing uses and should be recognised as an economic good.

***Source**:* ICWE 1992

New approaches developed internationally, and endorsed by LMB governments, call for communities (with the exception of the more affluent urban areas), to own and manage facilities, the private sector to provide goods and services, and governments to facilitate the process. In rural and low-income urban areas, demand-responsive approaches allow beneficiaries to guide and fully participate in making key investment decisions. These are in accord with the internationally-adopted Dublin Principles set out in Box 2.

In rural areas wells and spring water are preferable to surface water which is often polluted with human and animal wastes

Although the principle that users should invest in water and sanitation services has now become well-established, in Lao PDR and Cambodia, for example, government strategies recognise that where communities and users cannot afford to fully finance schemes, the government should contribute significantly towards their costs. When appropriate technology is used and communities take responsibility for managing and sustaining systems, this assures communities of a basic level of service. However, if users want more than a basic level of service, they are expected to pay for it.

Among the major institutional and structural challenges addressed in various LMB policy papers are the need to: (a) improve the design, implementation and management of water and sanitation services in both rural and urban areas through identification of affordable, sustainable and equitable solutions; (b) better integrate domestic water and sanitation within the context of water resources management as a whole, with emphasis on quality as well as quantity; (c) enhance the capacity of countries to design, mobilise and manage operational support and investment from a wider group of partners; (d) match the provision and type of services with the users' willingness to pay (economic demand), while at the same time providing initial help to ensure basic services to those who cannot afford to pay the full costs; (e) demonstrate best practices and share information to encourage wider use of these; and (f) apply, monitor, learn from and adapt new strategies in support of these principles, in accordance with international consensus.

The importance of improving domestic water and sanitation in the LMB has been recognised by the Mekong River Commission and will be a key consideration as MRC develops its Basin Development Plan by 2004. MRC also recognises that domestic water and sanitation are important transboundary considerations. Other agencies with Mekong Basin programmes such as ADB's Greater Mekong Subregion initiative, the World Bank Water and Sanitation Program for East Asia and the Pacific (WSP-EAP) and the United Nations Children's Fund (UNICEF) have also made domestic water and sanitation an important focus.

3. Country and basin-wide issues

Alongside the strategic issues related to the development and management of the sector already presented in the previous section, there are a number of more specific issues, at both country and basin level, that also affect domestic water and sanitation in the LMB. Some selected illustrations are presented, followed by a more-detailed review of what is likely to be a paramount basin-wide issue: water quality.

3.1 Some factors impacting on the provision of domestic water and sanitation

3.1.1 Drought

Drought is a frequent concern, particularly in Northeast Thailand. In 1992 and 1994, droughts in this part of the basin seriously reduced domestic water supplies in the dry season. The consequences of droughts in the Northeast could be made worse if plans are followed through to divert Mekong water into the Chao Praya River system for domestic, agricultural and industrial use in central Thailand.[3]

In Northeast Thailand, droughts can seriously reduce domestic water supplies in the dry season

3.1.2 Saline intrusion

If dams and irrigation withdrawals upstream and potential drought reduce the volume of water reaching the Mekong Delta in Viet Nam, the intrusion of saline tidal water could increase significantly and threaten surface and groundwater sources, as well as agricultural land (Box 3).

Box 3. Viet Nam - Increasing access to water supply and overcoming quality changes

Saltwater intrusion and increased agricultural activity have polluted surface water throughout the Mekong Delta.

To find fresh water, more than 43,000 tube wells up to 400 metres in depth have been drilled to tap fresh water aquifers. Furthermore, when surveys carried out in 1996 and 1997 indicated that thousands of wells were used at only about 5 percent of their capacity, efforts were made to effectively exploit existing wells, rather than drill new ones. In the commune of Luong Hoa, extensive discussions with community members led to an agreement to construct and maintain a piping system that brought water directly to people's homes. Virtually every household agreed to contribute financial support. The funds collected for each cubic metre of water supplied are enough to cover electricity and operational costs, as well as cover future repairs and expansion of the system.

The project has expanded to supply piping systems in 49 communes in the provinces of Vinh Long and Tien Giang, benefiting an estimated 22,000 people.

This experience shows that relatively small amounts of capital can act as a catalyst in helping people to help themselves. Community support for small piping systems can be a low-cost method of increasing rural water supplies.

Source: WHO/UNICEF/WSSCC 2001

3.1.3 Deteriorating infrastructure

The deterioration of domestic water and sanitation infrastructure is a concern, especially in urban areas. Infrastructure is reaching the end of its working life, and requires extensive funding for rehabilitation. In 2000, it was estimated that over 80 percent of sewage/storm water drains in Cambodia's urban centres were no longer functioning.[4] In addition, where preventive maintenance is insufficient, systems are declining even faster. These problems result not only in inconvenience and health problems, but also in economic losses due to investment wasted on infrastructure that under-performs, and the cost of pumping and treating water that is later lost.[5] Basin-wide investment planning priorities will need to include the cost of rehabilitating existing water and sewerage systems.

In many urban areas of the LMB, sewage and storm water drains are in poor condition and no longer function well

3.1.4. Recognising the importance of groundwater

Groundwater is often excluded from basin planning discussions, even though it is a crucial consideration both as a domestic source and because its quality is threatened by human waste and other pollutants. The use of groundwater in the basin for domestic purposes is already significant. In Thailand, for example, 60 percent of groundwater abstraction is used for domestic supply.[6] In Cambodia, more than half of the population uses groundwater for domestic needs, and in rural areas, the figure rises to 60 percent.[7] It is therefore particularly important to protect groundwater quality and ensure that water tables remain adequate to meet domestic needs. Unfortunately, compared with surface water, very little is known about the quantity or quality of groundwater or the factors that threaten it.

3.1.5 Other issues

Other issues in the basin that may have implications for domestic water supply and sanitation include deforestation due to logging and clearing of land for agriculture (reducing groundwater recharge and increasing runoff and sediment loads), and extraction of water for irrigation (lowering groundwater tables and competing for surface water). More generally, climate change could increase evaporation and reduce precipitation, which in turn could reduce the surface and groundwater available for domestic and other users.

3.2. Water quality: An example of a basin-wide issue affecting domestic use and sanitation

Although the issues listed above are all significant, one of the most important basin-wide concerns that affects domestic water use is that of *water quality*. Water quality is a good example of a growing basin-wide concern affecting many different uses. It has special relevance - and high importance - for domestic water and sanitation. Clearly, quality of water is especially important when the end-use is for domestic purposes such as drinking and personal hygiene. Unlike other uses, the final quality of domestic water has a very direct link with personal health, well-being and personal productivity.

Of course, surface water in the Mekong system cannot, and indeed should not, be maintained at drinking water quality. All water from rivers needs to be treated to render it fit for drinking without health risk. But maintaining good general water quality in the river and its tributaries will certainly reduce the cost of the treatment needed for domestic water. It will also reduce risks to people's health when bathing, swimming, boating, fishing and laundering.

Safeguarding groundwater quality is even more important. Achieving this can help to ensure that in most cases, if hygiene awareness is high and put into practice, protected wells in rural areas will continue to deliver an adequate quality of domestic water without treatment being required.

3.2.1 Sources of contamination

Pollution of water supply sources – both surface and groundwater – with human and animal waste, as well as garbage, is common in the basin and increasing. In Lao PDR, for example, the length of rivers where water quality is adversely affected by human activity was estimated in 1997 at 10 percent with severe impact, and 20 percent with moderate impact.[8]

Pollution of surface water is common in urban areas and increasing

Sources of contamination are widespread. They include the discharge of untreated or partially-treated human sewage; the practice of combining sewage with storm water drainage; the emptying or overflowing of septic tanks and cess pits; the use of untreated night soil in agriculture; seepage from pit latrines; defecation in the open; pollution by the waste from intensive livestock operations; and contamination from people bathing or washing clothes in water courses. These sources affect surface water or groundwater, and in some cases, both.

Pollutants from industries such as paper mills, textile mills and chemical factories may become a threat in the future as more of these industries are established in the LMB. Problems could occur not only in larger centres such as Phnom Penh and Vientiane, but also in fast-expanding smaller cities such as Ubon Ratchathani, Udon Thani, Khon Kaen and Nong Khai in Northeast Thailand and areas in the Mekong Delta in Viet Nam which have been targeted for development. Increasing pollution of water sources by industries in cities and towns may well hinder the already difficult task of extending basic water and sanitation services to the urban poor.

3.2.2 Contamination of groundwater, including arsenic contamination

Distinction needs to be made between shallow groundwater that is vulnerable to pollution but easily accessed with simple drilling equipment or digging by hand, and deeper, more reliable groundwater. Many rural communities rely, at least in part, on shallow groundwater. This is vulnerable to contamination from run-off, flooding, latrines and other sources of faecal contamination, and when users draw water. Contamination of groundwater may be made more likely as a result of poorly installed or badly maintained boreholes and wells. Mining, manufacturing and leaks from underground petrochemical tanks may threaten groundwater quality in future.

Contamination of groundwater from natural sources is receiving much greater attention following the discovery of high arsenic levels in groundwater in many parts of South and Southeast Asia, with associated impacts on the health of communities. Both fluoride and arsenic are now increasingly recognised as threats to water quality. Iron and manganese salts may be as well, but more for aesthetic than for health reasons.

A high frequency of gastro-enteric, worm-related and other diseases are linked with contamination of, or shortage of, domestic water and poor sanitation

Box 4. Arsenic

Arsenic, in particular, is an increasing concern. As a WHO meeting recognised in 2002[9], arsenic contamination of groundwater is a very complex problem, not only in terms of its origin, movement and transformation, but also because of its very significant health and social impacts. The areas at most risk in the LMB appear to be along the valley and floodplains of the Mekong/ Tonle Sap/Bassac and deltaic areas. Here rock, soil and aquifers may contain historic arsenic-rich deposits washed down from the Himalayas. The precise mechanisms of arsenic release from sediments into groundwater, and in particular, the influence of human activities (such as intensity of water use) on the process, are not yet clearly understood however, making exact predictions difficult.

What is clear from surveys so far is that arsenic is likely to be a significant future problem in Cambodia, Lao PDR and Viet Nam (the position in Thailand is less clear). However, because improved wells have been developed more recently in the Mekong countries, the use of potentially arsenic-contaminated waters may have been less universal and for shorter periods than in some other countries at risk. Therefore, if timely and appropriate action is taken by governments and their external supporters (including identification of alternative drinking water sources for the affected wells – or failing that, appropriate treatment of the water), the associated health problems need not be as serious as they have been elsewhere.

While arsenic in groundwater remains a serious issue for the LMB, it must also be set within the broader water quality context. Risks must be balanced with those of widespread microbial contamination of many traditional sources, and excess fluoride in others - both of which also have major health impacts.[10]

Source: After WHO 2002

3.2.3 Contamination of surface water

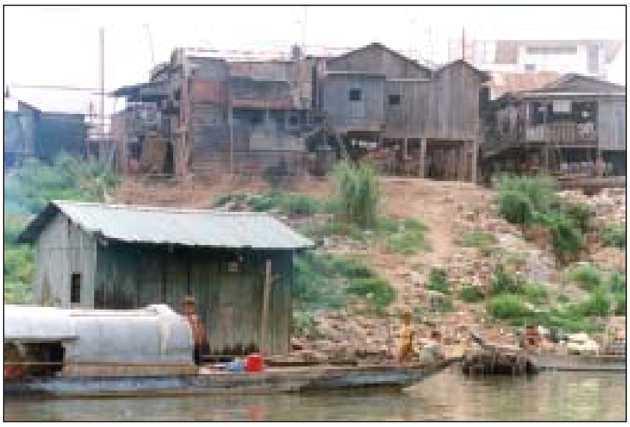
Deforestation leads to land degradation, soil erosion and increased sediment content in surface water, and raises the cost of water treatment. So does flooding, if it increases the organic content in water supplies. Coal mining, oil exploration and gem mining can increase turbidity in surface waters and also pollute them with toxic chemicals. These impacts are exacerbated by lack of monitoring and enforcement.

Natural erosion and that induced by human activity may expose toxic rock. For example, toxic aluminium compounds have been eroded from rock in western Cambodia. Construction of dams, roads and other infrastructure may contaminate drinking water sources directly with wastes, or indirectly by exposing toxic bedrock to erosion. Residues from past warfare are another un-assessed source of contamination, as is leechate from solid waste disposal sites, especially sites with hazardous wastes.

Pesticides could become a concern in future if their use increases as agriculture intensifies in the LMB. They can contaminate surface and groundwater through run-off after application, when irrigation water returns to watercourses, and when agricultural equipment is washed. In addition to damaging ecosystems, pesticides threaten humans both by contaminating domestic water supplies and by concentrating in the fish and other aquatic animals that humans eat.

Increasing use of fertilisers is also a potential problem, raising levels of nutrients in the delta in Viet Nam, for example. This may cause eutrophication and an explosive growth of algae. Algal blooms are a threat not only to fish, but some forms are also highly toxic to humans. However, a recent study[11] identified only a moderate risk of human waste and fertiliser triggering surface water algal blooms downstream from Phnom Penh. On the other hand, the potential increase in nitrate/nitrite levels in groundwater, particularly in areas where fertiliser use is extensive, needs to be monitored.

In the future, as river transportation increases both in the upper reaches of the river between China and Thailand, and between the mouth of the river and cities and ports in Viet Nam and Cambodia, spills of fuel and toxic chemicals could threaten domestic water sources. The impact of a spill would likely be felt for long distances downstream. (See Chapter 11 on trade and transport).



In all cases, river and other surface water in the LMB requires treatment to render it safe for drinking

In urban areas, where populations are increasing rapidly due to rural-urban migration, authorities are finding it impossible to keep pace with the requirements for water and sewerage infrastructure. Domestic water supplies, particularly those sourced from surface water, are increasingly threatened from human, industrial and hospital wastes. In Phnom Penh, for example, a preliminary assessment found a moderate-to-high risks of health problems if domestic water was drawn from the Chaktomuk or Tonle Sap Rivers, or the upper reaches of the Bassac.[12] Urban water supplies are also contaminated by deteriorating water systems.

3.2.4 Contamination during use and secondary risks

Contamination during the drawing, transport, handling and storage of water is often not given nearly enough attention. Whilst water may start out clean, it can be quickly contaminated during use if good hygiene is not practised at every stage. In some cases, contamination occurs because people lack knowledge about proper hygiene. In others they simply lack sufficient water and soap to wash their hands.

A high frequency of gastro-enteric, worm related and other diseases in the LMB are linked with domestic water supply and poor sanitation, particularly in rural areas. These diseases exacerbate the effects of poor nutrition and the ravages of other diseases. Survival rates, quality of life and economic productivity are all clearly affected. Section 4.6 gives some statistics on typical diseases.

There are also some secondary risks. Wild and cultured fish, shrimp and the other aquatic creatures consumed as human food in the LMB can all carry faecal bacteria in their gut and on their surfaces, and serve as intermediate hosts for parasites. With so many people dependent on aquatic products as their major source of protein, increasing contamination of water bodies with sewage could become a serious problem.

3.2.5 Monitoring and managing domestic water quality in the LMB

International guidelines exist on the recommended limits for pollutants in drinking water.[13] However, important linkages need to be made in the LMB (as is the case elsewhere in the world), between the standards required for drinking water and those required for other uses such as business and industry, and maintaining ecosystem health.

In the LMB, water quality surveillance programmes, particularly those for drinking water sources, are still limited and generally lack sufficient equipment, laboratory facilities, communications and skilled personnel. Among positive trends is the recent development of national drinking water standards in Viet Nam and Lao PDR and an ongoing process to do so in Cambodia (Thailand has had

In the LMB, drinking water quality increasingly needs to be monitored at the local level and be linked to early and appropriate action

them for some years). Cambodia has also undertaken a major drinking water quality assessment.[14] In rural areas, there is an increasing movement towards local monitoring of drinking water quality, leading to early and appropriate action, with less reliance on national or centralised monitoring programmes that sometimes proved ineffective in the past.

Measures to prevent the decline of water quality at its source or point of use – or any stage in between - and its recontamination after treatment need as much attention as setting standards and monitoring whether standards are being met. Water sources need to be protected to avoid contamination, leaking systems in urban areas need to be repaired and people need to understand the importance of hygiene and how to change their behaviour to prevent contamination between source and point of use.

4. Data on water and sanitation in the Lower Mekong Basin

4.1 The importance of monitoring equity, use, sustainability and impact – not just coverage

Traditionally, in the LMB as well as elsewhere in the world, progress in domestic water and sanitation provision has been measured in terms of number and types of improved water and sanitation facilities, numbers of people served, amount invested or quantity of water delivered. However, this “supply side” approach to monitoring is now recognised as giving no real indication of whether the improvements are: (a) equitable, (b) actually used, (c) maintained and financed, and (d) likely to yield positive health and socio-economic benefits to users (Box 5). Assessment of continuing use, sustainability and impact has not been widely attempted. It is also quite difficult to assess and compare data on the investment and recurrent costs for domestic water use and sanitation. This area clearly needs much more work in future, within the basin as well as globally.

Box 5. Some suggested definitions for equity, use, sustainability and impact

- **Equity** means that everyone (e.g. men and women, rich and poor, social minorities and major groups) has equal voice and an informed choice in decision-making, equal access to information, external inputs and benefits, and shares burdens and responsibilities fairly.
- **Use** means that water and sanitation improvements are actually used by all, and that users prefer them to their previous arrangements.
- **Sustainability** means that the improvements are maintained, repaired (and eventually replaced), and that this is fully financed by the users.
- **Impact** means that the improvements actually have a positive health and socio-economic benefit through reduced disease, time saving, convenience, security of women, etc.

***Source**:* After Dayal *et al.* 2001 and others

Although data on coverage are available for the LMB, these data are problematic. Definitions vary, as does the quality of data. For example, definitions of what is "rural" and what is "urban" vary. When service providers supply data, they often neglect to check whether facilities are actually functioning, let alone used or having any impact. Conversely, self-built or community-initiated facilities may not be counted by those gathering data. Data sets from different sources vary widely as well (see Table 2).

A further problem arises because national data do not necessarily conform to the boundaries of the Mekong Basin. This is not so important for Cambodia and Lao PDR (where 86 and 97 percent of each respective country lies within the basin), but may be significant when using national data for Viet Nam and Thailand, which have much less of their territory in the basin (20 percent and 36 percent respectively). For all these reasons, making comparison between countries and years can be difficult.

Box 6. Definitions of coverage

"Access to improved drinking water" in urban areas is usually defined as access to piped water or a public standpipe within 200 metres of a dwelling or housing unit. In rural areas, reasonable access implies that a family does not spend a disproportionate part of the day fetching water. Improved drinking water may include treated surface water and untreated water from protected springs, boreholes and sanitary wells. Other definitions also mention the need for an adequate quantity of water for good hygiene and household use.

"Access to improved sanitation" in urban areas usually refers to connections to public sewers or household systems such as pit privies, pour-flush latrines, septic tanks, communal toilets, and other such facilities. Rural population access is defined as those with adequate disposal such as pit privies, pour-flush latrines, or similar facilities. Other definitions specifically mention prevention of human, animal and insect contact with excreta, or pollution of water sources.

***Source**:* based on WHO/UNICEF/WSSCC 2001

The most important limitation, however, remains lack of data on use and sustainability (the degree to which facilities continue to be financed, maintained and operated) and on benefits (maximising health, saving users' time and increasing personal safety, especially that of women who are able to access water much closer to home). Nor is there data on equity of access within and between communities and between genders and age groups.

During the flood season river and other forms of surface water is even more likely to be contaminated

4.2 Coverage data

Although there are limitations with regard to coverage data, some recent consistent data are nonetheless presented below. But serious inconsistencies still remain. Rural Lao PDR, for example, is reported internationally as having 100 percent safe water supply coverage, although this is almost certainly not the case. The original country data presented below probably show more appropriate figures.

There are big differences between the four MRC countries with regard to providing safe water and sanitation services and these differences are likely to be reflected in each country's part of the basin. Viet Nam and Thailand have made relatively slower progress over the last decade, though from much higher starting points. In Cambodia and Lao PDR, coverage levels improved more sharply in the 1990s, albeit from very low levels. Nevertheless, Cambodia remains one of only three Asian countries with water supply coverage of less than 50 percent.[15]

Water quality and hygiene have a significant impact on human health and productivity

According to the World Resources Institute,[16] estimates of safe water coverage (rural and urban combined), averaged out over the period 1990-1996, indicated that Cambodia had approximately 36 percent coverage (ranking 89 out of 101 countries globally). Lao PDR had 52 percent coverage (ranking 74th), Thailand had 89 percent coverage (ranking 19th) and Viet Nam had 38 percent coverage (ranking 84th).

Comparable sanitation coverage figures from the same source and for the year 2000, were 14 percent for Cambodia, (ranking 97th out of 101), 28 percent for Lao PDR (ranking 78th), 96 percent for Thailand (ranking 6th), and 21 percent for Viet Nam (ranking 87th). The combined global ranking for "potential exposure to polluted water" placed Cambodia 89th out of 101, Lao PDR 76th, Thailand 18th and Viet Nam 86th.[17] Although the data for Thailand and Viet Nam are for the whole country and therefore include significant territory outside the basin, circumstances in the LMB are likely to be worse than national averages, not better.

Despite the wide variability in the data, referred to earlier, what is clear from the figures quoted above - and also from the sources used in compiling Tables 2 and 3 - is that in three of the LMB countries, as in almost every country worldwide, water supply coverage is higher than sanitation coverage. This seriously limits the benefits from improvements in water supply. Without parallel improvements in sanitation, it is difficult to improve hygiene and hence health.

According to a WHO/UNICEF/WSSCC report,[18] Thailand appears to be one of only seven countries worldwide where sanitation coverage has outstripped water supply, with sanitation coverage levels of over 95 percent. In contrast, and in the same report, Cambodia is noted for having "extremely low" levels of sanitation coverage, one of only two Asian countries where both sanitation and water supply coverage is less than 50 percent. In Lao PDR, over half the overall population also lacks proper sanitation, with one source also putting Viet Nam's sanitation coverage at less than 50 percent in rural areas.[19]

Moreover, rural services lag far behind urban ones, and the gap between urban and rural coverage is very wide. In Cambodia and Lao PDR, rural water supply coverage is probably half or less that which is available in urban areas, although for Viet Nam, the ratio is nearer 60 percent. In Thailand, the ratio is around 86 percent. Rural/urban comparisons for sanitation can be even greater. In Cambodia, rural sanitation coverage is only one-sixth as high as coverage in urban areas, while in Lao PDR, the rural/urban coverage ratio is less than 40 percent.[20]

The very poor are usually even worse off. In Cambodia, for example, it is estimated that for the poorest 20 percent of the rural population, the percentage with access to improved water supply falls to a mere 1 in 25.[21] Access to adequate sanitation is likely to be even lower.

Table 2. Improved water - population with access (%)

Country	Year	**Rural water supply coverage(%)** UNICEF/ WHO (country-level inputs to the 2000 Global Water Supply and Sanitation Assessment)	**Urban water supplycoverage(%)** UNICEF/ WHO (country-level inputs to the 2000 Global Water Supply and Sanitation Assessment)	**Total water supply coverage(%)** WHO/UNICEF/WSSCC (2000 Global Water Supply and Sanitation Assessment)
Cambodia	2000	26	54	30
Lao PDR	2000	29	61	90
Thailand	2000	81	95	80
Viet Nam	2000	72	95	56
Average for East Asia/Pacific Region(UNICEF)	*2000*	*67*	*93*	*76*

Notes: 1. Figures shown are national, in the absence of more specific data for LMB areas of countries.
2. To help comparison, a source that presents comparable data for all four countries has been selected, although other international and single-country data, varying widely, exist as well.

Sources: WHO/UNICEF/WSSCC 2001; UNICEF/WHO 2002; UNICEF 2002.

Table 3. Improved sanitation - population with access (%)

Country	Year	**Rural sanitation coverage(%)** UNICEF/ WHO (country-level inputs to the 2000 Global Water Supply and Sanitation Assessment)	**Urban sanitation coverage(%)** UNICEF/ WHO (country-level inputs to the 2000 Global Water Supply and Sanitation Assessment)	**Urban sanitation coverage(%)** WHO/UNICEF/WSSCC (2000 Global Water Supply and Sanitation Assessment)
Cambodia	2000	10	56	18
Lao PDR	2000	19	67	46
Thailand	2000	96	96	96
Viet Nam	2000	38	82	73

Notes: 1. Figures shown are national, in the absence of more specific data for LMB areas of countries.
2. To help comparison, a source that presents comparable data for all four countries has been selected, although other international and single-country data, varying widely, exist as well.

Sources: WHO/UNICEF/WSSCC 2001; UNICEF/WHO 2002; UNICEF 2002

4.3 Challenges in improving access: rural/urban ratios and population growth rates

The populations of all four LMB countries remain predominantly rural – between 77 and 84 percent overall, according to one estimate (Table 4). This presents special challenges for the equitable upgrading of domestic water systems because communities are often numerous, small and spread out. This is especially the case in the more remote areas of Lao PDR and Cambodia.

Rapidly increasing populations are another challenge. Targets for coverage are constantly growing, reducing the impact of new investment. According to the World Resources Institute, during the period 1995-2000, the population of Cambodia grew by 2.2 percent annually. In Lao PDR, population growth was 2.6 percent for the same period, 0.9 percent in Thailand and 1.6 percent in Viet Nam.[22] By 2025, the current LMB population of 55 million is projected to grow to as much as 90 million.

Rapidly growing populations are a problem not only in major cities, but also in secondary towns and cities as well. The latter are projected to bear the brunt of rural-urban migration as governments promote export-oriented agriculture and industry in areas such as the Mekong Delta in Viet Nam and around Savannakhet in Lao PDR. Urban growth is expected as well along the network of new and rebuilt roads that are being developed through the Asian Development Bank-funded Greater Mekong Subregion Programme, which is promoting integration in the Mekong Basin (See Chapter 14 on Cooperation).

Where communities live on or beside lakes and rivers, household sewage flows directly into the water without treatment

The special demands of tourism – and its influence both on localised water demands and waste management needs – are of growing importance in towns like Siem Reap in Cambodia and Luang Prabang in Lao PDR. Growing localised pollution and the difficulty of providing water supply to fast growing floating village populations in Viet Nam and Cambodia is another special case.

Table 4. Rural/urban growth rates and population ratios

Country	Total Population in 2000 (thousands)	Population growth rate (%)						Rural/urban ratio(%)		
		Rural			Urban					
		1980-1985	2000-2005	2020-2025	1980-1985	2000-2005	2020-2025	1980	2000	2020
Cambodia	11,168	2.1	1.0	0.3	6.2	4.4	3.1	88/12	84/16	74/26
Lao PDR	5,433	1.8	2.0	0.7	5.4	5.2	3.5	87/13	77/23	64/36
Thailand	61,399	1.6	0.2	(0.6)	2.8	2.5	2.3	83/17	78/22	67/33
Viet Nam	79,832	2.1	1.3	0.2	2.5	2.4	3.3	81/19	80/20	73/27

Sources: World Resources Institute 2000; World Resources Institute 2002

In summary, the populations needing water and sanitation services are not only increasing overall, but they are also concentrating in or near urban areas. It is clear that achieving the international target [23] of halving the proportion of people in the basin without access to improved water and sanitation services by the year 2015 will require enormous effort.

4.4 Types of water supply and sanitation systems used

Between rural and urban areas (and within urban centres between low and higher income areas), there are wide variations in the type of system or facility used. The same could be said for levels of service achieved (degree of reliability, availability, accessibility, and water quality).

Data on types of water supply and sanitation facilities in use, and their potential to be both safe and adequate, are extremely variable. As with data on coverage, definitions vary from one country to another, as does quality of data, again making it difficult to make comparisons between countries and between years. Trends in user preferences, affordability and convenience of systems are therefore difficult to track. But some trends are clear: there is high use of rainwater harvesting to ensure water security in Thailand (26.5 percent nationwide, but likely to be much higher in the dry areas of the Northeast that lie within the LMB). There are also a high percentage of unspecified wells in rural areas in Viet Nam (53.2 percent), with attendant risks of contamination if unprotected (Table 5).

Table 5. Types of water supply systems used

		Rural (% of population served)				**Urban (% of population served)**			
	Type of water supply	**Cambodia (2000)**	**Lao PDR (2000)**	**Thailand (1987)**	**Viet Nam (1997)**	**Cambodia (2000)**	**Lao PDR (2000)**	**Thailand (1987)**	**Viet Nam (1997)**
Improved (potentially safe)	Piped into dwelling, yard or plot	0.7	3.3	7.8	2.6	32.9	26.7	57.9	66.2
	Public tap/gravity-fed system	0.3	10.8	0.9	0.6	1.8	9.3	0.9	4.0
	Tube well, borehole with pump	22.2	15.7			13.8	17.0		
	Protected dug well or protected spring	2.1	7.4			1.6	13.3		
	Rainwater collection	1.0		26.5	17.4		0.2	13.7	4.8
Unimproved (likely to be unsafe)	Well in residence/yard	1.5		17.9	53.2	3.8		4.7	17.7
	Public well, unprotected dug well or spring	34.2	16.7	40.9	14.6	17.5	16.1	3.5	0.7
	River, spring, surface water			4.0				0.1	
	Pond, river, stream, lake or dam	30.0	32.7		11.4	11.8	5.0		4.5
	Tanker truck/vendor	3.5	0.1	0.7	0.2	11.1	0.1		0.2
	Bottled water	0.1	0.3	0.7		0.2	9.1	16.1	
	Other/missing	4.4	13.0	0.6		5.5	3.2	3.1	1.9
	Total	100	100	100	100	100	100	100	100

Notes: These are overall country statistics (rather than LMB only) and are for different years.
Blanks indicate no data available, not necessarily zero use.

Source: Based on WHO/UNICEF/WSSCC 2001

In general, there are more data on systems for water supply than for sanitation. Sanitation options range from simple improvements in open defecation (such as burying excreta), to simple pit latrines, ecological toilets, water flush latrines, composting or septic-tank linked facilities, and connection to a sewerage system, with or without piped water flushing. As with water supply, a range of choices is usually offered.[24]

Information is lacking on technologies being introduced, and those which have potential for use in the future. One example, (well illustrating the underlying concepts of integrated water resources management), is the use of wetlands for waste treatment as part of a hygiene/food production/waste management strategy. A second example is the composting of human and animal wastes to produce biogas for cooking and fertiliser. This has been successfully introduced for little cost in Viet Nam at the family farm level.[25]

Better and more comparable data on all of these aspects would facilitate step-by-step improvements in water and sanitation facilities, based on user preferences, cost-effectiveness, and willingness to pay.

4.5 Data on use and projected use

At the country level, estimates from 2001 indicated that for Cambodia, total annual water use for domestic purposes and sanitation was 136 million m^3 (versus 100 million m^3 for livestock use and 750 million m^3 overall). This is a significantly higher percentage than estimates in 1987. Urban water use (only 16 percent of the population in 2000) used approximately 51 million m^3 of this. In Lao PDR, total annual water production capacity in 1999 (again only for the 23 percent of the population living in urban areas in 2000) was approximately 60 million m^3. In Northeast Thailand, urban domestic water use was estimated at 130 million m^3 in 1990 and projected to triple to 390 million m^3 by 2000. In Viet Nam, estimates for urban domestic water supply in the Mekong Delta in 1990 were 52 million m^3, of which approximately 30 percent were from groundwater (expected to double by 2000). Data on rural domestic water consumption is harder to source, but a 1990 estimate for the Mekong Delta in Viet Nam was 33 million m^3, all supplied from groundwater.[26]

Out of 101 countries surveyed, Cambodia ranked 89th with regards to potential exposure to polluted water. Viet Nam ranked 86th, Lao PDR 76th, and Thailand, 18th.

As well as population concentration and growth, changed lifestyles and accelerating socio-economic development will lead to increasing demand, particularly in the urban areas. The wastewater burden will grow as well. Viet Nam offers an example of typical future projections. In Viet Nam, total projected demand for domestic water in the delta in 2000 was an estimated 400 million m^3. This figure was about five times the 1990 supply figure. Projections for 2015 are approximately double those for 2000.

By 2010, the population in Cambodia is expected to increase by 30 percent and domestic water use is expected to double, with annual demand likely to increase to an estimated 350 million m^3.[27] Overall within the basin, demand for domestic water is expected to grow by 50 percent over the next ten years,[28] with obvious major implications for investment and user support needs.

Taken together, and even with generous rates of growth, these figures still represent only a small percentage of the flow in the Mekong, notwithstanding the major contribution that groundwater makes in filling domestic needs. Nonetheless, as has been pointed out earlier, the importance of water for domestic and sanitation use cannot be measured based on volumetric demands alone. Much more important is the availability, security and quality of water, and its hygienic use – all essential to sustain daily life and reduce the spread of water-related disease.

4.6 Data on diseases related to domestic water and sanitation

Comparable data appear to be limited in detail, with rather more available from Lao PDR than elsewhere (see Table 6), but data are still largely limited to the monitoring of diarrhoea, cholera and schistosomiasis. There is still little systematic monitoring of the impacts from arsenic, fluoride, pesticides, nitrate from fertiliser, and other chemical pollutants. As stated previously, the country data discussed here are not necessarily representative of the LMB area.

Box 7. The benefits of wide access to proper sanitation in Thailand

Thailand has made remarkable progress in ensuring universal sanitation, and, as a result, in reducing mortality due to diarrhoea and other gastro-intestinal diseases. A sixteen-fold reduction in deaths related to gastro-intestinal illnesses was achieved from 1960 to 1999. During this time period, there was a parallel increase in sanitary latrine coverage from less than 1 percent to over 98 percent.

Source: UNICEF 2001

A recent MRC report [29] concluded that data collection on water-linked diseases is not systemised across the four countries and there is no common database from which to draw basin-wide summaries and conclusions.

There is clearly a need to establish a more standardised and complete monitoring system for diseases related to domestic water supply and sanitation. This could perhaps be divided into diseases that are microbiological in origin and those of chemical origin. Microbiological diseases could in turn be classified into those that are water-borne, linked to water washing, water-based, and water bred/vector transmitted. Classification would help to spotlight the most appropriate interventions. Such information could also enable broad comparisons between countries and over time (see example in Box 7 above).

If pesticide use increases, it will threaten humans both by contaminating water supplies and by concentrating in the aquatic animals that people consume

However, there are well proven difficulties in directly linking disease statistics with improved water and sanitation alone. Attempts should be made therefore to assess the proper use and functioning of improved supplies, and of monitoring behavioural changes with regard to hygiene. These could then be used as appropriate proxies for likely impacts on health.

From the limited data available, it is clear that alongside the more specific faecal-oral diseases such as cholera, typhoid, viral hepatitis and dysentery, general diarrhoea is widely prevalent and has a high impact. Usually diarrhoea is linked to lack of domestic water and sanitation, and exacerbated by poor hygiene practices and low availability of water. In particular, rapid dehydration caused by diarrhoea is likely to be a major cause of mortality among children in the basin. It has been estimated that improvements in safe water supply, and in particular improvements in hygiene and sanitation, could reduce the incidence of diarrhoea by one-fifth and deaths due to diarrhoea by one-half.[30]

Intestinal worms, cholera, dysentery, typhoid, viral hepatitis, schistosomiasis and trachoma (blindness caused by eye infections, which might be prevented by regular washing of infected eyes and better home hygiene), are also closely linked with domestic water and sanitation and hygiene practices within the LMB. Domestic water and sanitation contribute as well to the spread of some insect vector-transmitted diseases such as malaria and dengue through poor storage of water, ponding in pits or discarded containers around the home, and the inadequate drainage of surplus domestic water.

As an illustration, of the eight most common health complaints in rural Cambodia, all but two are water-linked. Four of these diseases (diarrhoea, hepatitis, typhoid and cholera) can be directly impacted by interrupting faecal-oral disease transmission routes through access to better domestic water and sanitation and improved hygiene. And most significantly, simple diarrhoea is still one of the two main causes of death of Cambodian children under five years.[31]

Table 6. Some country-wide statistics on water and sanitation-linked disease

Country	Example of water and sanitation-linked disease	1996		1997		1998		1999		2000	
		Cases	Deaths	Cases	Deaths	Cases	Deaths	Cases	Deaths	Cases	Deaths
Cambodia	Cholera	764	18	146	0	1,1723	74	2,850 1,788a	173 139a		
	Diarrhoea							8,729d			
	Schistosomiasis	39		31		9		23	2	129	1
Lao PDR	Cholera	568	7	451	1	780	5	107	1	146	0
	Diarrhoea	24,042 23,971d	65 124d	23,771	42	25,518	84	18,692	109	4,059	34
	Schistosomiasis	21	0	64	0	25	0	65	0	7	1
Thailand	Severe Diarrhoea			0be	0be	4,614e	25e	3,092e	13e	1,252e	5e
	Diarrhoea			50,418 1,054,904e	352e	1,157,629e	323e	963,246e	215e	954,019e	196e
	Typhoid/ Paratyphoid			14,527b 8,731e / 212e	3e / 0e	7,165e / 226e	1e / 0e	5,986e / 184e	1e / 1e	5,548e / 210e	5e / 0e
	Hepatitis			7,932be	37e	6,415e	21e	6,357e	18e	6,476e	26e
Viet Nam <>	Cholera	1,828b 149c	0c	7c	0c	9c	1c	212c#	0#	0#	0#
	Diarrhoea	60,105c#	10c	283,756c	283,756c	265,056c	14c	259,076c#	10#	255,793# 180,938d	7#
	Typhoid/ Paratyphoid	29,294b 10,950c	5c	14,175c	14,175c	15,992c	7c	11,055#	6#	6,929#	2#
	Dysentery	21,902c	0c	28,260c	28,260c	24,856c	0c	18,985#	0#	22,000#	0#
	Hepatitis	14,490b 679c#	2c#	669c#	669c#	1,017c#	1c#	976c#	3c#	585c#	1c#

Notes: 1. * indicates disaggregated for provinces in the LMB only
2. # indicates for Mekong Delta only
3. <>: for Viet Nam, unless otherwise marked, data applies to South Area, comprising 19 provinces
4. Blank indicates no data currently available to MRC

Sources: MRC 2000, except for those annotated: a: MBDSC 2002; b: SEAMIC 2002; c: T. K. Nguyen, Viet Nam National Mekong Committee, Personal correspondence, July 2002; d: WHO 2002a; and e: Ministry of Public Health 2002

4.7 Improving the focus, collection and use of LMB data

Of the eight most common health complaints in Cambodia, all but two are water linked

For success in measuring improvement, relevant stakeholders in the basin should be encouraged to collect data that: (a) meet uniform standards, preferably in accord with formats established by the joint Global Water Supply and Sanitation Assessment Report;[32] (b) can be grouped into LMB and non-LMB clusters, and ideally into Sub-areas corresponding with those used in MRC's Basin Development Plan and in national administrative units; (c) show the mix of technologies used in ways that are comparable, promote choice and monitor the essential transition from likely unsafe to potentially safe systems; (d) include insights into use, condition, sustainability, likely impact and equity (rather than just a "snapshot" of coverage); and (e) give a consistent basis for comparison of investment and recurrent costs (total, per capita and for each technology used) as well as for number of people served, installations completed, and quantity and quality of water supplied.

Regular monitoring procedures need strengthening so that data are more reflective of the changing situation, and provide managers, planners and communities with relevant information. Analysis and information sharing skills need improvement so that data are available and used. Finally, as water for domestic use and sanitation is a complex matrix of technical and social/behavioural issues, there also needs to be much more emphasis on mutual learning and feedback regarding the methodologies applied in order to understand what works and what does not work, and why. The focus should therefore be much broader than on statistical data alone.

5. Conclusion

Water treatment becomes increasingly difficult and expensive as pollution levels rise

Meeting needs in the LMB for adequate domestic water and sanitation services is a great challenge. In much of the basin, the population is growing rapidly, and as development increases, competition for water is likely to grow and water quality to decline as well. There is also a need to close the growing gap between people who have adequate water and sanitation services and those who do not. Inequities currently exist based on geographic location, income, gender and ethnicity.

The potential triple benefits from improved domestic water and sanitation, better health, time saving and convenience, are not automatic and must be vigorously pursued. In particular, in addition to improving water supplies and sanitation and making them financially and operationally sustainable, improvements must take place with regard to hygiene. Basin experience indicates that unless households protect water supplies, transport, store and use water hygienically and wash their hands properly, improvements in water supply will probably not have their desired health impact.

By ensuring near universal access to adequate sanitation, alongside safe water and hygiene improvements, Thailand has drastically cut deaths from gastro-intestinal disease

To ensure that investments in systems are worthwhile, monitoring is considered important not only with regard to coverage of services, but also with regard to how investments are made, how systems are managed and maintained and whether coverage is equitable and is having an impact.

The fact that governments have appropriate polices and strategies in place with regards to providing domestic water and sanitation and experience with multi-stakeholder participation, bodes well for success in attracting the necessary investment. If investment is based on sound nationally-derived policy and strategies, with high levels of user involvement, it is much more likely to be sustainable and successful in improving human health and welfare within the Basin.

Endnotes

[1] Gleik 2000
[2] Nielsen 2002
[3] Bangkok Post. *Many rivers to cross.* 30 December 1998. p.1; Hori 2000
[4] ADB 2000
[5] Webster *et al.* 2002
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Floods in the Lower Mekong Basin 13

Floods are a recurring event in the Lower Mekong Basin. Flooding of the mainstream and tributaries of the Mekong River is an important source for the wealth of biodiversity, abundance of fish and soil fertility in the basin. At the same time, each year, flooding results in loss of life and property, causes damage to agriculture and rural infrastructure and disrupts the social and economic activities of people living throughout the basin. At the same time, Flood management and mitigation (FMM) has become a priority issue at the national and regional levels, particularly in the aftermath of the disastrous floods of 2000 and 2001.

The chapter which follows presents information on the nature and extent of flooding, causes and contributing factors, the environmental benefits of floods, the economic and social costs, and trends, hotspots and trans-boundary issues.

The annual floods in the Mekong Basin contribute to the wealth of biodiversity, abundance of fish and soil fertility in the basin

1. Nature and extent of flooding

Climate, and particularly the southwest monsoon, is the immediate cause of the annual floods. The level of the Mekong starts to rise in May and reaches its peak in mid-August or early September in the upper reaches, and in mid-September or early October in the delta region.[1] However, the flood patterns are very different moving downstream through Lao PDR, Thailand, Cambodia and Viet Nam (see Chapter 2).

In Lao PDR, flooding is very much influenced by tributary flows. The combined effects of large flows in the tributaries and the mainstream of the Mekong cause serious damage, including flash flooding on tributaries and bank overflow in

In Lao PDR, the tributaries are largely responsible for flooding lowland areas. According to MRC estimates, 80 percent of the rural flooding and 20 percent of the urban flooding is caused by tributaries.[2] The four major flood prone areas in Lao PDR are situated along the mainstream near large tributaries: i) Vientiane Plain, ii) Khammoune Province (Thakhek town), iii) Savannakhet Province and iv) Champasak Province (Pakse town).[3]

In Thailand, the principal flood prone areas of the LMB in Thailand include low-lying areas along the Mekong and tributaries in Nong Khai, Mukdahan, Nakhon Phanom and Ubon Ratchatanee provinces.

In Cambodia, the Mekong enters the low-lying delta and becomes a wide, slow-flowing river. The area is very flat and there is extensive lateral flow of flood waters from Kratie to the border with Viet Nam. Bank overflows also occur along the entire length of the Tonle Sap River. Following heavy rainfalls, surface runoff often flows parallel to the rivers, filling land depressions lateral to and between the two rivers. Up to 4 million ha of lowland areas in Cambodia are inundated annually.[4]

The surface area of the Great Lake expands from 250,000-300,000 ha in the dry season to 1-1.4 million ha in the wet season.

During the wet season, the discharge capacity of the Mekong and Bassac Rivers south of Phnom Penh is inadequate to handle flood flows. This results in backflow up the Tonle Sap River and into the Great Lake until the water levels in the Mekong and Great Lake are equal (usually in late September). The total natural storage capacity of the Great Lake and the Tonle Sap is estimated to be 150 billion m^3. During the flood season, the surface area of the lake expands from 250,000-300,000 ha (dry season area) to 1-1.4 million ha.[5]

In Viet Nam, flooding frequently inundates the entire flood plain of the delta – up to 1.8 million ha

In Viet Nam, the Mekong River forms a highly fertile and productive delta. Flooding in the delta is influenced by tidal effects from the South China Sea, combined with high discharge from the Mekong River and heavy rain in the delta itself. Flooding frequently inundates the entire flood plain in the Vietnamese delta, that is, up to 1.8 million ha.[6] In the Central Highlands of Viet Nam, steep mountain slopes and insufficient storage capacity for rains during the wet season often result in flash flooding.

Figure 1. Duration of flooding in Cambodia and the Viet Nam Delta, 2000

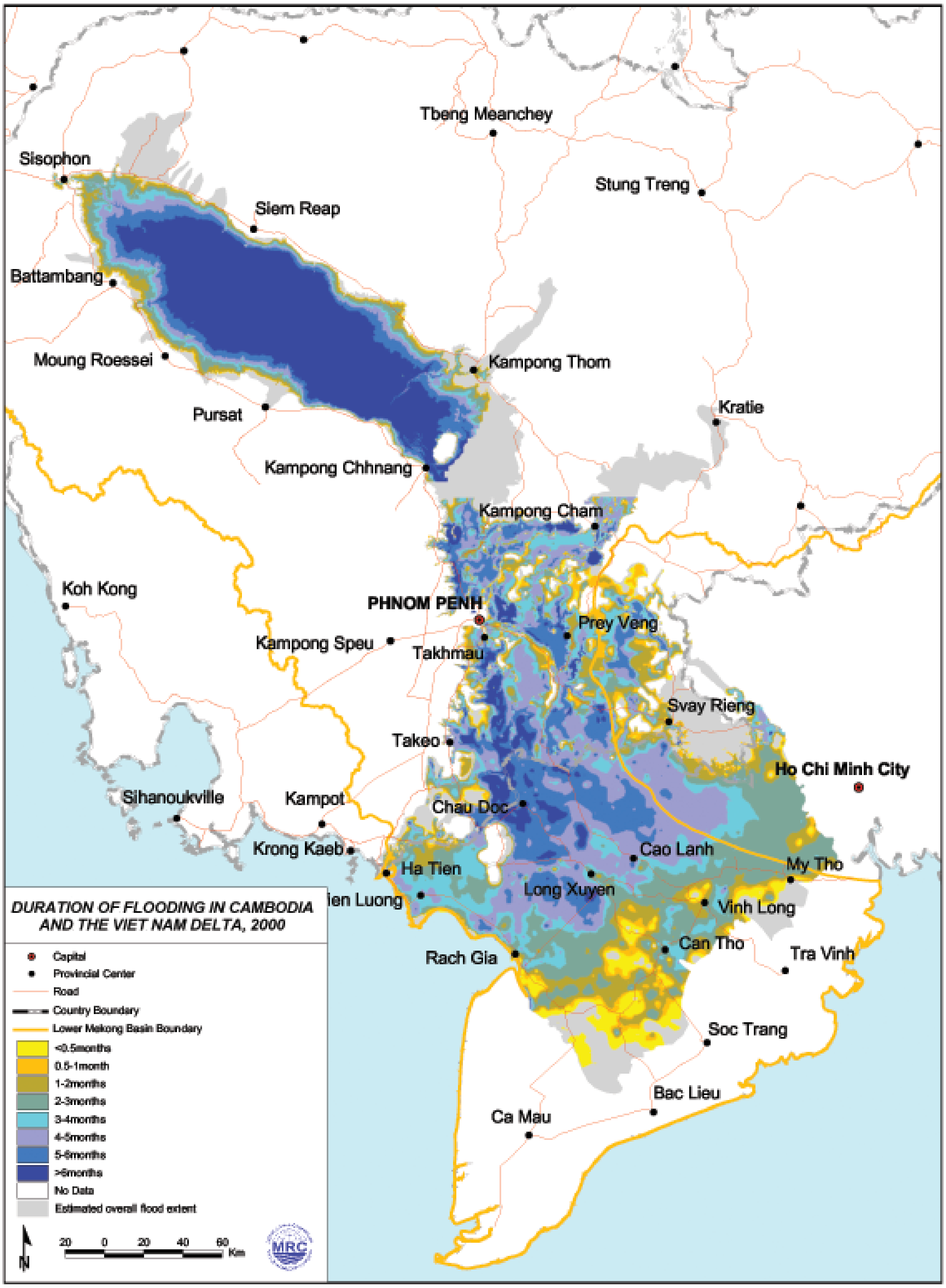
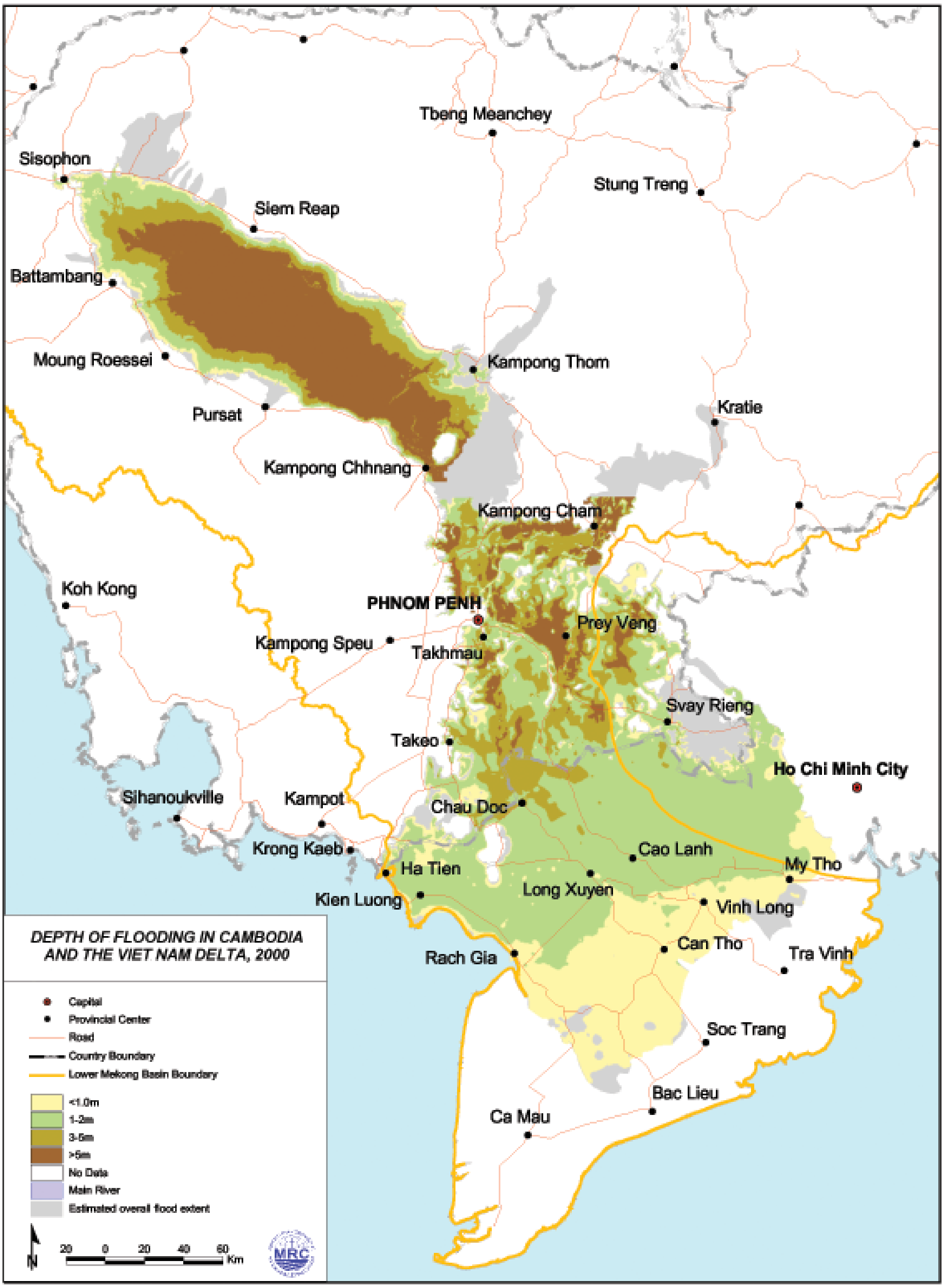


Figure 2. Depth of flooding in Cambodia and the Viet Nam Delta, 2000



2. Causes and contributing factors to flooding

The hydro-meteorological causes of floods in the Mekong Basin are prolonged, heavy rains on saturated soils. This leads to an increase in surface run-off that can only slowly be discharged through the river system into the South China Sea. Other natural and man-made factors can also affect flooding in the basin.

2.1 Climate change: Climate change and global warming are likely to be contributing factors to increased frequency and intensity of severe flooding, particularly in low-lying coastal and estuary areas. Warmer water temperatures in the South China Sea may increase the number and intensity of typhoons, in turn causing sea surges that inundate low-lying areas. Some estimates indicate that 15,000-20,000 km^2 of land in the Mekong Delta could be threatened.[7] However if there is lower rainfall in the basin as a result of climate change, which is possible under some modeling scenarios, there may be decreased flooding in some parts of the basin.

2.2 Deforestation: Deforestation and land clearance in upland areas of the basin results in increased volume and speed of surface run-off. This, in turn, contributes to increases in peak discharges and peak water levels. The impact of these factors on flooding is more pronounced for small and medium sized floods along tributaries of the Mekong.[8]

Deforestation and land clearance in upland areas can increase the volume and speed of surface run-off and lead to small- and medium-scale flooding in tributaries

2.3 Land degradation: Land degradation occurs in areas of intensive shifting cultivation, shortened fallow periods and where agricultural systems are not adapted to topographic and soil conditions. This leads to increased erosion and sediment deposit in the Mekong and tributaries that can reduce drainage capacity, thus contributing at a regional scale to increased flood hazards.[9]

2.4 Changes in flood storage capacity: The construction of flood embankments and other man-made structures designed to protect areas along the Mekong results in a loss of natural floodplain storage capacity. Flood waters continue downstream without the mitigating effects of that storage. In general, the impact of a single embankment may not be that great. However, the cumulative effects of many embankments can result in the loss of a significant volume of floodplain storage that causes increased discharge and higher flood levels both upstream and downstream.[10]

Reclamation and infilling of low-lying wetlands for agriculture and other purposes contributes to flooding in the LMB

2.5 Reclamation of floodplains and wetlands: Increased reclamation and infilling of low-lying floodplain land and wetlands for agricultural and other purposes is a factor contributing to flooding in the LMB. This process also results in the loss of floodplain storage and, like structural measures, can have significant cumulative effects on flood discharge and levels.

2.6 Rapid expansion of urban settlements and infrastructure: Increased urbanisation replaces natural vegetation with sealed surfaces such as roads, roofs of homes and other buildings. As a result, the lag time between intense rainfall and peak stream flow is shortened, peak flow is greater and total surface runoff is compressed into a shorter time interval – all favorable conditions for flooding. In addition, the development of roads, bridges and culverts can contribute to flooding, particularly where the location and design of this infrastructure impedes natural drainage patterns.

2.7 Channel migration and other man-made modifications to river channels: Channel migration due to erosion and sediment deposition along the Mekong can, as at Kampong Cham, threaten to destroy flood banks that presently protect large areas of the town from inundation during annual floods.[11] Similarly, dredging and other modifications to river channels can change the characteristics of water flow, erosion and sedimentation, affecting peak discharges during the flood season.

2.8 Reservoir operation: During the First Annual MRC Flood Forum in 2002, representatives from Cambodia and Viet Nam identified the presence and, particularly, the operation of reservoirs in the basin as a contributing factor to Mekong floods.[12]

3. Environmental benefits of floods

The environmental benefits of flooding are considerable. Not only do they contribute to the ecological health of the basin, they are also important in maintaining livelihoods:

3.1 Soil fertility: Flooding of agricultural land leaves behind silt deposits that add nutrients to the soils. Throughout the basin, flood recession agriculture is practiced to grow vegetables and other crops that are a source of food and cash income for rural households.

3.2 Ecological health of the river system: Flooding also serves to flush out pollutants that are deposited in the mainstream and tributaries during low flow periods. Floods also refill floodplain wetlands and recharge groundwater.

Flooding of agricultural land leaves behind nutrient-rich silt deposits

3.3 Fish and other wildlife: Many fish species in the Mekong migrate during the flood season to spawning grounds in the flooded forests of Tonle Sap Lake and other locations. Flooding that helps to maintain the river ecosystem, provides breeding, nesting, feeding and nursery areas for fish, migrating waterfowl and other wildlife.

3.4 River bank and floodplain vegetation: the local plant life that occurs along the river is adapted to the annual variation in flows including the floods. If there are changes in flood extent or frequency the distributions of the plants will change as a consequence, including the distributions of many plants that are used by the local people.

3.5 River channel maintenance: Floods are essential to maintain the physical form of the river channel. They flush out fine deposited material, cleanse gravel beds and reset the vegetation on islands. In the absence of floods, river channels reduce in capacity as fine sediments deposit and vegetation encroaches to fill in the channel.

4. Economic and social costs of flooding

The 2000 floods in the Mekong Basin were the worst in the region in 40-50 years. High levels of flooding in 2000 were followed by serious floods in 2001 and, some early reports suggest, in 2002. Due to this pattern of recent flooding, people and governments in the basin have suffered substantial direct, indirect and cumulative economic and social costs.

In the Viet Nam Delta in 2000, a total of 5 million people were affected by floods

In 2000, severe flooding affected 22 of the 24 provinces in Cambodia.[13] The Royal Government of Cambodia (RGC) put the death toll at 347 people, of whom 80 percent were children. A total of 760,000 families (over 3.4 million people) were affected, with 85,000 families (387,000 people) temporarily evacuated from their homes and villages. The RCG estimated total physical damage at $161 million. In 2001, 62 people died, again mostly children, and damage amounted to $36 million. In October 2002, the National Disaster Management Committee estimated that nearly 1.5 million people and 60,000 ha had been affected by 2002 flooding.[a]

Some 80 percent of those who die in floods are children

Flood levels in Lao PDR in 2000 reached unprecedented levels in the central and southern provinces, and remained high for long periods.[14] Preliminary estimates indicated that nearly 73,000 rural households (395,600 people) were seriously affected in 1,200 villages in seven provinces (Vientiane, Bolikhamsay, Khammouane, Savannakhet, Saravane, Champassak, Attapeu). A total of 80,000 ha of rice fields were flooded and an estimated 10 percent of the wet season production was completely lost. Irrigation systems and rural road infrastructure were widely damaged, as well as large parts of provincial towns. Production losses amounted to approximately $20 million.

[a] In 2002, Cambodia also suffered severe drought in many regions, with effects that were more widespread than flooding in 2002.

In the portion of Thailand in the Mekong Basin, reported production losses due to the 2000 floods amounted to about $21 million.[15] In 2001, the region of Udon Thani was particularly hard hit by flooding, with 2.8 million affected people (727,600 households); 47,350 km^2 of farmland inundated; and, 5,300 km of roads damaged.

In 2000, the total cost of flood damage in Viet Nam was an estimated $285 million

In the Mekong Delta in Viet Nam, over 500 people died due to the 2000 floods. As in Cambodia, most were children. A total of 5 million people were affected; 825,000 homes damaged or destroyed, and 60,000 households had to evacuate their homes. Nearly all the summer-autumn rice crop was lost, and thousands of kilometers of national and provincial roads were damaged. The total costs of flood damage amounted to $285 million. In 2001, 230 people drowned during floods in the delta, including 180 children. As of late September 2002, flood waters covered half of the 12-province delta region, affecting about 270,000 people. A total of 71 people died due to floods, including 65 children. Although 112,000 people were in urgent need of food relief, most of the rice crop had not been affected because of early completion of the harvest. About 54,000 houses were flooded and nearly 700 km of roads submerged.

If global climate change results in higher temperatures and sea levels, flooding in the Mekong Delta will be more severe

In addition to these direct costs, flooding causes significant indirect and cumulative effects. The most serious problems facing many people living in rural flood prone areas are food and income security. In the immediate aftermath of floods, the lost production of rice and other food crops means months of insufficient food for many households. The lack of grazing lands for livestock forces farmers to sell animals at low prices. The time required to regrow damaged fruit and plantation trees means lower incomes for several years.

Official government figures for flood damage do not include the costs to households to repair or replace their damaged housing and crop storage facilities. Transportation costs increase when damaged roads and bridges can not be restored quickly, causing increases in the prices of some goods and services. This, in turn, undermines trade and production efforts. The direct and indirect effects on national economies can be significant. In Cambodia, for example, it is generally agreed that the 2000 floods reduced GDP growth by 1.0 percent (from predicted levels of 5.5 percent to about 4.5 percent for the year).

When flood-damaged roads and bridges are not restored quickly, transportation and shipping costs rise and with them, the prices paid by consumers

During prolonged flooding, community and family social structures are disrupted and individuals suffer increased stress-related problems

Damaged hospitals and clinics seriously limit the availability of health services at a time when the risk of flood-related diseases is high. Children frequently loose many weeks of education as schools are flooded or damaged. During prolonged flooding, community and family social structures are disrupted and individuals suffer increased stress-related problems related temporary displacement, anxiety, etc. Following floods, there is often increased rural-urban migration of flood-affected people seeking work.

The impacts of flooding on the poor are particularly significant. In Cambodia, for example, rural households generally have one hectare of rice land. The loss of 350,000 ha of paddy during the 2000 floods meant that a very large number of households lost their primary asset for assuring their own food security, as well as for generating cash income. Catastrophic events such as this often cause households to sell their land in order to buy food or other essentials, with significantly higher risks that they will fall below the poverty line or not be able to get out of poverty.

5. Trends, hotspots and trans-boundary issues

The interaction of natural and man-made factors suggests a number of important trends for flooding and the effects on people living in the basin. Some of these may become serious hotspots or trans-boundary issues among the riparian countries.

5.1. Increasing frequency of serious floods: As measured by the number of people killed by floods, historical data suggest that the frequency of serious floods is increasing in the basin. For example, in Viet Nam about 540 people were killed by floods and typhoons annually in the years 1985-1989, compared with 225 people killed in the 1976-1979 period.[16]

5.2 Increased flooding in low-lying coastal and estuary areas: Climate changes that increase temperatures and sea levels will cause greater flooding in low-lying estuary areas in the Mekong Delta. Effects may include altered flow of estuaries, coastal rivers and wetlands, and increased erosion and salinisation of tidal wetlands and coastal mangrove forests.

5.3 Population growth and increased urbanisation: The growth of primary and secondary urban centers in the Mekong floodplains will result in expanded areas of residential development, other buildings, roads, etc. The loss of floodplain storage capacity will increase the severity of the direct effects of flood events (extent, depth and duration of flooded areas), as well as the economic and social consequences (urban centers as the location of higher, "value-added" economic activities; number of people living in urban centers; etc.).

5.4 Rural development issues in the LMB: National policies in support of higher value commercial agriculture in the basin increase the economic risks associated with exposure to floods. Increased population pressures in upland areas that result in deforestation may also contribute to the intensity of flooding in the basin, although there is no data so far that demonstrates an increase in floods as a result of forest clearance at the scale of large basins such as the Mekong.

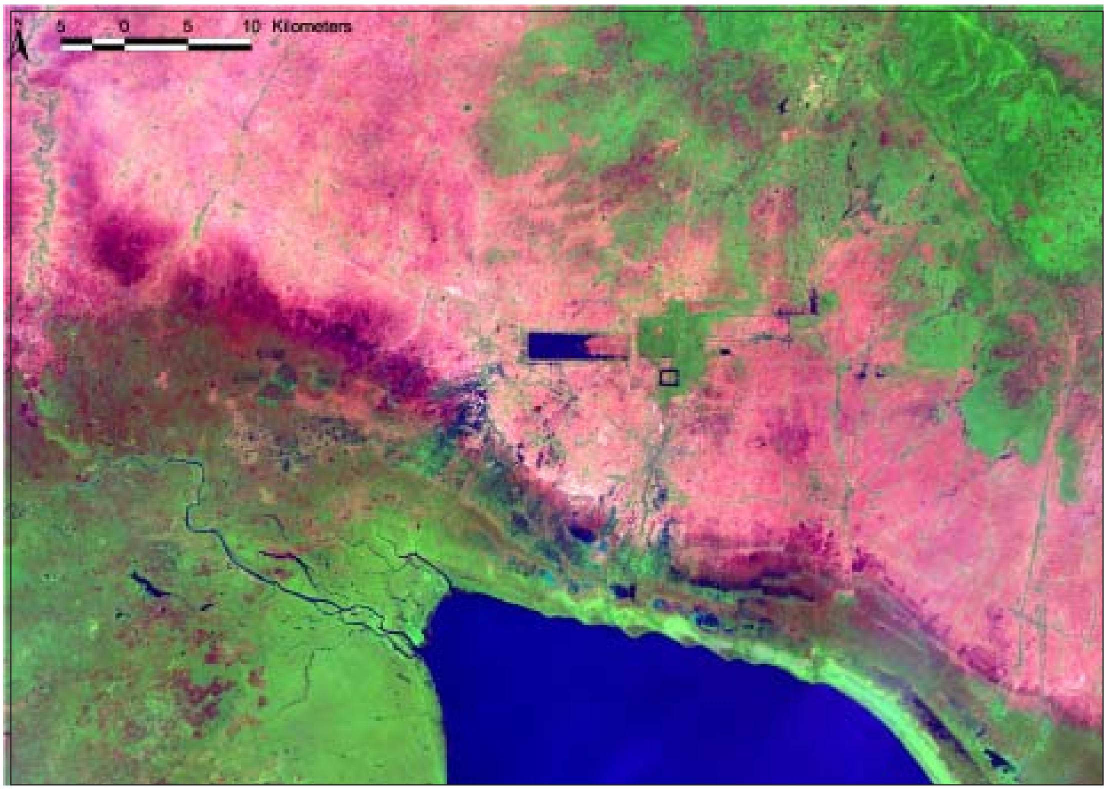
5.5 Reduced capacity to cope with floods: The recent phenomenon of serious flooding in the basin in successive years has raised another major concern – that of reduction of the capacity of governments, communities and households to cope with floods due to the cumulative social and economic effects. For example, recovery in the basin after the 2001 floods was more difficult due to lingering effects of the 2000 floods: infrastructure had not yet been repaired; households had not fully replaced houses and other assets lost the previous year; and economic production (agricultural and non-farm) had not been fully re-established, etc.

Hotspots and trans-boundary issues related to flooding in the basin are interrelated. Cambodia and Viet Nam, the downstream countries, are most severely affected by flooding. Land management, structural measures and in-stream modifications that occur in the northern part of the Mekong Basin (including the Upper Basin) have the potential to influence flooding in the downstream portions. In terms of flooding, Northeast Thailand is also "downstream" of flood season discharges from the tributaries in Lao PDR.

Other hot spots may emerge due to interventions that cause loss of floodplain storage capacity (e.g., structures and/or land reclamation), particularly in areas of the Mekong floodplains being developed for higher value uses (e.g., commercial agriculture, urban development). Whether they will be considered to constitute a trans-boundary flood management issue will depend on their locations and the degree of cumulative impacts.

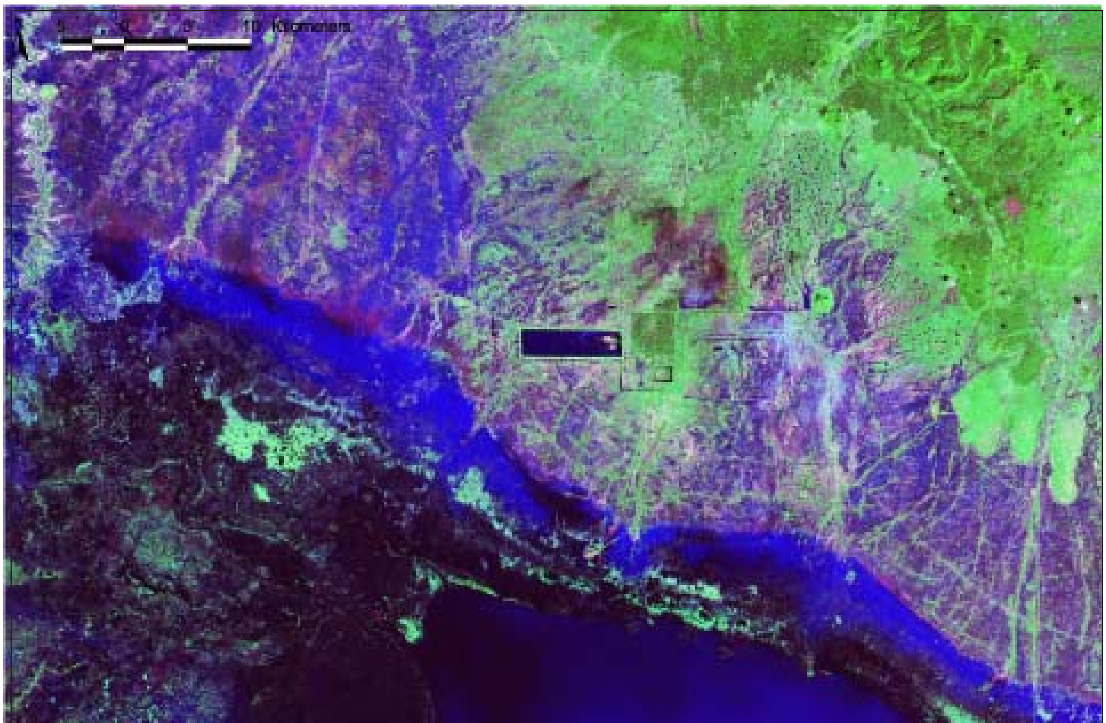
Figure 3. Satellite images of the Tonle Sap Great Lake in the wet and dry seasons

Dry season



Note: Image is a single Landsat ETM image from 25 March 2000, the end of dry season (RGB=542). Colour code: black = deep or clear water; blue = shallow or turbid water; green = actively growing vegetation; pink/ red/orange = dry, bare or hot areas (e.g. bare soil or rock).
Source: TRFIC database (http://www.bsrsi.msu.edu/trfic/)

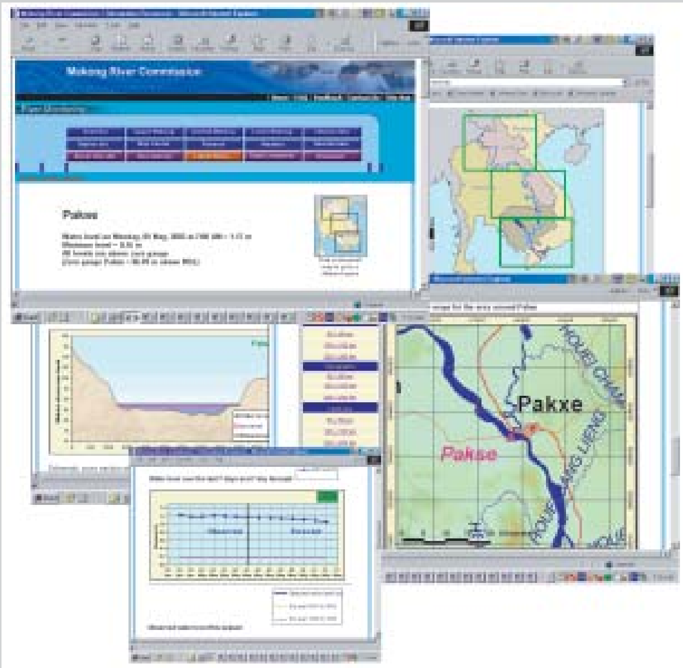
Wet season



Note: Image is a composite Landsat image, circa 1990, from the end of the wet season (RGB=742). Colour code: black = deep or clear water; blue = shallow or turbid water; green = actively growing vegetation; pink/ red/orange = dry, bare or hot areas (e.g. bare soil or rock).
Source: Earthsat (https://zulu.ssc.nasa.gov/mrsid/)

Flood forecasting in the Lower Mekong Basin

Every year starting in mid-June, the Mekong River Commission broadcasts daily information on flood risks at key points along the Mekong mainstream in Cambodia, Lao PDR, Thailand, and Viet Nam. This information is made available on the MRC website, www.mrcmekong.org, until the end of the flood season in late October or November.



This important part of MRC's website aims to provide the most up-to-date information available about current and forecasted hydrological conditions in the Mekong Basin, and presents this in an easily-understandable manner. Clicking on the point for each monitoring station on a digital map provides information on daily water levels as well as a 5-day forecast of water levels. These data are shown both on a schematic cross-section for each station and on a graph. Each station's point on the map of the lower basin and on a list of stations is colour-coded to show three levels of warning – "no warning", "alarm level" and "flood level". For each station, the website also makes available a series of maps in different scales which depict areas of flood risk, land use and topography. The MRC website also provides maps for the basin as a whole.

MRC oversees the operations of 41 monitoring stations, including two in China. These are all located along the Mekong mainstream from Jinghong in China to the Mekong Delta at Tan Chau, in Viet Nam. Every day throughout the flood season, each monitoring station transmits information on water levels and the previous day's rainfall to the MRC Secretariat in Phnom Penh. Upon receipt, these data are entered into a mathematical model and then compared with data from weather maps and rainfall forecasts received from the US National Oceanic and Atmospheric Administration (NOAA). Based upon this comparison, a 5-day forecast of water levels is made and the results broadcast every day on MRC's website at 12:00 pm.

Between flood seasons – from November to May/mid June – MRC continues to broadcast data on water levels and 7-day forecasts. This information is updated once a week on a Monday, rather than daily, as is the case during the flood season.

MRC is continuously improving its forecasting capability and working closely with partners to ensure that forecasts meet communities' needs and that warnings are effectively and accurately disseminated. MRC also encourages agencies and individuals working on disaster preparedness to send enquiries and suggestions directly to MRC, where improvements in flood forecasting are continually being made.

Endnotes

[1] MRC, 2001
[2] MRC, 2001
[3] MRC, 2001
[4] MRC, 2001
[5] MRC, 2001
[6] CNN, 2002
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[14] Data on Lao PDR are summarized in WFP, 2000 and MRC, 2001
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Cooperation in the Mekong Basin 14

1. Cooperation is crucial

Countries that share boundaries are strongly influenced by their neighbours. Populations have always moved, but increasing numbers are moving to seek employment and better living conditions. Thus wealthy countries attract people from poorer neighbouring countries and this can cause social problems in both countries. Similarly, environmental and other political decisions taken in one country can affect its neighbours. If one country introduces very strict industrial effluent laws, some polluting industries may relocate to neighbouring countries. If over-exploitation uses up a particular natural resource in one country it may lead to increased exploitation in neighbouring countries to supply the market.

Toxic spills in a river can affect water quality and aquatic life far downstream

Where countries share river basins, the potential for the actions of one country to influence another is even more acute. Upstream countries may divert water, reducing availability for downstream users. Flood protection works at one site along a river may exacerbate flooding problems elsewhere, either by downstream retardation structures increasing upstream flooding, or upstream drainage structures increasing floods downstream. Barriers erected to control saline water intrusion may impede the movements of anadromous and catadromous fish that move between the river and the sea, thus affecting upstream fisheries, while pollution from upstream sources may impact on downstream fisheries.

If people from several countries are to live peacefully and equitably within a river basin it is obvious that there must be a spirit of transparency, trust and cooperation both within and between countries. If development is to be successful within river basins, it is also clear that development must take a basinwide perspective if it is to help in reducing, rather than intensifying, tensions between countries.

Within the Mekong River Basin, building cooperation is particularly challenging. Extensive development is required to raise the standard of living of the people, which means that there is the possibility of intense competition for resources, both natural and economic, if development is not carefully managed. The countries that share the basin have profound differences in their political, economic and social systems. Some have long histories of political conflict, and the past ten years represent the only time in recent history that all have been at peace.

Barriers to stop sea water intrusion may prevent fish moving between the river and sea

2. Beginnings of cooperation – the Mekong Committee[1]

Formal cooperation commenced relatively early in the Mekong Basin. In 1957 the Committee for Coordination of the Investigation of the Lower Mekong Basin, known as "The Mekong Committee" was established. Members were Cambodia, Lao PDR, Thailand and Viet Nam, and the agency was set up with the assistance of ECAFE, the Economic Commission for Asia and the Far East (now called ESCAP, the United Nations Economic and Social Commission for Asia and the Pacific).

ECAFE and the Mekong Committee undertook extensive studies in the lower basin

In the era of post-World War II reconstruction, the plan was to develop one of the world's great 'untamed' rivers, and the 'Mekong Project' was the largest single project undertaken by ECAFE. In 1965, U Thant, Secretary General of the United Nations, described it as "…one of the most important and one of the most significant actions ever undertaken by the United Nations".

The founding statute establishing the Mekong Committee was itself groundbreaking. No international river body had previously been given such a broad mandate. It included responsibilities for financing, construction, management and maintenance of projects on the river.

Mekong Committee logo

Under the auspices of ECAFE and the Mekong Committee, a series of surveys were conducted to "gather sufficient data to permit adequate planning" for development of the Mekong. Surveys of the basin's geology, hydrology, meteorology, topography, sedimentation, fisheries, agriculture and navigation were completed in the 1950s and 1960s. This led to the development of the Mekong Committee's Indicative Basin Plan in 1970, which identified 180 potential projects worth an estimated $12,000 million.

In the years that followed, for a variety of reasons, including conflict in some of the Basin's countries, few of the Mekong Committee's ambitious projects were ever realised. However, the Plan did lay the foundations for the Lower Mekong governments' involvement in natural resource planning.

In the late 1970s, lack of political stability in the region led to the interruption of Mekong Committee sessions. As a consequence, in 1977, Lao PDR, Thailand and Viet Nam adopted a new statute to establish an Interim Mekong Committee to allow activities to continue. The statute provided for the reactivation of Cambodia's membership, which was requested in 1991. The request led to lengthy discussion that resulted in the transformation of the Mekong Committee into the Mekong River Commission through the 1995 Agreement.

3. The Mekong River Commission [2]

The "Agreement on the Cooperation for the Sustainable Development of the Mekong River Basin" was signed at Chiang Rai, Thailand on the 5th April 1995. The agreement broadened the focus of Mekong cooperation from the development of large-scale projects to sustainable development and the management of natural resources.

The Mekong River Commission (MRC) differed significantly from the Mekong Committee that preceded it because it was no longer under the direction of the United Nations. The overall management responsibility is vested in a ministerial council which appoints the Chief Executive Officer. The CEO reports to a Joint Committee of senior government officials of the member countries who in turn report to the Council.

To demonstrate their commitment to the Mekong River Commission, in 2000 the member countries agreed to increase their annual contributions to the Commission's operating budget. They plan to incrementally take over the financing of all core activities by 2014. The Council adopted a vision for the basin and a mission statement committing the organisation to equitably sharing resources and sustaining the environment and human welfare.

MRC's Vision for the Mekong Basin: An economically prosperous, socially just and environmentally sound Mekong River Basin

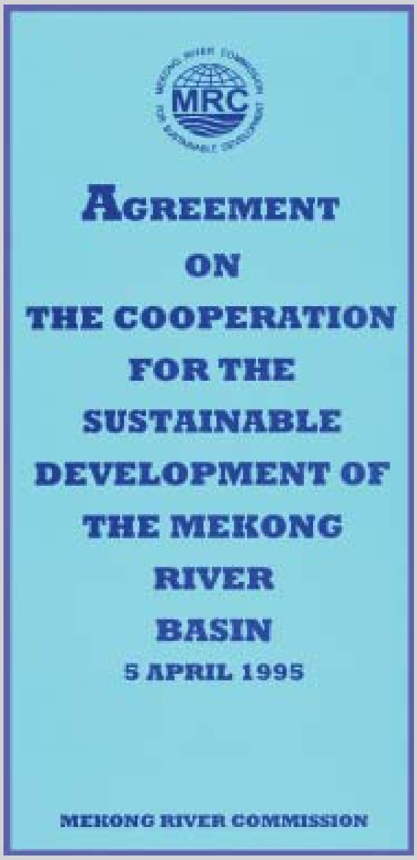
MRC's Mission Statement: To promote and coordinate sustainable management and development of water and related resources for the countries' mutual benefit and the people's well being by implementing strategic programmes and activities and providing scientific information and policy advice

The 1995 Agreement on Cooperation for the Sustainable Development of the Mekong Basin[3]

The 1995 Agreement is a relatively short document that codifies general principles of international water law and emerging principles of international environmental law. It also provides a basis for cooperation, which will be robust enough to enable decision-making under a variety of conditions.

Similar to the 1997 United Nations Convention on the Law of the Non-Navigational Uses of International Watercourses, the 1995 Agreement is a framework agreement that needs to be further developed by adopting various technical rules and procedures through a dynamic consensus-building process. It is common international practice, especially with resources shared by more than two countries, to set up a framework agreement and agree to develop additional rules or standards through subsequent studies and negotiations, or to separate technical standards from the basic treaty.

Under the 1995 Agreement, all decisions must be adopted by a unanimous vote, unless otherwise decided by MRC's governing bodies. In practice, decisions are reached by consensus through a process of consultation and negotiation that balances the interests of all stakeholders and seeks acceptable solutions for all parties without any vote required.


MRC
AGREEMENT ON THE COOPERATION FOR THE SUSTAINABLE DEVELOPMENT OF THE MEKONG RIVER BASIN
5 APRIL 1995
MEKONG RIVER COMMISSION

The 1995 Agreement significantly broadened the focus of Mekong Cooperation

If disputes arise, the agreement provides for a four-step process. At the first level, MRC's governing bodies, its Council and Joint Committee, attempt to resolve the dispute. If the dispute cannot be resolved at that level, then diplomatic channels are used to negotiate among the governments concerned. If diplomacy fails, then third-party intervention takes place that includes fact-finding missions and mediation. Finally, if all these efforts fail, principles of international law are applied. These provisions are a considerable change, as the Mekong Committee, which preceded MRC, never considered contentious items.

Cooperative decision-making is assured by MRC's structure. The four countries are equally represented on the two bodies that govern the Mekong River Commission – the MRC Council and the MRC Joint Committee. The MRC Council, which is comprised of one cabinet-level minister from each country and meets once a year, sets the overall policy for the organisation. The Joint Committee, which is comprised of one member at director-general level from a water resources line agency in each country, meets at least two times a year to approve MRC annual work plans and oversee the financial management of the organisation. The Secretariat undertakes the work of the Commission and provides administrative and technical support.

National Mekong Committees (NMCs) were originally established under the Mekong Committee to coordinate implementation of projects at the national level. Today each NMC provides support to its national members of MRC's Council and Joint Committee. The NMCs also play an increasingly important role in coordinating MRC's work at the national level and in implementing MRC programmes in conjunction with line agencies.

4. Cooperation to promote economic development

UN-ESCAP, the United Nations Economic and Social Commission for Asia and the Pacific, is the agency with the longest history of promoting economic development in the Mekong Region. With an ambit far broader than just the Mekong, ESCAP was established in 1947 as the Economic Commission for Asia and the Far East (ECAFE) to assist in post-war reconstruction. It serves countries in the Asia Pacific Region, including all six Mekong Basin countries. Although ESCAP covers a broad territory, it has a long history of fostering cooperation in the Mekong Region, with ECAFE being instrumental in setting up the Mekong Committee and ESCAP establishing the Asian Development Bank, an important contributor to Mekong Basin economic cooperation.[4]

Although ESCAP's involvement in the Mekong Basin declined in the 1970s and 1980s, as did the work of the Mekong Committee, in the last few years, ESCAP has again had basin-oriented programmes. In 2000, at its annual Commission Session, ESCAP declared 2000-2009 the Decade of Greater Mekong Sub-region Development Co-operation. The goal of the decade is to draw attention to the region and encourage international support in intensifying economic and social development in the region.[5]

MRC's Secretariat carries out the work of the Commission and provides administrative and technical support

ASEAN, the Association of Southeast Asian Nations, is another organisation that fosters economic linkages in the Mekong Basin. Set up in 1967 to promote free-market principles and improve standards of living, ASEAN includes all the countries in Southeast Asia. The original members of ASEAN were Indonesia, Malaysia, Thailand, the Philippines and Singapore. Brunei joined nearly 20 years later in 1984, Viet Nam in 1995, Lao PDR and Myanmar in 1997, and Cambodia in 1999.

In keeping with ASEAN's focus on raising standards of living and closing the gap between the original members and the newer (and poorer) ones, in 1996, ASEAN inaugurated the Basic Framework of ASEAN-Mekong Basin Development Cooperation (AMBDC). This framework lays out the objectives and principles for cooperation, and also identifies infrastructure, trade and investment activities, agriculture, forestry and minerals, industry, tourism, human resource development, and science and technology as priorities. It also seeks to complement the development initiatives of other Mekong-related multilateral institutions. Several AMBDC meetings have been held since 1996 and identified possible AMBDC projects, including the Singapore-Kunming Rail Link Project. Momentum for these projects lagged in the aftermath of the 1997 Asian Financial Crisis, but has recently increased again. Recent discussions have considered expanding AMBDC's core membership to include Japan and Korea. [6]

The largest of the programmes promoting regional economic cooperation in the Mekong area is the Greater Mekong Subregion (GMS) Economic Cooperation Programme.[7] This was established in 1992 by the Asian Development Bank to realise and enhance development opportunities; encourage trade and investment among GMS countries; resolve or mitigate cross-border problems; and meet common resource and policy needs. All four Lower Mekong Basin countries are members, as well as Myanmar and Yunnan Province of China.

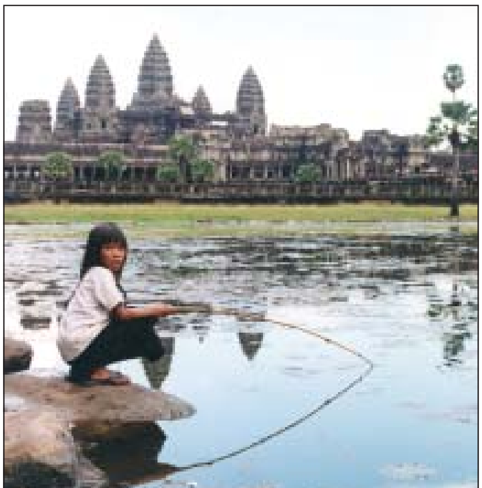
In its first decade, the GMS Programme promoted economic cooperation in eight sectors: transportation, energy, telecommunications, human resource development, tourism, environment, trade and investment. In 2002, agriculture and water resources management were added as additional sectors.

Lack of transportation infrastructure in the LMB impedes economic development

At the end of 2002, GMS investment totalled about $2,000 million. A few examples of ADB/GMS projects include a network of roads now under construction that will link all six GMS countries with each other and with seaports. When completed, these highways will be promoted as "economic corridors" – geographic areas where infrastructure improvements are linked with production, trade and other development opportunities. GMS agreements are also reducing non-physical barriers such as customs regulations that impede the flow of goods, vehicles and people. In the energy sector, the GMS programme is encouraging subregional cooperation in developing fossil fuel and hydropower projects as well as a subregional power network that will facilitate sales of electric power from one GSM country to another. In the telecommunications sector, projects include upgrading infrastructure, creating common standards, and adjusting regulations, policies, and tariffs to facilitate communications. Tourism is another important area of regional cooperation, as are initiatives to promote trade and investment and to sustain the environment.

The ADB/GMS programme is an important contributor to regional cooperation not only because of the resources the programme can mobilise to foster and strengthen cooperation, but also because it promotes cooperation among all six Mekong Basin countries.

Recognising the importance of private sector involvement in strengthening economic linkages in the basin, ESCAP, in partnership with ADB/GMS, established the GMS Business Forum.[8] This independent, non-governmental body brings together representatives from industry and national chambers of commerce in all six Mekong countries and develops local private sector capacity. Chambers of commerce from developed countries outside the region have been encouraged to join as well so that the Forum articulates private sector perspectives from both inside and outside the GMS sub-region. ESCAP and ADB/GMS have also collaborated in establishing the Mekong Tourism Forum, which brings the six Mekong countries together to plan ongoing tourism initiatives, including an annual exhibition and conference.[9]



Tourism is an area with strong potential for regional cooperation

5. Cooperation to promote environmental sustainability

A number of international organisations have developed basin-level initiatives to promote environmental sustainability and natural resource conservation. These include the World Conservation Union, the World Wide Fund for Nature (WWF) and Oxfam. All of these agencies have long histories of promoting cooperation to sustain the environment in individual Mekong countries, but fostering regional cooperation is a relatively new initiative.

The World Conservation Union (IUCN)[10] has recently developed an Asia programme that focuses on conservation of forests, bio-diversity and aquatic ecosystems. Thailand was one of the original signatories to the IUCN Charter, and in the early 1960s IUCN assisted the government in setting up Thailand's National Park system and developing legislation concerning wildlife. In the 1980s and 1990s, IUCN played similar roles in the other three Lower Mekong countries and has worked with them on preparations to sign and implement international agreements such as the Ramsar Convention and the Convention on Biological Diversity.

In the 1990s, with the coming of peace to the LMB and the planning of large-scale infrastructure projects such as regional highways and dams, IUCN has been helping governments and development agencies to conduct baseline studies in environmentally-fragile areas such as wetlands and watersheds. IUCN has also been working with local communities in fragile areas to develop sustainable livelihoods such as eco-tourism.

Pressure to develop resources is growing rapidly in the LMB

In 2003, in partnership with MRC and UNDP, IUCN began a five-year, $32.6 million programme to promote regional cooperation in assessing and conserving biodiversity. *The Mekong River Basin Wetland Biodiversity Conservation and Sustainable Use Programme* is being funded by the Global Environment Fund through UNDP. Working in demonstration areas within the four lower Mekong basin countries, the programme will include components to determine the economic value of biodiversity in the Mekong Basin and test the suitability of incentives to preserve biodiversity. A study of environmental flows will identify the water quantity and water quality requirements of Mekong River and flood plain ecosystems and determine how to ensure that these requirements are considered in planning and managing water resources development.[11]

The World Wide Fund for Nature, like IUCN, has a long history of promoting cooperation among multiple stakeholders and has been working in the Lower Mekong Basin for more than a decade. In 2002, WWF launched its five-year Indochina Strategy that encompasses Cambodia, Lao PDR and Viet Nam. The goal of this strategy is to ensure that biological diversity is valued and conserved by current and future generations. To identify priority conservation problems and develop realistic solutions, WWF promotes collaboration among LMB government agencies, local communities, mass organisations and international agencies. WWF has also identified the Mekong River as one of its Global 200 Highest Priority Ecoregions and featured the Mekong as one of five "Living Rivers" in its worldwide "Living Waters Campaign".[12]

In 2002, MRC and WWF signed a memorandum of understanding that allows the two organisations to work together in areas of common interest that include: promotion of the Mekong's natural richness rather than just its short-term economic potential; sustainable agricultural practices; conservation of threatened species; sustainable watershed management; sustainable use of natural resources; promotion of wetland conservation and restoration; consideration and promotion of renewable energies and energy conservation; and development that meets the needs of the people but at the same time ensures the long-term sustainability of the river and its related resources.[13]

IUCN, WWF and Oxfam are all working at the community level to ensure that local people are involved in planning resource development

Oxfam works with local partners in more than 100 countries to achieve greater impact in addressing issues of poverty and related injustice around the world. Projects focus on humanitarian relief, community-driven development and social justice. In the Mekong Basin, the Oxfam Mekong Initiative (OMI)[14] works in all six Mekong countries on four thematic issues: trade, poverty reduction, infrastructure, and capacity building. At a time of rapid development with transboundary impacts, OMI works with local-level NGOs to ensure that people have a voice in planning, managing and monitoring what happens to their resources and their communities.

The initiatives of all the agencies just described are strengthening the capacity of governments, civil society groups and other key stakeholders to work together at a regional level in finding solutions to basin-wide and transboundary environmental problems and continuing this collaboration for the long term.

There are still very few bridges across the Mekong

6. Challenge of cooperation

The Mekong Basin is a complex region politically, socially and in terms of its environment. There are many players: international organisations such as ASEAN, ESCAP and MRC, six national governments, and many provincial and local level government organisations. In addition there are organisations providing development support, including the World Bank, the Asian Development Bank and many donor countries. Civil society organisations complete the mix, and these range from large international organisations such as IUCN, WWF and Oxfam to small local groups including unions, cooperatives and conservation groups.

Previous attempts at regional planning such as the Mekong Committee's Indicative Basin Plan in 1970 are seen as having had limited success. There are a number of possible contributing factors. Clearly any planning process must achieve some sort of consensus on what the basin should be. The technical aspects of planning, development and environmental management are relatively simple in comparison with the challenge of identifying the preferred outcome for the basin.

One can envisage two extremes along a development spectrum. At one end, a completely pristine basin with intact ecosystems and almost no people – a kind of wilderness. At the other extreme a basin covered in concrete and factories, with a polluted river reduced to a chain of reservoirs. Neither extreme would be acceptable to most of the people in the basin – but the challenge lies in achieving consensus on what point, between the extremes would be acceptable. What kind of river, what kind of environment, do the people of the basin want?

The six countries within the Mekong Basin have different national development goals. The visions of development held by national governments do not always accord with development visions of people at the village level. Plans of government agencies may not match the views of civil society groups. There is now broad recognition throughout the world that successful planning must be inclusive, and take into consideration the needs and aspirations of all the stakeholder groups.

The Mekong River system is still in good condition and basin wide cooperation at all levels is crucial to ensure that it stays that way

The MRC Basin Development Plan project is one recent initiative that is working to develop an inclusive planning process. However, the achievement of that goal will not be easy. Even in developed countries with far greater resources of time and money, inclusive planning processes have been difficult to achieve. Inevitably the plans produced leave some stakeholder groups dissatisfied, and usually no group achieves all it wants.

The first step in effective planning is to build cooperation across the basin. There is a need for greater understanding, trust and breadth of vision. The advantage that the Mekong Basin has over many other regions is that a start has been made while the river is still in good condition, and there are still sufficient natural resources available in the basin. It should be easier to limit degradation and loss of resources than to restore degraded systems. However, the longer we wait the more difficult it becomes.

Endnotes

[1] MRC 2002
[2] Sokhem 2002
[3] Sokhem 2002
[4] Dore 2001
[5] UN-ESCAP 2000
[6] MITI 2001
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[8] GMS-BF 2001
[9] Dore 2001
[10] IUCN 2002
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