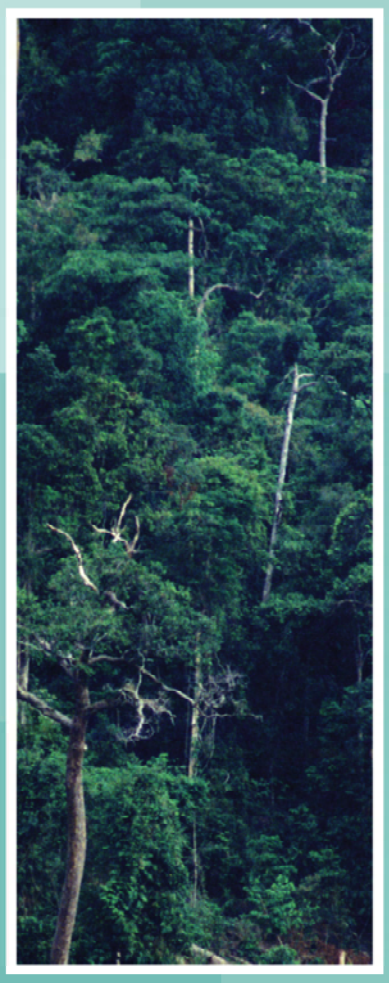

The MRC Basin Development Plan

Regional Sector Overviews

BDP Library Volume 14

November 2002
Revised September 2005

Mekong River Commission

BDP

The MRC Basin Development Plan

Regional sector overviews

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November 2002, revised September 2005

Mekong River Commission

Foreword

The BDP Library was compiled towards the end of Phase 1 of the BDP Programme. It provides an overview of the BDP formulation, together with information about the planning process and its knowledge base, tools and routines.

The library incorporates the essence of more than a hundred technical reports, working papers and other documents. It consists of 15 volumes:

1 The BDP planning process

2 Sub-area analysis and transboundary planning

3 Sub-area studies (including 13 sub – volumes)

4 Scenarios for strategic planning

5 Stakeholder participation

6 Data system and knowledge base

7 MRCS Decision Support Framework (DSF) and BDP applications

8 Economic valuation of water resources (RAM applications)

9 Social and environmental issues and assessments (SIA, SEA)

10 IWRM strategy for the Lower Mekong Basin

11 Monographs. March 2005

12 Project implementation and quality plan

13 National sector reviews

14 Regional sector overviews

15 Training

The work was carried out jointly by MRC and the NMCs with comprehensive support and active participation by all MRC programmes and more than 200 national line agencies. Financial and technical support was kindly granted by Australia, Denmark, Japan, Sweden and Switzerland.

The library has been produced for the purpose of the BDP and is intended for use within the BDP Programme. The work was done from 2002 to 2005, and some information may already have been superseded by new developments and new knowledge. The library does not reflect the opinions of MRC nor the NMCs.

It is hoped that the work will contribute to the sustainable development of water resources and water-related resources in support of the MRC vision of *'an economically prosperous, socially just and environmentally sound Mekong River Basin'.*

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Acronyms and abbreviations

ADB	:	Asian Development Bank
BDP	:	Basin Development Plan (of the Mekong River Commission)
EIA	:	environmental impact assessment
ESCAP	:	Economic and Social Commission for Asia and the Pacific (of the UN)
FMM	:	flood management and mitigation
GIS	:	geographical information system
GMS	:	Greater Mekong Sub-Regional Economic Cooperation Programme (of ADB)
GWP	:	Global Water Partnership
IUCN	:	The World Conservation Union
IWRM	:	integrated water resources management
LMB	:	Lower Mekong Basin (the Mekong Basin parts of Cambodia, Lao PDR, Thailand and Viet Nam)
LFA	:	logical framework approach
MCA	:	multi-criteria analysis
MRC	:	Mekong River Commission
MRCS	:	Mekong River Commission Secretariat
NGO	:	non-governmental organization
NMC	:	National Mekong Committee
NRE	:	natural resources and environment
PIP	:	project implementation plan
R&D	:	research and development
RBC/RBO		River Basin Committee/Organization
SEA	:	strategic environmental assessment
SIA	:	social impact assessment
TNA	:	training needs assessment
UN	:	United Nations
WSM	:	watershed management
WSS	:	water supply and sanitation
WUP	:	Water Utilisation Programme (of the Mekong River Commission)
WWF	:	World Wild Fund for Nature

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Chapter 11 Watershed management) is based on reports produced by the GTZ Appraisal Mission on Watershed Management in the Lower Mekong Basin (February 2002).

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Executive Summary

The regional sector overviews were prepared in 2002 as an important part of the basis for the subsequent scenario and strategy formulation.

AGRICULTURE AND IRRIGATION

Agricultural activities provide the livelihoods of the majority of the basin's population and comprise the most important use of and pressure on natural resources. Over 40 percent of the basin's land area is devoted to agriculture, and there are important relations between the ongoing expansion of the agricultural cultivation area and land use change, especially deforestation. In terms of water use, irrigation, either through the storage of receding floodwaters at the end of the rainy season, or the diversion of water from rivers and streams, comprises approximately 80-90 percent of all water abstractions in the basin.

There is scope for expanding agricultural production in the region by increasing the scale, intensity, and efficiency of production. Such a change could significantly enhance rural incomes and national macroeconomic performance. Increasing commercialization 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.

FISHERIES

The Mekong River stands third in the world as having the highest number of freshwater fish species and fourth in terms of tonnage caught. To date, there are 1,200 recorded species of fish found in the Mekong River. Many of these species are endemic to the river.

It is estimated that most of the 12 million rural households (approximately 40 million people) earn their living by rice farming and fishing. The capture fishery is the most important element in rural households in terms of nutrition and income generation. Approximately 71% of rural households (2.7 million people) in Lao PDR rely on fishing to a varying degree as a livelihood strategy. About 1,200,000 people living in fishing communes around Tonle Sap depend nearly entirely on fishing as their main occupation, with 10.7 million people in Cambodia dependent to some extent on capture fisheries. Of the 2,000,000 tons of fish consumed in the basin, two-thirds (1,750,000 million tons) are from natural water bodies and reservoirs with the remaining from aquaculture.

HYDROPOWER

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. The remainder is on the tributaries (13,000 MW in Lao PDR, 2,200 MW in Cambodia and 2,000 MW in Viet Nam). Only 5 percent (some 1,600 MW) of the Lower Mekong's hydro potential has been developed. All projects are on the tributaries, not on the mainstream.

NAVIGATION

The greater operating efficiency and lower costs of inland waterway navigation compared with other forms of transport are widely recognized. Yet, the advantages offered by IWT do not appear to have been reflected in greater use by passengers or for cargo, nor in the evolution of government plans, policies and spending priorities in such a way as to encourage its greater use. Four main factors influence the extent to which the Mekong River and its tributaries are used for transportation: economic and trade growth; the non-physical (or institutional) barriers to international navigation; the strength of competition from other transport choices (most notably from road transport) and physical restrictions such as limitations on vessel draft imposed by the maximum available water depth during the dry season or, in the case of the estuarine region, at low tide.

The review aims to provide a measurement of the value of navigation on the Lower Mekong River and its tributaries to a diverse community of users, ranging from the inhabitants of small villages to large trading and ship operating organizations. Other issues covered include the status of navigational channels and inland ports, environmental protection measures for IWT, conditions for increased international navigation, contribution of river transport to poverty alleviation, passenger and cargo traffic, IWT vessel fleets, government transport policies related to IWT development and modal shares of inland waterway transport versus those of competing transport.

TOURISM DEVELOPMENT

Southeast Asia – and the Mekong Basin in particular – is one of the fastest growing tourism destinations in the world. To date, tourism activities are largely restricted within the geographical boundaries of each LMB country, although national tourism products are complementary to one another. Tourism authorities would like to offer the region as a 'single destination' and countries are discussing plans to integrate visa policies. Ecotourism and sustainable development of tourism are regional priorities.

Tourism is increasingly multi-country with national and regional initiatives to promote the Mekong region as a single destination. For example, with more integrated air access, people are able to travel to several countries during a visit to the region. In line with worldwide trends, there is an increased regional and national demand in the Mekong region for different types of ecotourism – nature-based, cultural and water-based tourism.

Sustainable development of tourism will assess economic opportunities in the context of the carrying capacity of natural and cultural resources to support tourism, as well as greater emphasis on equitable distribution of economic benefits.

DOMESTIC WATER SUPPLY AND SANITATION

Domestic water supply and sanitation (WSS) is often seen as a national responsibility, with few transboundary implications because domestic water supplies usually represent small volumes relative to total withdrawals. Three aspects of domestic water use make it a regional concern:

- Demand for domestic water use is universal;
- Wastewater disposal may contaminate water for downstream users; and,
- Social and economic consequences of disruption of supply are very serious.

INDUSTRIAL WATER USE

The Mekong River Commission's sector programmes do not cover the water supply sector, and the Secretariat knowledgebase on this aspect is limited. Therefore, it is foreseen that more research on industrial aspects will be needed.

Industrial development in the Lower Mekong Basin is at an early stage, however, urbanization is rapid and the growth rate of the industrial sector is high. Northeastern Thailand and the Mekong Delta are the most advanced industrial areas in the region. Industrial development in Cambodia and Lao PDR is almost exclusively taking place in the capital municipalities, Phnom Penh and Vientiane.

FLOOD MANAGEMENT AND MITIGATION

Floods are a recurring event in the Lower Mekong Basin (LMB). Each year, flooding results in loss of life and property, damage to agriculture and rural infrastructure and disrupts the social and economic activities of people living throughout the LMB. At the same time, flooding of the mainstream and tributaries of the Mekong River is an important reason for the wealth in biodiversity, abundance of fish and soil fertility.

Flood management and mitigation (FMM) has become a priority issue at the national and regional levels within the LMB, particularly in the aftermath of the disastrous floods of 2000 and 2001. This regional overview summarizes the characteristics, issues and trends affecting flooding and the roles and orientations of the different national and regional "players" promoting more effective and integrated approaches to FMM.

WATERSHED MANAGEMENT

The sub-watersheds of the Mekong River in the four LMB countries have experienced rapid deforestation and watershed degradation, particularly in the upland regions. As a result, a number of serious environmental and socio-economic problems have developed, including increased run-off, erosion, siltation, and the loss of rural livelihoods. LMB governments have attempted to respond to these problems through new policy and legislation, reforestation programs and other forms of watershed management. However, the WSM process faces numerous challenges.

Firstly, national-level planning procedures and guidelines tend not to reflect a watershed perspective. Although significant amounts of regulation have been generated over the last decade, much of it is not relevant and stems from government efforts focused on other issue areas such as agriculture or forestry. As a result, there are many contradictory, unclear, and insufficiently supported regulations and policies. All four countries have many government organizations and agencies involved with WSM, but none has a clear national locus of authority. This situation creates a need for high levels of coordination, which is made more difficult by the sectoral thinking of most government agencies. Many of the relevant agencies are understaffed and lack experience in WSM.

There have also been difficulties incorporating local participation into the watershed management process, although all four countries are gradually moving towards decentralization of natural resources management. Along with government WSM efforts, there are also numerous bi- and multi-lateral projects, often pilot projects and capacity building initiatives, as well NGO activities, which generally involve local endeavours to increase community participation in natural resources planning.

1 Introduction

The MRC Basin Development Plan (BDP) was instituted by the April 1995 Mekong Agreement. Following a series of preparatory studies, the BDP project document was approved by the MRC Council in October 2000. The BDP formulation (Phase 1) started in October 2001 and is scheduled for completion in July 2006.

The present report present information collected and observations made during a series of regional sector studies in 2002.

The studies cover the sectors with major relevance in the context of the BDP, as identified during the BDP programme formulation:

- Agriculture and irrigation;
- fisheries;
- hydropower;
- navigation;
- tourism development;
- industrial water use;
- flood management and mitigation; and
- watershed management.

Between them, the sector studies are intended as a starting point for a process that will lead to integrated (and inter-sector) analysis and planning.

1.1 Origin of document

The document is a compilation of 8 separate documents[1] that were prepared by the MRC BDP team, with comprehensive support and active participation by the other MRC programmes:

MRC-BDP (Nov 02a): Regional sector overviews, executive summary. Working paper

MRC-BDP (Nov 02b): Regional sector overviews, fisheries. Working paper

MRC-BDP (Nov 02c): Regional sector overviews, tourism development. Working paper

MRC-BDP (Nov 02d): Regional sector overviews, agriculture and irrigation. Working paper

MRC-BDP (Nov 02e): Regional sector overviews, watershed management. Working paper

MRC-BDP (Nov 02f): Regional sector overviews, hydropower. Working paper

[1] Publications BDP-012-1 to 012-7, Nov 2002

MRC-BDP (Nov 02g): Regional sector overviews, navigation. Working paper

MRC-BDP (Nov 02h): Regional sector overviews, domestic water and sanitation, and industrial water use. Working paper

MRC-BDP (Nov 02i): Regional sector overviews, flood management and mitigation. Working paper

1.2 Basis and context

1.2.1 Link/relationship of subject to IWRM

While IWRM involves a holistic and cross-sector perspective, a lot of the basic information and knowledge is related to individual sectors. This is the case for a large part of the data and trend analyses, as well as the institutional framework. Also, important development opportunities and constraints exist not only among sectors, but also to a high degree within each individual sector.

The value of good water management increases when its context is duly observed. In relation to economic and social development, water availability is an important determinant, but still only one among several other important ones, some of which are related to one sector (or a few sectors) only. For example for agricultural development - a priority of all four MRC member countries - the water availability is important, but so are other sector-specific factors, such as access to new technology, and good distribution networks and market systems.

The integrated perspective is not an alternative to the sector perspective, but rather an expansion and over-all framework for development that will in many cases take place within each of those sectors that in some way or another are influenced by the availability of water.

1.2.2 Link/relationship of subject to BDP Inception Report

The BDP Inception Report (July 2002) retains the stage-wise approach to BDP formulation that had been identified during the programme formulation:

Stage 1 - analysis of the LMB and of sub-areas

Stage 2- analysis of development scenarios

Stage 3- strategy formulation

Stage 4 - compilation of long-list of programmes and projects

Stage 5 - compilation of short-list of programmes and projects

The regional sector overviews are one of the Stage 1 activities.

1.2.3 Link/relationship of subject to other BDP reports / activities

The regional sector overviews were initiated following an information needs assessment carried out in 2002 with the objective of identifying the data and knowledge needed for subsequent activities.

The work was one among several other activities to build a knowledge-base for the planning. National sector reviews were reported by the NMCs from May 2003 to April 2004, and the

comprehensive sub-area studies (totalling 15 reports) were published by the NMCs between July 2003 and October 2004.

The results have been carried forward to the subsequent scenario analyses and strategy formulation in stages 2 and 3 of the planning process.

1.2.4 Link/relationship of subject to BDP's Logical Framework Matrix

The work builds on results of activity 1.3.1 (Information needs assessment) in the LFA matrix for BDP Phase 1. It contributes to the following outputs:

Output 2.1: Sub-area studies

Output 2.2: 20-year scenarios

Output 2.3: Sub-area strategies

Output 2.4: Basin-wide strategies

1.3 Significance

1.3.1 Significance of subject for strategic planning

The regional sector overviews contribute to an insight that is a necessity in connection with strategic water resources planning: Baseline conditions, trends, development opportunities, constraints (including inter-sector constraints), and development policies and planned initiatives, whether sector-wise or integrated.

1.3.2 Significance of subject for Mekong Basin

The main perspective of the BDP is IWRM at the basin scale, and the regional sector overviews were been prepared accordingly.

The basinwide significance is achieved by placing local and national sector information and sector development issues in a regional context. This is one step towards an understanding of regional (and inter-sector) synergies and trade-offs that can contribute to a healthy regional development in its own right, as well as by adding value to the many development programmes at the national level.

1.3.3 Significance of subject for MRCS / BDP 1

Together with the subsequent national sector reviews and the sub-area studies, the regional sector overviews have formed a platform for scenario analysis of inter-sector dependencies (synergies and constraints), as well as for the preparation of a holistic, integrated IWRM Strategy[2] and for identification of viable development projects.

[2] In preparation (mid 2005)

2 Summary of approach

An information needs assessment for the BDP was carried out in early 2002. It provided an initial overview of the information that was relevant in connection with the BDP formulation, mainly comprising aggregated data and analyses (for example of water availability and projected water demands), socio-economic information, and information related to sector development needs and options and regional sector strategy formulation, as well as information about related development projects and plans.

In many cases, the required information was available from the national 5-years plans and sector plans. Other information was acquired from literature, and from international development banks and other development organisations. A substantial volume of information was readily available (or was in preparation) within the MRC Secretariat.

The regional sector overviews were prepared in parallel with the MRC State of the Basin Report (MRC June 2003), which to some extent follows the structure of the sector overviews. In some cases, the various authors worked on the same subjects, and otherwise, the work took place in a close collaboration

3 Agriculture and irrigation

3.1 Overview

Agricultural activities provide the livelihoods of the majority of the basin's population and comprise the most important use of and pressure on natural resources. Over 40 percent of the basin's land area is devoted to agriculture, and there are important relations between the ongoing expansion of the agricultural cultivation area and land use change, especially deforestation.[3] In terms of water use, irrigation, either through the storage of receding floodwaters at the end of the rainy season, or the diversion of water from rivers and streams, comprises approximately 80-90 percent of all water abstractions in the basin.[4]

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 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.

There are great variations in productivity, with rice yields in upland Lao PDR about, 1.55 ton/ha, compared to approximately 5 ton/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 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.

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 problems with contaminating runoff from fertilisers and pesticides affecting downstream water uses.

[3] MRC (2001)

[4] FAO (1997, 1999a, 1999b, 1999c)

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.

Low productivity and institutional limitations keep agricultural incomes low, and rural poverty remains common across the region. There are many social problems connected with the sector including gender work and income disparities, rural-urban migration and rural-rural migration, landlessness, rapid population growth, and increasing land and resource scarcity.

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

There is scope for expanding agricultural production in the region by increasing the scale, intensity, and efficiency of production. Such a change 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.

3.2 Economic significance

Agriculture is the single most import economic activity in the Lower Mekong Basin (LMB). 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.[5] The tables below show the contributions of the sector to GDP and national exports in the basin area.[6]

[5] MRC (1997), p 5-1

[6] Unless otherwise specified, statistics in this paper referring to the "basin area" cover the Northeast region of Thailand, the Mekong Delta, and Central Highlands provinces of Viet Nam, and all of Lao PDR and Cambodia.

Table 3.1: Contribution of Agriculture and Forestry to GDP

	Cambodia		Lao PDR		Thailand		Viet Nam*[7]	
	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[8]	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%**	**38.7%**	**23.6%**

Source: Lao PDR Ministry of Agriculture and Forestry (2000), Thailand National Statistics Office (2000), Viet Nam General Statistical Office (1999), IMF (2002a), IMF (2002d)

* Includes entire country rather than only Mekong Basin Area

Table 3.2: 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%

Source: Thailand National Statistics Office (1997, 2001), Viet Nam General Statistical Office (1999), IMF (2002a), IMF (2002b)

* Includes entire country rather than only Mekong Basin Area

The differences between the countries reflect varying levels of industrialisation, with agriculture and forestry contributing considerably less to exports and 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 nation-wide aggregates, which understate the importance of agriculture in the basin region, particularly in the Mekong Delta area, 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.[9] 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.[10] 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.

[7] In the case of Thailand or Viet Nam, the "*" symbol indicates that data for the entire country rather than the basin region alone are used. In all other case data cover only the Northeast region of Thailand and the Mekong Delta and Central Highlands regions of Viet Nam. Data for Cambodia and Lao PDR always cover the entire country.

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

[9] UNDP (2002)

[10] KOICA (2000), p 21

In Lao PDR the declining relative importance of agriculture reflects the fact that growth in this sector has lagged that for 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.[11] However, despite national rice self-sufficiency, there are serious rice shortages up to 6-8 months per year in a number of provinces.[12] While agriculture and forestry comprise a high proportion of Lao PDR employment and GDP, their contribution to national exports is lower than might be expected in a pre-industrial economy because of the large amounts of hydropower sold to Viet Nam and Thailand.

Between 1995 and 1999 the importance of agriculture to the Cambodian economy has 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.[13] 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 ton, approximately 15 percent above national requirements.[14] 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. There are provinces that have chronic shortages despite national sufficiency.[15] Furthermore, the overall margin of surplus is comparatively thin and the situation could go into deficiency easily due to flood or drought. There is thus an ongoing need for emphasis on promoting food security.[16] With food security a major concern, Cambodia has not exported rice or other food crops in considerable quanties over the past decade. The bulk of export receipts 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 80 percent of exports in 1999.[17] Almost all of Cambodia's non-forestry agriculture sector exports are dry rubber.[18]

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 has increased by 12 percent between1995 and 1999 in Cambodia, by 22 percent in Lao PDR, 10 percent in Thailand, and 19 percent in Vietnam.[19] The trend is thus not one of contracting agricultural sectors but rather of agricultural growth lagging growth in the manufacturing and services sectors.

In all four countries the agriculture, forestry, and fisheries sector is by far the largest employer. For Cambodia and Lao PDR, agriculture is of greater importance as a source of employment for women than men. This situation reflects the fact that a wider range of non-agricultural employment options are open to men, and rural men are more likely than women to migrate to urban areas in search of work. However, there is evidence to suggest that the

[11] Lao PDR Ministry of Agriculture and Forestry (1999), p 15-17

[12] Lao National Statistical Centre (1999)

[13] IMF (2002a)

[14] Cambodia National Institute of Statistics (2000), p 6

[15] FAO/MAFF (1999); FAO/WFP (1999)

[16] Cambodia Ministry of Planning (1996)

[17] IMF (2002a)

[18] IMF (2002a), p 25

[19] IMF (2002a); IMF (2002b); IMF (2002c); IMF (2002d)

proportion of women migrating to cities is rapidly increasing.[20] Also, in Lao and Cambodia, where the urban-based garment industry is important, women make up as much as 95% of the labour force of this industry. The parity suggested by the figures for Thailand may be misleading because mine and quarry workers (traditionally male dominated occupations) are aggregated with agricultural workers.

Table 3.3: Employment by Gender in the Agriculture, Forestry and Fisheries Sector

	Cambodia 1998	Lao PDR 1995	Thailand 1999[21]	Viet Nam*
Share of Employment				
Women	82.4%	89.5%	68.3%	-
Men	70.5%	81.2%	68.3%	-
Total	76.6%	85.5%	68.3%	63.6%

Source: Lao PDR Ministry of Agriculture and Forestry (2000), Thailand National Statistics Office (2000), Cambodia National Institute of Statistics (1998), IMF (2002d)

* Includes entire country rather than only Mekong Basin Area

3.3 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.[22] 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 3.4: Land Use in the Lower Mekong Basin in 1997

Land Cover	Lao PDR	Cambodia	Thailand	Viet Nam Delta	Viet Nam Highlands	Viet Nam Total
Forest	40%	54%	16%	0%	43%	21%
Woodland / grassland	42%	15%	3%	0%	25%	13%
Agriculture	14%	23%	79%	84%	29%	57%
Wetland/water	1%	5%	1%	10%	0%	5%
Other	2%	0%	0%	4%	0%	2%

Source: MRC Land Cover Dataset

[20] Thailand National Statistical Office (1998)

[21] Thailand employment figures also include quarry workers and miners

[22] MRC (2001)

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 Vietnam 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 the extent of agricultural land has been increasing at the expense of forest land over the 1990s.

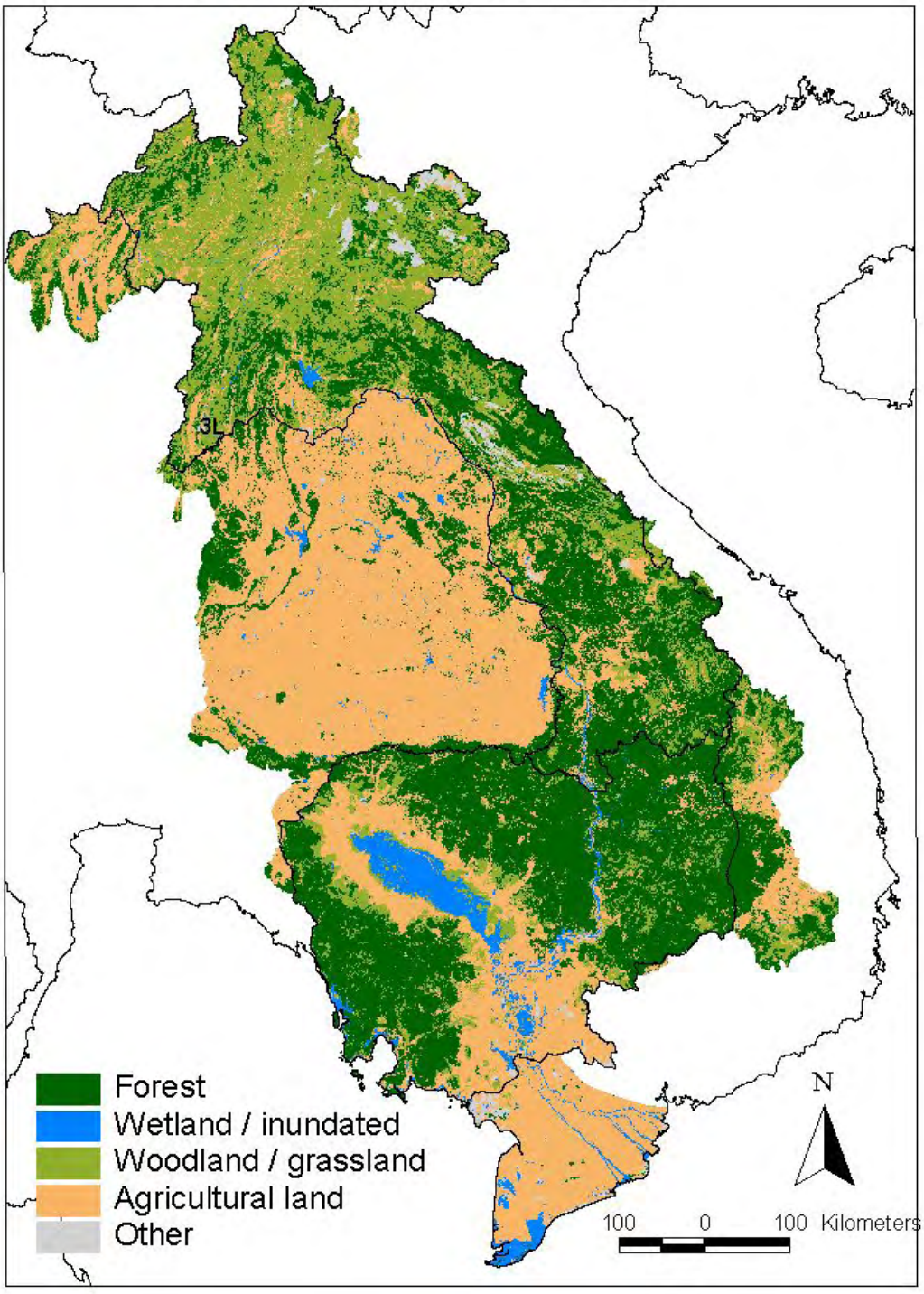
The soil quality of land used for agriculture varies substantially across the basin. Areas of soil with few limitations to development (deep, non-gravely with medium-high fertility) are not extensive, but do occupy nearly 20% of the whole basin area.[23] A preliminary land suitability assessment prepared by the MRC Land Resources Inventory for Agricultural Development Project indicated that for paddy rice, upland crops, and tree crops, 70-75% of the basin land is suitable. However, the majority of this area is only marginally suitable for such cultivation.[24] Furthermore, there is, according to the methodology used, a complete 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. The data are only preliminary at this stage and further study is required before firm conclusions about the potential for future agricultural development based on land suitability can be drawn.

[23] MRC (2002d), Executive Summary

[24] MRC (2002d), p56

The landcover in the basin in 1997 is shown in the map below.

Map 3.1: Landcover in 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.[25] While considerable effort has been invested into mine clearance, 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.[26]

Estimates of arable land in the 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. [27] 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.[28] Conceptually, Lao PDR can be divided into two distinct categories of land area which support dual agricultural economies.[29] 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 agricultural inputs are increasingly delivered through commercial channels and farmers 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 capital annual income is 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.[30]

In Viet Nam there are major land-use differences between the Mekong Delta and Central Highlands regions. The delta consists of almost entirely (84 percent) 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.[31] 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 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

[25] MRC (1997), p 5-1

[26] Desbarats & Sik (2000)

[27] MRC (1997), p 5-2; MRC (2001); Lao PDR Ministry of Agriculture and Forestry (1999), p 7; Lao PDR Ministry of Agriculture and Forestry (2000)

[28] MRC (1997), p 5-2

[29] Lao PDR Ministry of Agriculture and Forestry (1999), Executive Summary

[30] Lao PDR Ministry of Agriculture and Forestry (1999), Executive Summary

[31] KOICA (2000), p 21

Mekong tributaries. The soil is generally low in fertility and highly saline.[32] 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.

3.4 Agricultural methods and production

3.4.1 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 and 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 also (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.[33]

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 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, the Central Highlands. This trend is likely to accelerate as governments stress increased regional and global economic integration and 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 have the double challenges of ensuring food security and transitioning into market-oriented, commercial agriculture, which is likely to ensure that the process of change is a slow one in these countries.

3.4.2 Irrigation

Irrigation is any process other than natural rainfall, which 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 refers in reality to irrigated rice. The prevalence of irrigation is increasing in the lowland areas of the basin, not only as a means of allowing dry season and even third

[32] Hori, (2000) p15

[33] MRC (1998a), p 13

season rice crops, and dry season or perennial industrial crops, but also and as a supplement to wet season rainfed production. 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.34 There are, however, significant intra-basin differences, with the Viet Nam Delta, for example, enjoying an estimated irrigation ratio of approximately 60%.35

There are huge variations in the scale and type of irrigation schemes 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 2-3 crops per year. Major types of irrigation systems include: river, lake, or stream diversion by gravity for wet season supplementary irrigation without storage; pumping of water from rivers in the wet or dry season without storage; reservoir systems storing water from streams, rivers and runoff, and employing gravity or pump-based abstraction; and flood recession reservoir systems using floodwaters for land preparation and wet or dry season irrigation.[36]

Present LMB irrigation systems face significant challenges that complicate the balancing of priorities between increasing agricultural production and conserving water resources. There is a lack of conveyance and application efficiency and a tendency toward over-irrigation that has led to the construction of dams 3-5 times as large as they need to be.[37] There are problems with scheme financing that include: no mechanisms for control and measurement of water use; lack of appropriate charging structures to encourage efficiency improvements; and insufficient financial resources for maintenance and management.[38] Irrigation fees are being selectively introduced 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 issues relating to the management of irrigation schemes. These problems include: top-down design with a lack of farmer planning and management participation; a lack of legal entity for Water User Associations; a lack of mechanisms for transferring management responsibility to these organisations; poor extension; and a lack of coordination and integration between various responsible bodies.[39] Measures have been taken to improve local participation by handing scheme management over to farmer groups, however there is currently little data available on the effectiveness of such transfers. Finally, a bias in irrigation systems toward the idiosyncrasies of rice production (particularly regarding lower drainage requirements for rice and the distribution of water between plots) makes it difficult for farmers to diversify out of rice production.[40]

The table below gives details on the extent of irrigation across the LMB. The data is drawn from the MRC Irrigation Database and covers only schemes recorded by local authorities and thus omits many small unrecorded schemes. The data refer to the potential area under irrigation if the schemes were operating to full capacity.

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[34] MRC (1998a), p 13

[35] MRC (2002e)

[36] FAO (1999a) p.4-5

[37] MRC (1998a), p 18

[38] MRC (1998a), p 17

[39] MRC (1998a), p 19

[40] MRC (1998a), p 17

Table 3.5: Irrigated Areas in 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 (total)	8764	-	-	-	941,425
-RID (med/large)	*441*	*330,056*	*72,140*	*0*	*330,056*
-RID (other)	*291*	-	-	-	-
-RID (small)	*5497*	-	-	-	-
-DEDP	*1072*	-	-	-	*517,205*
-MOI	*1463*	-	-	-	*94,164*
Cambodia	1012	248,842	181,506	0	392,117
Vietnam Delta	85	1,683,094	1,417,549	351,506	1,683,094
Vietnam Highlands	76	36,008	7,290	-	36,008
Total 3/	**12,469**	**-**	**-**	**-**	**3,276,876**

Source: MRC LRIAD database 2002. Dash (-) indicates no information.

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 280,000ha, the difference being many small schemes, which have not been formally inventoried or mapped.

3/ Total of schemes and areas where data is available.

Irrigation in Cambodia is dominated by the annual floods with large parts of the irrigation area using the receding floodwaters as the source of irrigation water. Irrigated recession rice is gradually replacing the 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 0.5m requires about 3-4 adult hours per day for 1 ha of flood recession rice, approximately a 40-50 percent greater labour requirement than automated pumping. Dry season cropping occurs in only approximately 10 percent of the total wet season rice production area and limited water control capabilities constrain the further expansion of second season cropping.[41]

The use of irrigation in Lao PDR has expanded rapidly over the 1990s, with the government reporting an eight-fold increase in irrigated rice area over the decade.[42] 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 increasing prevalence of irrigation use in the lowlands is partly due to a move away from large, government managed schemes in favour of greater numbers of small farmer managed arrangements.43 The creation of Water User Associations and a related legal framework has been important also.44

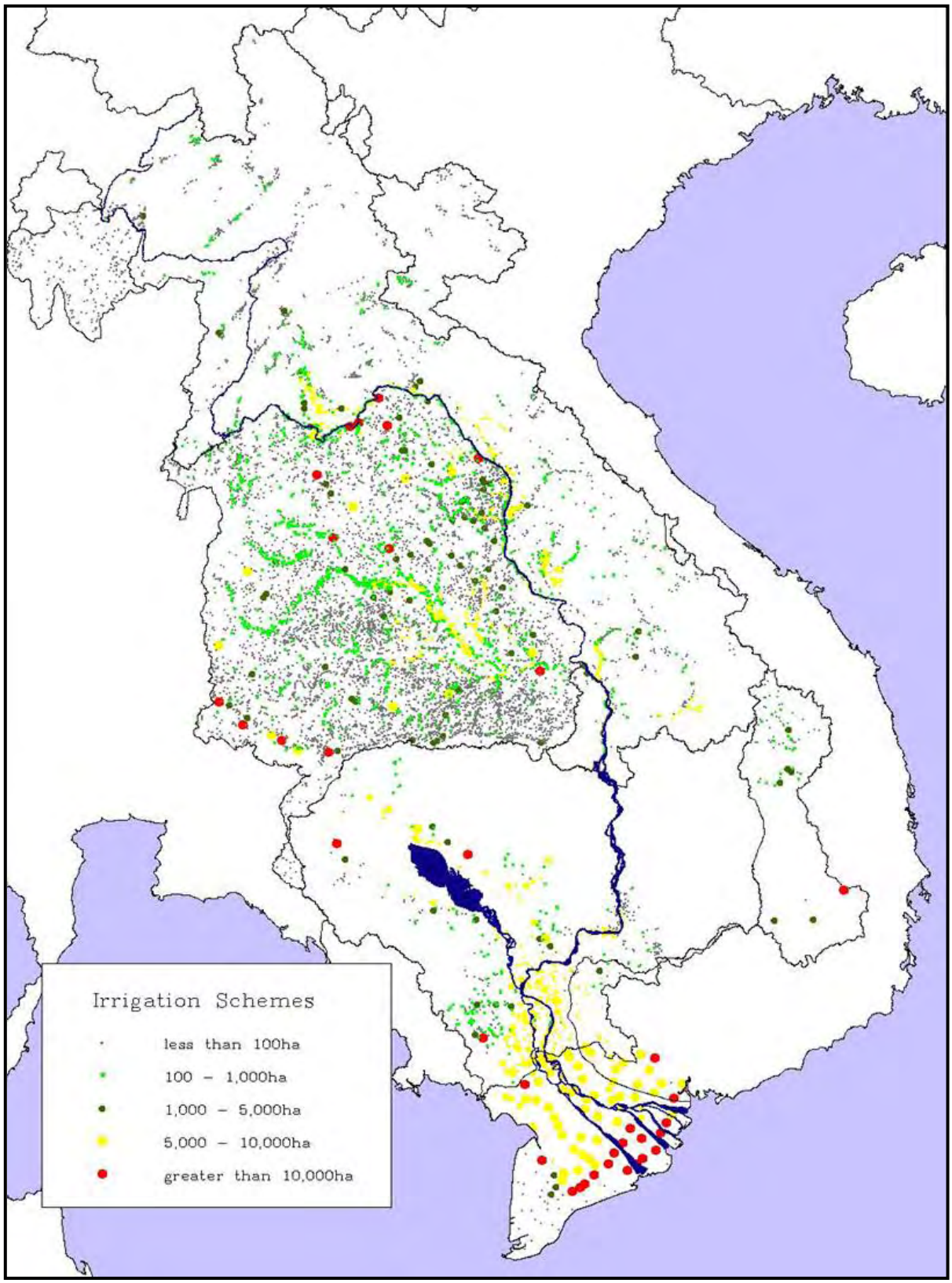
[41] Hori, 2001. p48

[42] Lao PDR Ministry of Agriculture and Forestry (2000)

[43] Lao PDR Ministry of Agriculture and Forestry (1999), p 25

[44] Lao PDR Ministry of Agriculture and Forestry (1999), p 26

Map 3.2: Irrigation Schemes in the Lower Mekong Basin



Irrigation ratios are much lower in Thailand's Northeast, where farming methods remain comparatively traditional, than elsewhere in the country.45 Various large-scale irrigation projects have been constructed on the Chi and Mun Rivers, but very strong local opposition to dam projects has made it difficult for the government to undertake further large and medium scale developments.46 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.47

Irrigation is extremely important in the Viet Nam Mekong Delta region, and forms the basis of the very high productivity of this area. More than half of the total area of the delta is flooded during the rainy season, which means that irrigation schemes have a critical role to play in allowing farmers to plan and maximise the intensive rice cropping into the flood free period.48 Irrigation and flood control works have tripled food production from 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 has been as a result of intensive investment in irrigation and related flood and salinity control works together with the Doi Moi economic reforms. Government planning and management of irrigation has been decentralised, with the provincial authorities now autonomous and self-financing many of the irrigation activities. Irrigation in the Vietnam Highlands is less developed than in the delta, the main crops irrigated are upland rice and coffee.

3.4.3 Rice production

Rice cultivation is the most important agricultural activity in the LMB countries. Estimates based on national statistics suggest that across the basin approximately 8.6 million ha is under active rice cultivation, representing 12 percent of the entire basin area and 34 percent of all land designated as agricultural by the MRC land-use data.[49] As shown in the tables below, rice production has increased greatly over the last 10-15 years: by 23 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 North-east Thailand; and by 27 percent between 1995 and 1999 in Delta and Central Highland 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 sub-region depending upon location, irrigation, and season. Spring paddy in the Mekong Basin region of Viet Nam yields 5 tonnes per hectare, while the figure is only 1.55 for unirrigated upland crops 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.[50] The average yield for the entire area is 2.75 ton/ha, whereas the average for the Asia-Pacific region in 2000 was 3.9 ton/ha.[51]

Rice production in Cambodia has increased slowly in efficiency since the early 1990s due to ongoing post-war rehabilitation and infrastructure reconstruction. While total wet season

[45] Hori, (2000), p43

[46] Hori, (2000), p43

[47] MRC (1997b), p 33

[48] Hori (2000) p45

[49] This estimate is made by using the wet season harvested areas (or planted areas if statistics were available) for the four countries from the national agriculture statistics.

[50] MRC (1999), p 16

[51] FAO (2001), p 21

cultivated area has increased during this period from 1.7 million ha in 1993 to 1.9 million ha in 2000, this area is still considerably less than the 2.5 million ha devoted to rice growing the late 1960s.[52] Furthermore, yields continue to lag those in neighbouring Viet Nam and Thailand, mainly as a result of poorer 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.[53] Deepwater and floating rice is also found around the shores of 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.[54]

Table 3.6: Cambodia rice production 1993-2000

	1993	2000
Wet Season Rice		
Area harvested ('000 ha)	-	1,846
Production ('000 ton)	-	3,333
Yield (ton/ha)	-	1.81
Dry Season Rice		
Area harvested ('000 ha)	-	233
Production ('000 ton)	-	708
Yield (ton/ha)	-	3.04
Total Rice		
Area harvested ('000 ha)	1685	2,079
Production ('000 ton)	2,221	4,041
Yield (ton/ha)	1.31	1.94

Source: Cambodia National Institute of Statistics (1994, 2000)

Rice is the dominant crop in the Lao PDR, covering approximately 600,000 ha or 80 percent of the total cropped area.[55] There are major disparities in productivity across the country, with yield in irrigated areas above 4 ton/ha, compared with 1.5 ton/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 successful attempts to discourage shifting cultivation (discussed below.)[56]

Over 80 percent of the cultivated area in North-east Thailand is used for growing rice or a mix of rice with 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.57 There are three main rice cropping patterns based on generalised land types.58 Lower paddy land is planted annually with paddy rice in the wet season and faces risks of flooding and temporary

[52] FAO/UNDP (1994), p 32

[53] FAO/UNDP (1994), p 32

[54] Hori, 2001. p48

[55] Lao PDR Ministry of Agriculture and Forestry (1999), p 7

[56] JICA (2001), AP6-5

[57] JICA (1993), p 2-3

[58] JICA (1993), p 2-3

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 used bunded planting.

Table 3.7: Lao PDR rice production 1990-1999

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

Source: Lao PDR Ministry of Agriculture and Forestry (2000)

Table 3.8: Thailand North-eastern Region Rice Production 1990-1999

	1994	1997	2001
Major Rice			
Area harvested ('000 ha)	4,356	4,557	4,675
Production ('000 ton)	7,125	7,978	9,046
Yield (ton/ha)	1.64	1.75	1.93
Second Rice			
Area harvested ('000 ha)	14	63	138
Production ('000 ton)	32	190	451
Yield (ton/ha)	2.25	3.03	3.27
Total Rice			
Area harvested ('000 ha)	4,370	4,620	4,813
Production ('000 ton)	7,158	8,168	9,497
Yield (ton/ha)	1.64	1.77	1.97

Source: Thailand National Statistics Office (1997, 2001)

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 the rice grown in this region is grown in irrigated lowlands, with the remainder under rainfed lowland cultivation.[59] Rice yields in the delta are extremely high by LMB standards and the area is nearing carrying capacity with high yielding rice varieties and very intensive cropping - up to three harvests per year in some places.[60] There is scope for further improving efficiency by overcoming constraints to production and productivity which include inefficient farm scale and inadequate physical and market infrastructure and post-harvest facilities that result in post-harvest losses as high as 13-16 percent.[61] There are also 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 Rees 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 3.9: Viet Nam (Mekong Delta Region) Rice Production 1995-1999

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

Source: Viet Nam General Statistical Office (1999)

[59] MRC (2002e)

[60] MRC (1997), p 5-2

[61] MRC (1997), p 5-2; IRRI (2002)

Table 3.10: Viet Nam (Central Highlands Region) Rice Production 1995-1999

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

Source: Viet Nam General Statistical Office (1999)

3.4.4 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, and 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.[62] In particular, the basin as a whole faces shortages of oil crops such as soybean that are necessary for cooking and animal protein feed, which creates profitable opportunities for farmers willing to diversify.[63]

In Cambodia, non-rice crops accounted for 8 percent of GDP in 1999.[64] 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.[65] 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 small holders 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 being used for producing such products in the 1960s.66 This phenomenon is most likely a result of the lingering presence of minefields. Rubber tapping areas cover approximately 40,000 ha and their output comprises the main Cambodian agricultural export earner.

[62] MRC (1998a), p 16

[63] MRC (1998a), p 13

[64] IMF(2002a)

[65] FAO/UNDP (1994), p 33

[66] FAO/UNDP (1994), p 32

Table 3.11: Cambodia Selected Non-Rice Crops 1999/2000

Crop	Harvested Area (ha)	Production (ton)	Yield (ton/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

Source: Cambodia National Institute of Statistics (2000)

In Lao PDR, the maize planting area has fluctuated over the 1990s, although yields have increased substantially. Mungbean production and harvested area have seen major declines because of poor local markets for the product. As far as industrial crops are concerned, coffee and sugarcane production have increased by average annual rates of 22.3 percent and 36.7 percent between 1996 and 2000 respectively.[67] 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. [68] There has been a concurrent decline in production of tea by 23.5 percent per annum and cotton (12.2 percent,) also in response to market conditions.[69] Vegetable production has increased rapidly, mainly driven by demand in urban centres and exports to Thailand.

[67] JICA (2001), AP6-5

[68] JICA (2001), AP6-5

[69] JICA (2001), AP6-5

Table 3.12: Lao PDR Selected Non-Rice Crops 1990-2000

Item	Crop Area ('000 ha)		Yield (ton/ha)	
	1990	1999	1990	1999
Maize	48.1	40.7	1.70	2.36
Strachy roots	19.8	13.1	8.22	6.15
Vegetables/beans	7.9	41.1	7.68	5.74
Mungbeans	4.6	1.7	0.57	0.88
Soybeans	5.6	6.8	0.80	0.87
Peanut	8.5	12.9	0.94	1.01
Tobacco	12	4.3	4.87	5.44
Cotton	6.9	4.4	0.72	0.98
Sugarcane	4	4.7	27.98	36.94
Coffee	17.3	42.3	0.31	0.41
Tea	0.4	0.9	4.00	0.44

Source: Lao PDR Ministry of Agriculture and Forestry (2000)

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.70 However, non-rice crops still only cover approximately 20 percent of the cultivated area in the Northeast Region. 71 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 mungbean are often grown as mono-crops.[72] The major constraints on production in such upland areas are soil quality problems and the build-up of disease in continuously cropped areas.[73] 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 are unavailable, there have been major increases in the production of vegetables such as shallots and garlic.[74] Yields for most crops have seen moderate improvements since 1994, with a major (28 percent) increase for the yield of sugarcane.

[70] MRC (1998a), p 13

[71] MRC (1997b), p 33

[72] JICA (1993), p 2-3

[73] JICA (1993), p 2-3

[74] JICA (1993), p 2-2

Table 3.13: 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

Source: Thailand National Statistics Office (1997, 2000, 2001)

NB: Figures for fruit and vegetable production for the Northeastern region not available

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 has decreased by 10 percent in the Mekong Delta and increased by 36 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 freeing up of socialist market controls. Also important are government attempts to increase rice production in the delta and promote the growing of cash-crops in upland areas by encouraging migration to the highland provinces so as to exploit the potential for expanded production of industrial crops.

Table 3.14: Viet Nam (Mekong Delta Region) Selected Non-rice Crops 1995-1999

	Planted Area ('000 ha)		Output ('000 ton)		Yield	
Name	1995	1999	1995	1999	1995	1999
Other Cereals	46.3	39	159.2	49.8	3.44	1.28
Maize	20.2	15.8	84	49.8	4.16	3.15
Sweet Potatoes	11.5	10.7	123	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	1.1	1.67	1.83
Rush	5.2	2.8	38.2	16.1	7.35	5.75
Sugar Cane	98	102.8	5395.7	6435.5	55.06	62.60
Peanut	15	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	0.7	1.9	1.2	1.90	1.71

Source: Viet Nam General Statistical Office (1999)

Table 3.15: Viet Nam (Central Highlands Region) Selected Non-rice Crops 1995-1999

	Planted Area ('000 ha)		Output ('000 ton)		Yield	
Name	1995	1999	1995	1999	1995	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	6.8	62.6	46.3	6.96	6.81
Cassava	29.3	32.3	262	278	8.94	8.61
Cotton	1.8	9.9	2	11.4	1.11	1.15
Sugar Cane	11.3	27.9	464.2	1230.2	41.08	44.09
Peanut	22.5	18.3	23.6	18.9	1.05	1.03
Soybean	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.[75] 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 Central Highlands areas of Vietnam. More broadly, fertiliser use is much higher in Thailand and Viet Nam, which use 100 and 263 kg of mineral fertiliser per hectare of cropland, than Cambodia and Lao PDR, which use 2 and 8 kg per hectare respectively. In Thailand's Northeast, although use of fertilisers is widespread (employed by about 86% of

[75] MRC (1997), p 5-4

farmers) it is lower in intensity than the rest of the country, with an average application of only 47kg/ha for rice.[76]

Table 3.16: LMB Total Consumption of Mineral Fertiliser ('000 MT)

	1989	1999	Average Annual Growth Rate
Cambodia	0.3	7.9	3.9%
Lao PDR	0.3	8.1	25.8%
Thailand*	818.8	1801.7	7.2%
Viet Nam*	563	1934.6	14.5%

Source: FAO 2001

* Includes entire country rather than only Mekong Basin Area

Table 3.17: LMB Consumption 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

Source: FAO 2001

* Includes entire country rather than only Mekong Basin Area

The tables below show FAO estimates for consumption 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.[77] 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% depending upon the province, with a range of 40%-100% for dry season farmers.[78] The same study found that the most commonly used pesticides in the country fall under the World Health Organisation's most hazardous classification.

Table 3.18: Lao PDR Pesticide Consumption (MT)

Item	1992	1993	1997
Carbamates Insecticides	0	18	3
Fungic/Bacterial/Seed Treat	0	8	0
Herbicides	0	0	1
Inorganics	0	8	0
Insecticides	17	34	3
Organo-Phosphates	17	16	0

[76] JICA (1993), p 2-3

[77] FAO (2002)

[78] IRRI (1997), p 90

Item	1992	1993	1997
Rodenticides	4	4	0
Triazine	0	0	1
Total	38	88	8

Source: FAO 2002 (FAOSTAT Agriculture)

Table 3.19: Thailand Pesticide Consumption (MT)*

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

Source: FAO 2002 (FAOSTAT Agriculture)

* Includes entire country rather than only Mekong Basin Area

Table 3.20: Viet Nam Pesticide Consumption (MT)*

Item	1994	1995	1996	1997
Fungic/Bacterial/Seed Treatment	3139	3465	8188	7684
Herbicides	2547	4979	7205	6710
Insecticides	15226	16452	17352	17851
Plant Growth Regulators				667
Rodenticides				107
Total	20912	24896	32745	33019

Source: FAO 2002 (FAOSTAT Agriculture)

* Includes entire country rather than only Mekong Basin Area

3.4.5 Upland agriculture/shifting cultivation

One of the most important agricultural systems in the LMB is the family 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 for the household consumption needs large numbers of people, and is often deeply rooted in the cultural practices 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.[79]

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.[80] 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.[81] 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.[82] Most groups also combine shifting cultivation with other activities such as the gathering of Non Timber Forest Products.[83]

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

[79] MRC (2000), p 20

[80] Lao PDR Ministry of Agriculture and Forestry (1999), p 26

[81] Lao PDR Ministry of Agriculture and Forestry (1999), p 26

[82] MRC (1997), p 5-3

[83] MRC (2000), p 20

population density.[84] 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 held to be a major environmental problem.[85] 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.[86] Other consequences of excessively short fallow periods involve increased erosion and reduced soil water retention. Sloping lands are particularly vulnerable to developing erosion problems when fallow periods become too short and when such areas are near to river tributaries increased river siltation can also result.

Increasingly, the carrying capacity of shifting cultivation land is exceed 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.[87] 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 annexed and giving them less incentive to ensure its environmental preservation.[88] Such social pressures and changes can start an often observed cycle whereby increased land pressure leads to shortened fallow periods causing a loss of soil fertility and declining crop yields, as well and increased erosion, downstream siltation, flooding and drought, all of which increase human poverty and vulnerability.[89]

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 was cleared and planted for shifting cultivation by an estimated 280,000 families. [90] 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 and 198,868 households and by 1998 to 148,000 ha and 156,720 households. However, most of the rehabilitated area was in the sloping lands surrounding the Mekong corridor, while the practice continued unabated in the remoter upland areas.[91] It is estimated that 70 percent of northern households practice shifting cultivation, compared to only 12 percent for the flatter southern region.[92] 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 practice 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.[93] This practice is not limited to subsistence farmers, large-scale cash-crop cultivation

[84] MRC (1997), p 5-3

[85] MRC (2000), p 20

[86] Lao PDR Ministry of Agriculture and Forestry (1999), p 26-27

[87] MRC (2000), p 20

[88] MRC (1997), p 5-3

[89] MRC (2000), p 20

[90] Lao PDR Ministry of Agriculture and Forestry (1999), p 26

[91] Lao PDR Ministry of Agriculture and Forestry (1999), p 26

[92] MRC (2000), p 20

[93] MRC (2000), p 19

is also carried out in this fashion and local minority groups are often driven out of traditional lands by encroaching outsiders.[94]

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.[95] These farmers 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.[96]

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 upland forest to make a living.[97] Comprehensive mine clearance is thus required before shifting upland cultivation will end and people will return to the lowlands.

3.4.6 Livestock

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 financial safety net and store of value 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 farmhouse holds 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.98 Intensification of production has increased and the role played by animals has change 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.)99 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 all have experienced a decrease in buffalo population and increased numbers of cattle, chickens, and ducks.

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[94] MRC (2000), p 19

[95] MRC (1997), p 5-3

[96] MRC (2000), p 28

[97] MRC (1997), p 5-4

[98] Falvey (2000), p 245

[99] Falvey (2000), p 208

There is significant scope for increasing livestock production, particularly in the 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 species.100 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 internationally.

Table 3.21: 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

Source: FAO (2001)

1989-1991 = 100 gross livestock products

Table 3.22: 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%

Source: FAO (2001)

3.4.7 Fish in the rice fields

In many areas, fish growing and trapping is combined with rice farming. Fish are either grown in small ponds or swim into the rice fields from rivers when the floods come. As waters recede during the dry season, special trenches and trap ponds are often dug to prevent the fish from leaving and sometimes rice fields at higher elevations are stocked with fish captured in flooded areas. A mechanism for enhancing the value of fish in the rice fields is rice-fish culture, which involves the active stocking of fields with fish fry to increase fish population. This technique is common in northeast Thailand. The addition of aquaculture activities to a rice farm provide supplementary opportunities for securing cash income or

[100] Lao PDR Ministry of Agriculture and Forestry (1999), p 28-9

animal proteins. Such fish are used for consumption or sale by an estimated 80 percent of lowland rural households, with an estimated annual catch of between 100 and-608kg per family per year.[101] Studies in Cambodia suggest that the market value of fish and other aquatic animals caught in rice fields is worth 40-80 percent of market value of the rice produced.[102] Reliable statistics for basin-wide or national-level rice field fish output are not currently available.

3.5 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.

3.5.1 Environmental impacts of deforestation

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.[103] 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 – because such land is particularly prone to erosion. The problem is exacerbated in steep areas of Lao PDR and Northeastern 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.[104] 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.[105] 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.[106] The reduction of sediment loads could be the result of the development of large numbers of small irrigation schemes that allow for the collection of sediment runoffs into reservoirs.

3.5.2 Environmental Impacts of Irrigation

Comprising by far the greatest use of water in the basin, irrigation has implications for water levels and water quantity in the Mekong River and it tributaries. It is estimated that in Cambodia water abstractions for irrigated agriculture account for around 94 percent of total abstractions, with 82 percent for Lao PDR, 91 percent for Thailand, and 86 percent for Viet Nam.[107] Because of rapidly increasing demand there are strains on the supply of water for

[101] MRC (2002c)

[102] Gregory and Guttman (2002)

[103] MRC (1997), p 5-4

[104] MRC (2000), p 9

[105] FCMP (1999), p 5

[106] MRC (2002b)

[107] FAO (1997, 1999a, 1999b, 1999c)

agricultural use with water supply in many communities being insufficient for 2-5 months of the year, and irrigation reservoirs often not sufficiently full, especially in Thailand.[108] The reductions in river flow are most significant between January and April. In April, for example, irrigated agriculture abstracts in the order of 53 percent of the total flow in the basin.[109] This percentage is exceeded in some of the tributaries. In particular there are water deficits in the Isarn region and in the Mae Nam Phraya drainage and cultivation areas. Low water levels also feed into other environmental problems as there is evidence to suggest that soil acidity and saline intrusion in the Mekong Delta will increase if there is increased upstream water abstraction leading to less water to flush away these contaminants.[110] 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 are less water intensive than rice is a potential response to this problem.

Irrigation reservoirs can cause changes to the river's flow regime, which has important environmental implications. Reservoirs can reduce severe flooding and the associated shortened flood period generally assists wet season cultivation in the flood plain. It also delays the onset of the 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 fish catches. 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 or greater to the natural river flows and cause major damage to cropping (and life) 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.

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 surface and cause immediate damage to agriculture and fish production and productivity as well as long-term soil deterioration. There are salinity related problems in the Korat Plateau in Thailand stemming from the irrigation of saline soils and improper rock-salt exploitation.[111] Sodium chloride concentrations in this area range from 2,000-10,000 mg/L.[112] There are similar issues in the Vientiane Plain. In the Viet Nam Delta salinity intrusion from the sea is a concern to farmers around the mouth of the river where about 750,000 ha is under the influence of saline water during the dry season. [113] Second order problems result from efforts to control salinity intrusion, with control gates causing stagnation and preventing polluted water from flushing into the sea.[114] Furthermore, the need to use river water to flush away intruding saline puts pressure on the availability of water for irrigation. At the end of the dry season total flow in the coastal part of the delta is about 2000m3/s, which would be sufficient for irrigation purposes, except that approximately 1500m3/s is required to wash away the intruding saline water from the river mouth.[115] However, recent MRC water quality testing shows that salinity levels have been

[108] FCMP (1999), p 6

[109] Ringler 2001

[110] MRC (1998a), p 24

[111] MRC (1997), p 5-6

[112] MRC (1997), p 2-22

[113] MRC (1998a), p 24

[114] MRC (1997), p 5-6

[115] Hori, (2000) p45

decreasing across the basin, particularly in Northeast Thailand.[116] It is as yet unclear why this change has occurred, possible reasons could include a general shift from smallholder to commercialised salt extraction, which may involve more efficient practices that result in lower levels of salt run-off.

3.5.3 Environmental impacts of pesticide and fertiliser use

Pesticide and fertiliser use is also an important means by which agricultural activity is linked to the environmental resources of the basin. While 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.[117] 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.[118] However, investigation into the build-up of pesticide residues in the bodies of such fish have revealed that contaminant levels are well below the maximum safety levels specified by the World Health Organisation.[119] 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, which has been held responsible for localised outbreaks of pests such as brown plant hopper.[120] There is currently little available data to indicate the extent of such problems.

Because of their 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.[121] In the Delta there is concern over excessive fertiliser use affecting water quality and damaging integrated aquaculture operations, and MRC water quality surveys have revealed an increase in levels of nutrients in the water of the area.[122] There is a need for further systematic investigation of this issue, however it appears that in general the use of nitrogen, phosphate, and potassium fertilisers is not currently at dangerous levels.[123]

3.5.4 Acid sulphate soils

The conversion of acid-sulphate soils to agricultural use, especially in the Mekong Delta, is creating more agricultural land but damaging other subsystems such as downstream fish and rice fields because of acidic runoff.124 Acid sulphate soils occur in the mangroves and grasslands of the delta, covering some 1.6 million ha, or 40% of it soils, mainly in the Plain of Reeds, Long Xuyen Quadrangle, and Ca Mau Peninsula.125 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

[116] MRC (2002b)

[117] MRC (1998a), p 24

[118] Monrith et. Al. (1999), MRC (1993)

[119] Monrith et. Al. (1999), MRC (1993)

[120] MRC (1998a), p 24

[121] Lao PDR Ministry of Agriculture and Forestry (1999), p 5-6

[122] MRC (2002b)

[123] MRC (1998a), p 24

[124] MRC (1997), p 5-6

[125] IRRI (2002)

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.

3.5.5 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. 126 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 act as their natural predators. 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 environmental degradation in turn constrains agricultural production.

3.6 Social aspects of agriculture

3.6.1 Agriculture and gender

The roles of men and women in agriculture are different, but overall they contribute equally to the production of rice. Women are primarily responsible for vegetable growing for household consumption and sale, although less so in the case of commercial field crop production. Women also do most of the marketing of farm products. However, women are now facing additional burdens as resource depletion and the need for cash income cause major male out-migration from forested and rural areas.[127] Women are also more likely than men to take agricultural employment, mostly because there is a narrower range of non-agricultural employment options open to them. In Cambodia, for example, 82 percent of female employees are classified as skilled agricultural workers, while for men the figure is only 71 percent.[128] Concurrent with an increasing agricultural workload for women, market, technological, and legislative changes are acting to give women less control over agricultural production. Essentially, the increasing emphasis on the use of advanced technological inputs, from irrigation to machinery and improved seed varieties, serves to disenfranchise women who traditionally have far less access to the channels through which these inputs are delivered than men.[129] Agricultural and forestry extension is typically male orientated and male dominated, which results in information and resource imbalances.[130] Women rarely sit on the boards of Water Users Associations, and for irrigation purposes cash crops, which tend to be male dominated, are given priority over the subsistence agriculture sector in which

[126] IRRI (1997), p 89

[127] MRC (2000), p 29

[128] Huguet, et. Al. (2000), p1

[129] MRC (1998a), p 23

[130] MRC (2000), p 35

women are more often working.[131] Credit and technology are also most accessible to men, and women have lower purchasing power for agricultural inputs, which increases gender wealth and income disparities.

3.6.2 Agriculture, income distribution, and poverty

There is a widening gap in the LMB between rural and urban incomes and hence the living standards of those who practice agriculture and those who do not. This situation is particularly pronounced in rapidly industrialising Thailand and Vietnam which have seen large increases in urban wealth while incomes in rural areas have languished. There are important relationships between agricultural practices, environmental degradation, and poverty. Agriculture has traditionally been an important support mechanism for the poor, generally allowing them to at least meet their subsistence needs. However, present conditions and trends in the agricultural sector are threatening this role. Population pressures and weak land tenure systems that fail to prevent the annexation of smallholder land are increasing the phenomenon of landlessness, which effectively closes off agriculture as a means of backstopping livelihoods for the poor. Resource depletion and environmental degradation (both of which can be partially traced to agricultural and forestry practices) can decrease the returns from working the land. For example, in some places deteriorating soil quality and contaminated waters are resulting in lower crop yields and thus reduced food security and income earning potential. Such degradation is most likely to occur in land worked by poorer people who cannot afford to invest in environmental protection. The poor, who often occupy marginal lands, also suffer more than the rest of society in terms of environmental vulnerability and are more likely to directly feel the consequences of such disasters as floods, droughts and landslides, which again are partially the result of environmental harmful agriculture and forestry practices. Finally, the ongoing commercialisation and intensification of agriculture is increasing productivity gaps between those who have access to advanced technological and financial inputs and those who do not. There is a danger that the continuing government and donor emphasis on increasing agricultural production will generate new wealth for successful and efficient producers with adequate investment resources, but will leave behind large numbers of the poor.

3.7 Institutional factors affecting agriculture

3.7.1 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.[132] 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.[133] 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, lacking the required technical knowledge. This situation hampers attempts to

[131] MRC (1998b), p 27-28

[132] MRC (1997), p 5-1

[133] MRC (1998a), p 13

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.[134] 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.[135] 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 8) promotion of community-based integrated agroforestry systems. [136]

In its "Strategic Vision for the Agriculture Sector" the Lao PDR government lays out a dual strategy to deal with the dual rural economies of the Mekong corridor and the 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.137 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.138 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.139

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.[140] 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

[134] MRC (2002a)

[135] MRC (2002a), p 7

[136] MRC (2002a), p 12-13; Cambodia Ministry of Planning (1996), p 36

[137] Lao PDR Ministry of Agriculture and Forestry (1999), Executive Summary

[138] Lao PDR Ministry of Agriculture and Forestry (1999), Executive Summary

[139] Lao PDR Ministry of Agriculture and Forestry (1999), Executive Summary

[140] Lao PDR Ministry of Agriculture and Forestry (1999), Executive Summary

incapable of helping the growing sloping land populations 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.[141]

The crux of Thai agricultural policy is raising rural incomes through crop diversification and improved agricultural practices, especially for products with good export potential.[142] 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 Associations143 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.144 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 programs in the Northeastern region of the country and Thai agricultural extension programs are well resourced and well coordinated compared to those in the other LMB countries.145

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 support by way of extension, research, irrigation and water management, flood control, and infrastructure improvement.[146] 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 system to deal with acid-sulphate soils and salt intrusion.[147] 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.[148] 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.[149] The policy for the Central Highlands is a strong push on industrial crops such as coffee, tea, rubber. Expansion

[141] Lao PDR Ministry of Agriculture and Forestry (1999), Executive Summary

[142] MRC (1998a), Annex 4

[143] MRC (1998a), Annex 4

[144] MRC (1998a), p 25-6

[145] MRC (1998a), p 21-22, p 25-26

[146] MRC (1998a), Annex 4

[147] MRC (1998a), Annex 4

[148] Viet Nam Ministry of Agriculture and Rural Development (2000); Viet Nam Ministry of Planning and Investment (2001).

[149] IRRI (2002)

of these crops is one of the reasons that the government has resettled lowlanders into the Central Highlands to 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 program 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% by 2020.

3.7.2 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, which 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.[150] 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.151 It was therefore relatively easy for big developers to annex smallholder 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.152 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 livings and increasing land-use intensity in the areas in which they end up.153

The Cambodian Land Law of 1992 specifies three types of land-ownership.154 The first is private property covering housing plots that can be inherited and sold. Second is occupancy, the classification for land under 5 ha which be used and inherited but not sold. Such land must be used for a minimum of three years before an occupancy permit can be issued, and will revert to the state if left fallow. The final category is for concessions of more than 5 ha of agricultural land which are issued for up to 25 years (renewable) and cannot be sold, leased, or given as inheritance. The status of upland forests is ambiguous, with large areas allocated to logging concessions that overlap with areas traditionally occupied and exploited by forest dwellers, putting these people in a tenuous legal position.[155] There is generally no tenure or recognition of the land-use rights of people practising shifting cultivation. Property conflicts are common and many have been amplified by the return of previously displaced persons. The resulting land tenure situation in rural areas is confused and the majority of farmers do not have title.[156] Provisional titling by government authorities has been slow and is hampered by resource constraints. The weak tenure system means that annexation of

[150] MRC (2000), p 13

[151] MRC (1997), p 5-3

[152] MRC (2000), p 13

[153] MRC (2000), p 25-26

[154] FAO/UNDP (1994), p 29

[155] MRC (2000), p 13

[156] FAO/UNDP (1994), p 29

smallholder land is common, creating a growing problem of landlessness which is exacerbated by land sales forced by poverty.

Lao PDR recognises the transfer and inheritance of land use rights, but not title. Households own homesteads, villages communally own village land, and land outside village areas is largely unallocated, which is problematic, because these are the areas in which shifting cultivation typically takes place.[157] The government (often proxied by local village authorities) has a system whereby individual farmers are allocated various amounts of land for lease depending upon the use to which they intend to put it and the characteristics of the land in question. In the flatland areas ownership rights are gradually being formalised.[158] Article 5 of the Forestry Law 1996 states that although natural forests and associated land is vested in the state, individuals and non-governmental organisations may possess, use, transfer, own and inherit trees and forests planted by them under certain conditions and with the state's acknowledgement.[159]

Thailand is in the process of transferring all land to private ownership, but there are still large numbers of farmers in the northeast without tenure or other formal land rights documents. There is also no specific legislation for dealing with forest land.[160] Laws that granted tenure rights to degraded forests were rescinded after it was discovered that people were intentionally damaging forest to qualify for tenure. The passing of a Community Forestry bill was stalled by controversy over the allocation of land use rights to indigenous peoples, requiring the Royal Forestry Department to attempt to fill the vacuum with community-based land planning.161

In Viet Nam, where all land is owned by the state, there are laws for long-term individual rights over lands. While most lowland agricultural land is held in this fashion, only 5 percent of forest land is officially allocated, affecting only about 1 percent of forest dwellers, and much of this area is actually protected land, which limits the range of uses to which it can be put.[162] The Land Law of 1993 allows for long-term leasing of forests to private enterprises, community groups and families. By 1996 the government had allocated 2 million ha of forests to State Owned Enterprises and families. Average plot sizes are 15,000-20,000 ha for enterprises and 3-20 ha for families.[163] The titling process has caused problems where new owners or occupants have not had previous experience managing forest resources and need technical support making sustainable forest management decisions.

3.7.3 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 outputs. 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

[157] MRC (2000), p 13

[158] Lao PDR Ministry of Agriculture and Forestry (1999), p 20-21

[159] MRC (2000), p 22

[160] MRC (2000), p 14

[161] MRC (2000), p 22

[162] MRC (2000), p 13

[163] MRC (2000), p 22

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.[164] 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.[165] 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 excessively high interest rates. 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 interest rates have run as high as 15 percent per month.[166] There is also a lack of medium and long-term credit facilities. Similar problems can be seen in the 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.[167] 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."[168]

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."[169] In general, such facilities are underdeveloped across the basin, making it harder for farmers to make the best decisions on what crops produce, and ensuring the prices they receive are lower than might otherwise be possible. 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.170 Another marketing related issue is the development of mechanisms such as product grades to ensure that crop qualities meet the standards of local, central and terminal 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 22 percent of the population lived in areas not accessible by truck and over half were more than 10 km from the nearest market.[171] While it is difficult to estimate the costs of such a situation to rural

[164] MRC (1998a), p 21

[165] JICA (1993), p 1-3

[166] MRC (1998a), p 21

[167] Lao PDR Ministry of Agriculture and Forestry (1999), p 30

[168] Lao PDR Ministry of Agriculture and Forestry (1999), p 30

[169] MRC (1998a), p 15

[170] MRC (1998a), p 16

[171] Lao PDR Ministry of Agriculture and Forestry (1999), p 18

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 rural development priority.

3.8 Indicators for monitoring the agriculture sector

In monitoring the ongoing sustainable development of agriculture in the Lower Mekong Basin, indicators reflecting the economic, productive, environmental, and social aspects of the sector must be used. The various indicators discussed in this chapter go some way towards giving an integrated picture of agricultural trends and development, but they require refinement and further development. This section makes suggestions for such development.

The economic indicators analysed above (agricultural GDP, exports, and employment) are useful and can be easily gathered from national sources, but greater detail is required. Information about the costs and comparative returns of various kinds of crops and productive systems, as well as barriers to entry and investment requirements, would give a better picture of the economic consequences of farmers' production decisions. Such information is not readily available but could be obtained by surveys of production costs and output prices in various regions. Also, national economic statistics fail to capture the value of much subsistence agriculture and should be supplemented by estimates of the economic importance of such activities.

Levels of production for various kinds of crops, along with yields and cultivation areas, are of course critical for understanding trends in the agriculture sector. National statistics are good data sources for these indicators, but need to be supplemented with estimates of production volumes under subsistence farming systems. Other useful production indicators could include figures on livestock populations, which are available from national sources, and on rice-field fish production, which are not currently available. It could also be useful to disaggregate production statistics below the national level to get a clearer picture of varying levels of productivity under differing topographic and other regional conditions.

Having more information of the geographic extent of various kinds of farming and irrigation systems is important. A geographic inventory of farming systems could include information on cropping patterns and intensities, as well as use of irrigation and other inputs including fertilisers and pesticides. It would be particularly useful to have more data on shifting cultivation systems, including areas under cultivation, numbers of people involved, and the length of fallow periods. Gathering such information would probably require specialised studies, although geographical data on existing irrigation schemes is available in the MRC Irrigation Database. It would also be useful to gather data on proposed irrigation schemes and flow measures to gain estimates of irrigation abstractions.

Land use statistics are also a key indicator. Land cover data can provide information about the scale of deforestation and can also help in estimating the extent of areas under shifting cultivation. The MRC Land Use Dataset provides useful indications of the land areas under various kinds of land cover but there is a need to continuously update the data to reflect changing land use patterns. This task is complicated by the fact that the dataset is based on satellite imagery, the interpretation of which is difficult and sometimes subjective. It is therefore difficult to ensure the consistency of land use data based on satellite images, which calls the validity of comparisons over time into question. However, gathering more precise data on land use trends across the entire region using alternative methods is currently not feasible.

The institutional aspects of agriculture are difficult to monitor with quantitative data. Indicators such as the percentage of farmers with land tenure, or with access to an effective transport network could be useful, but assessment of the effectiveness of agricultural policies and extension services and the efficiency of markets is not possible by such means. Qualitative monitoring of these factors is thus required. Other relevant institutional indicators could include personnel, human resource development, budgeting systems, planning procedures, decision-making strategies, and basin wide consultation procedures.

Finally, there are currently few useful systematic indicators related to the environmental impacts of agriculture. It is important to remedy this deficiency by gathering basin-wide data on the links between agriculture and such environmental factors as salinity, erosion, sediment loads, deforestation, pest populations, water regulation capacity, etc. While data is available for some of these indicators, (salinity and sediment loads for example), it is very difficult to prove causal links to agricultural activity or to present the information in relation to agriculture in a meaningful way. It is also difficult to find basin-wide evidence of feedback between agriculture and the environment, with yields and productivity being damaged by environmental change, for example. Further investigation into the selection and construction of indicators related to the environmental implications of agriculture is thus required.

4 Fisheries

4.1 Economic and social value

The Mekong River stands third in the world as having the highest number of freshwater fish species and fourth in terms of tonnage caught. To date, there are 1,200 recorded species of fish found in the Mekong River. Many of these species are endemic to the river. These include the Mekong Giant catfish (Pla Buek), giant barb (Catlocarpio Siamensis) seven line barb (Probarbus Jullieni) and several other large species. Dolphins are valuable because of their rarity and economic potential in terms of ecotourism.

The recent estimate of fresh water fish production in the LMB, based on consumption, is 2,000,000 tons per year. The fresh water capture fishery in the LMB is one of the single most important commercial and subsistent economic activities in the basin. It provides food, employment, economic activity and is a source of livelihoods for a growing, mostly rural poor.

It is estimated that most of the 12 million rural households (approximately 40 million people) earn their living by rice farming and fishing. The capture fishery is the most important element in rural households in terms of nutrition and income generation. Approximately 71% of rural households (2.7 million people) in Lao PDR rely on fishing to a varying degree as a livelihood strategy. About 1,200,000 people living in fishing communes around Tonle Sap depend nearly entirely on fishing as their main occupation, with 10.7 million people in Cambodia dependent to some extent on capture fisheries. Of the 2,000,000 tons of fish consumed in the basin, two-thirds (1,750,000 million tons) are from natural water bodies and reservoirs with the remaining from aquaculture.

The total value of this catch at farm gate is US$1,478 million per year. Assuming that fish consumed is equal to the fish caught (no data available for fish export/ import) the total freshwater fish production is 500,000 tons for Cambodia, 133,000 tons for Lao PDR, 795, 000 tons for Northeastern Thailand and 597,000 tons for Viet Nam. The average basin consumption of fish is 36 kg/person/year. This varies from 20 kg/person/year in the mountain zone to 60 kg/person in the flood plain area of Cambodia and Viet Nam. In Northeastern Thailand, the average consumption is 35 kg/person/year and 26 kg/person an average for Lao PDR.

Fish are considered a 'shared' natural resource and are transboundary in nature. Many species of fish require different habitats and locate in different countries during their life cycle. Fish have important economic and social benefits to the large population of the basin in each country and thus will occupy an important place in development debate of the Mekong. Collaborative management among the four countries is of crucial importance to sustain this resource.

4.2 Ecological requirements for sustainable fisheries

What makes the Mekong so productive? Productivity and diversity are based on the rich and wide-ranging permanent and seasonal habitats, which result from the Mekong's complex geological system.

Hydrological cycle: The hydrological cycle is the main parameter influencing the river ecology. The annual flood pulse caused by monsoon rains is responsible for flooding the highly productive plains. These flood plains are productive because the flood pulse results in

the recycling of plants, animals and nutrients. A flood pulse regime supports higher yields than stable aquatic or terrestrial ecosystem. Seasonal changes in water flow and level cause changes in aquatic habitats, water quality, food availability for fish and fish recruitment.

Habitats: Fish depend on the existence of diverse and suitable habitats and access to these habitats at different stages of their life cycles at different seasons of the year for spawning, nursing, shelter and feeding. Habitat diversity is greatest in the flood plain areas with flooded forests, channels, permanent and seasonal lakes and pools. Fish feed, breed and nurse their young in the flood plains. Between flood-seasons they take refuge in deep water habitats, mainly in permanent lakes and deep pools in the main channel or tributaries. Certain parts of the Mekong and its major tributaries contain deep pools, which are very important for fish in the dry season.

Deep pools: Deep pools provide safe places for fish during the dry season. There are numerous deep pools in the main channel and some in the tributaries. Deep pools and channels in the main stream of the Mekong near Kratie, in Nam Thuen and Nam Hin Boun in Lao PDR and in Sesan in Cambodia are widely acknowledged as the most important dry season refuges for fish. Deep pools that lie in the stretch between Khone Falls to Kratie are important habitats for fish in Cambodia and the Delta in Viet Nam.

The deep pools in the Mekong River and their locations in relation to other habitats is one of the main factors influencing the fish ecology of the Mekong. The position of various deep pools is believed to be a main influencing factor in the major migration routes. The Lower Basin Migration System (below Khone Falls) is a migration from dry season habitats in Stung Treng- Kratie area to important flood season feeding areas in the South in the Tonle Sap flood plains and the Viet Nam Delta. The location of these pools, their size, associated fish species and function are listed in FIP Technical Paper # 4.

- Kratie and Stung Treng Province: 58 deep pools identified to be primary rearing and dry season refuges for large catfish and carp. These pool habitats are important for the whole of Cambodia and Viet Nam.

- Khone Falls: 8 deep pools are listed as important fish habitats. Some of are important feeding grounds and dry season refuge for Irrawady Dolphin as well as a spawning area for Giant carps.

- Northern Lao PDR: Deep pools in the northern part of Lao PDR Ko Keow and Syaburi area are known to host the Mekong Giant catfish (Pangasianodon Gigas).

Rapids: Rapids help keep rivers healthy. They perform several vital roles: oxygenation of the water and breaking down organic matter allowing uptake by the higher organisms. They also provide a large surface area for growth of attached plants and insects as well as spawning and feeding grounds for many species. Of all the river habitats, rapids are the most productive and biodiverse (Roberts, 1993)

Fish migration: Major fish migration routes are an important feature of the Mekong fisheries. Most fish species migrate at certain times in their life cycles. Many fisheries activities in the basin are based on capturing the migrating fishes. People in villages along the Mekong and its tributaries adjust their daily lives to annual fish migrations. The separation of major fish habitats in time and space force Mekong fish to migrate to seek places for their survival at different times of the year. Some fish migrate only a short distance, between permanent and seasonal water bodies and over hundreds of kilometers to downstream feeding areas to upstream deep pools for dry season refuge. Typically, blackfish species are more sedentary

and whitefish are migratory. Blackfish are short distance migrates and white fish are long distance migrates.

Forty percent of the fish catch is blackfish. The remaining 60% are whitefish including carps (cyprinids), river catch fishes (pangasids). The most economically important fish in the Mekong are highly migratory. Some migrate 500 to 1,000 km, often crossing national borders.

The onset of floods triggers many fish to spawn. Eggs and lavae drift downstream with the current and distribute throughout the flood plain; an optimal rearing condition for the young and fragile lavaes.

When the water recedes, fish move out from the flood plain back into the main channel and start the spectacular migration towards their dry season refuges. They wait there for the next monsoon and repeat the cycle. Migration of Mekong fish can be roughly categorized into three routes.

The lower part of the Mekong Basin: A large-scale fish migration takes places between the upstream dry season refuge near the boarder of Lao PDR and north of Cambodia to down stream flood plain habitats in the Tonle Sap and Delta. Some species spawn near or in the flood plain feeding habitats, while others spawn upstream allowing their lavae to drift down with the current. Larger whitefish species (Giant Barbs, catlocarpio sismensis, seven line barbs, Julieni Probarbu), as well as several river catfish species follow this migration route.

The middle migration systems run from Khone Fall to Loei River. Flood plain habitats are mainly connected to the large tributaries on both side of the Mekong. Fishes move from the main channel to flood plain rearing and feeding habitats through these tributaries. There is a complex interconnection to the lower migration system with some species following both patterns at different stages of their life cycle. Sekong/Se San/Sre Pok is the largest tributary system in the basin. Many species migrating north use this system rather than the Khone Falls (e.g. Trey Riel).

The upper system between Loei River and the upper basin: This section is characterized by smaller flood plains and fewer major tributaries. The migration is characterized by movement to upstream spawning areas at the onset of the rainy season. Most well known is the Mekong Giant Catfish, a highly endangered species, caught in Northern Thailand and Lao PDR during April and May when the fish are migrating upstream to spawn.

Although rivers and their associated flood plains encompass a range of different fish habitats, they all are ecologically linked in a complex fish migration network. Therefore, from the point of view of migrating fish, the Mekong River Basin functions as one large ecological unit. The fish migration corridors interconnect upstream spawning habitats with downstream nursery habitats and dry season refuge habitats. The large flood plain areas of Mekong Delta and the great lake flood plain areas are crucial nurseries habitats for Mekong fishery.

4.3 Consumption, marketing and processing

Inland capture fisheries and rice are the basis of food source for the rural population of the LMB. Fish is the single most important protein and rice the main source of carbohydrate. In all parts of the basin, fish is a part of any meal if a household has a means to get it. During lean seasons, dried and fermented fish products are used in place of fresh fish. Fish sauce is a staple used in all households all year round as the main ingredient in cooking. The average

consumption of fish in the basin is 36 kg/person/year. In Lao PDR and around Tonle Sap, consumption of dry and fermented fish is 14 kg/person/year.

Aquaculture products are becoming common in local fish markets, especially in Viet Nam and Thailand. Markets determine the success of aquaculture and products from aquaculture have a significant influence on local markets. Culture fish have two main advantages: they can be marketed live, which means fresher fish; and they can be marketed at a time when there is insufficient supply of wild fish.

The bulk of catches taken by small-scale farmer/fishers is consumed locally or traded in local markets. Storage time from catch to consumption is short – requiring little or no chill. Some species are marketed live. Ice is used in Viet Nam and Thailand for storage and transport to large cities.

Overseas markets exist for a number of spices. One examples is the Sand Goby, which is widely known in Asia and sells for high prices in Hong Kong and Singapore. River catfish (pangasius spp) are now being increasingly cultured and are exported to western countries where large numbers of Vietnamese immigrants are settled and to the United States where a market for catfish has been well established.

Most significant is the fish trade within the basin. Fresh and smoked fish from Tonle Sap are exported to Thailand in large quantities. River catch juveniles for culture find their way to Viet Nam. A lively trade in fish is taking place between Lao PDR and Thailand, with Lao PDR traders sending high valued fish to Thailand and in exchange buying tilapia and other species. Prahok (fish sauce) is highly valued in large part of Thailand. None of this cross-border trade is recorded and does not appear in national statistics.

4.4 Aquaculture

Total production in the LMB is estimated at 260,000 tons/year with a value of US$270 million. In the past 10 years, there has been an almost five-fold increase in aquaculture production from 60,000 in 1990. Production is the highest in the Delta and the Korat Plateau in Thailand. This production encompasses the production and sale of fry and raising wild or artificially produced fry. Supplies of inputs for aquaculture, handling, processing and marketing of products provides employment for people in many remote parts of the basin. Small-scale aquaculture contribute to food supply in wild fish deficit areas and in seasons when wild fish are not available.

It is widely believed that the LMB has great potential for increasing fresh water aquaculture. Recently, the governments have been emphasizing aquaculture as a part of their rural development and poverty reduction policies. Thus, much of governments' efforts have been directed at developing this sector. However, a continued increase of about 10% per year of fish supply is necessary to meet consumption demand as projected on population growth. Given the current management regime of wild capture fisheries, the rate of loss in the wild capture fishery cannot be offset by the increase in aquaculture production.

Increases in aquaculture involve more intensive production which requires high protein and fat contents (from marine and fresh water 'trash fish'). These would normally be processed and eaten by people involved in the wild capture fishery. Subsequently, this will lead to decreased fish production. Aquaculture also has a direct and adverse affect on wild stock population as well as substantial risks to local species from alien species escaping into the wild. Fish produced by intensive raising will be comparatively expensive and not easily affordable by a majority of the basin's poor. Unless the level of wealth in the basin increases

in the near future, large amounts of cultured fish will be exported for luxury consumption elsewhere.

4.5 Threats to fisheries resources

The relationships between fisheries, agriculture, hydropower, navigation and tourism are complex. Generally other sectors have impacts on the fisheries more than the other way around. The impacts are brought about by changes in the aquatic environment, which are generally negative as fish rely heavily on the health and integrity of the aquatic system to maintain the resource. The threats to LMB fisheries are:

- Deforestation leads to changes in hydrological flows, deterioration in water quality and impacts sedimentation in the aquatic ecosystem;
- dams create constraints to fish migrations, as well as negatively impacting fish stocks through changes in water flows and quality; and,
- alteration of aquatic habitats including destruction of spawning grounds, dry season refuge (stream bed blasting, dredging, removal of rapids, siltation resulting from removal of vegetation).

The Mekong River has more hydropower potential than other systems in East Asia. Today, less than 9% has been realized. By changing the flow, sediment, nutrients, energy and biota; dams interrupt and alter important ecological and physical process of a river. Thus, dams have local upstream, downstream and cumulative impact on fisheries.

More than 30 major dams have been constructed on Mekong tributaries in the last 35 years. This is in addition to the 20,000 small dams/wiers in Thailand and hundreds of small irrigation projects in Lao PDR waiting for funding. These could eventually increase the impact on fisheries. Small scheme irrigation is typically planned and implemented with little consideration to the impacts they may have on aquatic ecosystem for fisheries. It is possible that the cumulative effect of many small dams could be larger than a few large dams.

The effects of dam/reservoir projects in fisheries can be categorized in four groups:

- Effects on water fluctuation (reduction in duration/extent of flooding downstream;
- in-stream flow changes that impact mainstream ecology;
- blocking fish migration; and,
- water quality alteration.

To a large extent, the deforestation and dam construction threats can be traced to the lack of cross-sectoral planning, combined with insufficient recognition of the importance of the fresh water fishery. What are considered opportunities by one sector, may be of serious threat to another. The general lack of the above recognition by the government and their tendency to focus fishery management effort on aquaculture, instead of maintaining the wild stock, is considered one of the most serious threats.

4.6 Trends: Supply, demand and management issues

In the next 10 years, preliminary calculations suggest that demand for fish and other aquatic animals in the LMB will be 2.44 million tons. An increase of 0.44 million tons will be needed to maintain this level of consumption. There are three ways to meet this demand: wild capture fishery, cultured fish and imported fish. Importing fish is not a likely alternative since it would be prohibitively expensive for most of the population.

Aquaculture is growing in the basin and some say that this will cover the increased demand in fish. However, the high inputs and intensive methods of production is predicted to have an adverse affect on natural capture and potentially will not achieve distributional effects benefiting people in the lower income brackets. Low-input aquaculture will be able to fill in some of the gap. The main argument for low-input culture is it increases ecological efficiency since the inputs are from the low end of the food chain using by-products from farms. Development of fish feeds based on protein and oil from plants could eventually lead to low-input culture transforming the system with production and profits similar to the present intensive culture.

The wild capture fishery is close to being fully exploited. Its importance now and in the future cannot be overemphasized. The wild capture fishery is spatially dispersed and a large proportion of the basin's population relies on the capture fishery for their livelihood. This kind of fishing requires little investment and it provides quick returns. In addition, the fishery is accessible to large numbers of the rural people and thus serves as fall back when other occupations fail. The cost of replacing this 'free resource' with another source of food, income and employment will be extremely expensive. Therefore, the conservation of the wild capture fishery is crucial to maintaining food security and social stability.

The capture fishery has some potential for increased landings, provided that the environment is not overly degraded by other development activities and that smaller species are used for human consumption.

Fishing in the LMB is likely to increase with the population and general ease of access. This may result in an increase in an overall catch (at least up to a point). This increase will comprise a high proportion of small fish and continuously decreasing proportion of larger slow growing (migratory) whitefish. From the food security point of view, this development may be acceptable even if the value of the catch decreases (larger fish earn better prices per kg). However, the partiality that people throughout the basin have for larger fish species would make it desirable to most stakeholders to mitigate the decline of this biodiversity.

To reverse or slow the decline will be difficult and requires coordinated intervention and management at many levels. Communities that control the breeding and nursing habitats may not benefit from catching the adult fish and thus not be inclined to protect these habitats. If the protection of the feeding and nursing habitats would lead to an increase in catch for them locally, then management intervention may be left to local communities. Where migration routes cross international borders, stock-management becomes a transboundary issue and requires international cooperation.

With the adoption of policies on decentralization, the four member countries have taken steps towards vertically integrating management-intervention, which is crucial for effective management of migrating fish stocks. For these steps to be successful, it is important that all parties share a common understanding of issues regarding conservation and development of fishery resources and the causes and effects involved.

Presently, there are few institutional arrangements for the joint management of transboundary fish at the regional level, although several fish species are shared. The endangered giant fish, about which there is a knowledge base and motivation to improve management, presents an immediate opportunity to rectify this.

4.7 Information gaps and needs for the BDP

The fisheries is one of the most important resources of the Mekong River. The main argument is that fisheries contribute immensely in economic terms to people of the basin and most importantly these benefits are well distributed among its inhabitants, particularly among the rural poor. Therefore, maintaining the common stock of wild fish should be one of the main basin-management objectives as it helps meet the national development objectives of each riparian country in terms of poverty reduction, assuring food security and social stability.

One of the major threats to sustaining capture fisheries is environmental degradation arising from other development activities in other sectors. Thus, to reduce such threats one way is to factor the true value of the fisheries in the costing of other water development activities.

Another issue is the transboundry nature of the fisheries. The importance of shared benefits and shared responsibility towards maintaining capture fisheries needs to be highlighted. On overall estimate, 60% of all the fish consumed today are migratory whitefish, many species of which travel long distance across national borders. There is a need to demonstrate clearly the nature of these 'shared benefits': although adult fish are not caught by those who maintain nursing habitats, benefits are shared indirectly through regional fish trade and affordable prices for the fish in the region. Additionally, the ecology of key economic migratory species needs to be better understood (migration routes, important habitat locations etc.) for international cooperation among the riparian countries.

A great deal of information on the fisheries has been assembled and recently made available in an easy to read format. This information now forms an important basis for the initial and rough analysis of the fishery sector. However, for LMB resource planning, the information needs to be more specific in some respects. There are two themes around which additional information on fisheries would be needed. They are:

- The economic value of the capture fisheries (and other aquatic animals) and its contribution to the economic and social well-being of the large Mekong Basin population; and,
- The need for transboundary management of key migratory species and fish ecology.

4.7.1 The economic value of the capture fisheries

The current assessment is based on consumption only and the pricing is based on farm gate prices at one stage. The total economic (and social) value of the fisheries could be represented completely by calculating the 'multiplier effect'. This includes all those engaged in the fisheries and the activities related to fishing. These include employment in fishing related jobs like making tools, trading and repairing fishing gears, fish processing, fish trading at the local and regional levels and processing from catch to the consumer.

A comprehensive valuation of non-fish aquatic resources, animal and plants, should also be included. This would be an important contribution to rural food security. Facts about fish and fish products traded within the LMB and exported would assist in a better understanding

of the real volume of catches and their value, as well as the current status of the inter-dependence of LMB countries in assessing the level of shared fish resources.

4.7.2 Migratory fish species: Their ecology and economic value

While there is information about fish migration patterns, there remains a general lack of information on the ecology of the LMB's aquatic environment. There is a need to understand the life cycle of important fish species. The current understanding about fish migrations is derived from the main stream and is very limited on tributaries, especially the main ones like Se San, Se Pok and Se Kong. In addition, since many arguments have been made for slowing the drastic decline in migratory whitefish, quantitative analysis of the impacts of streams and river flow on migration is necessary. The following are some of the areas where information is required:

- The inter-connectivity of essential habitats for long distance migratory fish species.
- Information on spawning sites and habitat requirements for important species (e.g. river catfish).
- Information on fish yield and habitat types to better understand implemention measures for habitat protection.
- Quantitative data on fish yield by species, especially those of greater economic importance. There is information now on total fish catch in the Mekong system, but not by species and habitats.While the macro-habitat requirements for a few species are known, the micro-habitat which some fish require is unknown. Such micro-habitat requirements determine the type of pools certain fish prefer and indirectly determine migration routes.

5 Hydropower

5.1 The state of 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. The remainder is on the tributaries (13,000 MW in Lao PDR, 2,200 MW in Cambodia and 2,000 MW in Viet Nam). Only 5 percent (some 1,600 MW) of the Lower Mekong's hydro potential has been developed. 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 China, total hydro potential is an estimated 23,000 MW. Two projects totaling 2,850 MW have already begun operating.

A list of the hydro projects over 10 MW are already operating in the Mekong Basin is presented in Table 5.1. These projects are also indicated on the map in Figure 5.1.

Table 5.1: List of Completed Hydropower Projects (over 10 MW)

Country	Name	Location	Capacity (MW)	Output (GWh/year)	Commissioning
China	Manwan	Main stream	1,500	7,987	1993
	Danchaoshan	Main stream	1,350	6,478	2001-03
Lao PDR	Nam Ngum	Tributary	150	1,040	1971
	Xeset 1	Tributary	45	180	1991
	Theun Hinboun	Tributary	210	1,620	1998
	Huoay Ho	Tributary	150	556	1999
	Nam Leuk	Tributary	60	230	2000
Thailand	Sirindhorn	Tributary	36	52	1968
	Chulabhorn	Tributary	40	59	1971
	Ubo lratana	Tributary	252	26	1966
	Pak Mun	Tributary	136	251	1997
Viet Nam	Dray Ling	Tributary	13	70	1995
	Yaly	Tributary	720	3,500	2000

Ref: MRC Hydropower Development Strategy and Indicative Master Plan on Power Interconnection GMS countries by ADB November 2001.

Map 5.1: Completed Hydropower Projects in the Mekong Basin (over 10 MW)

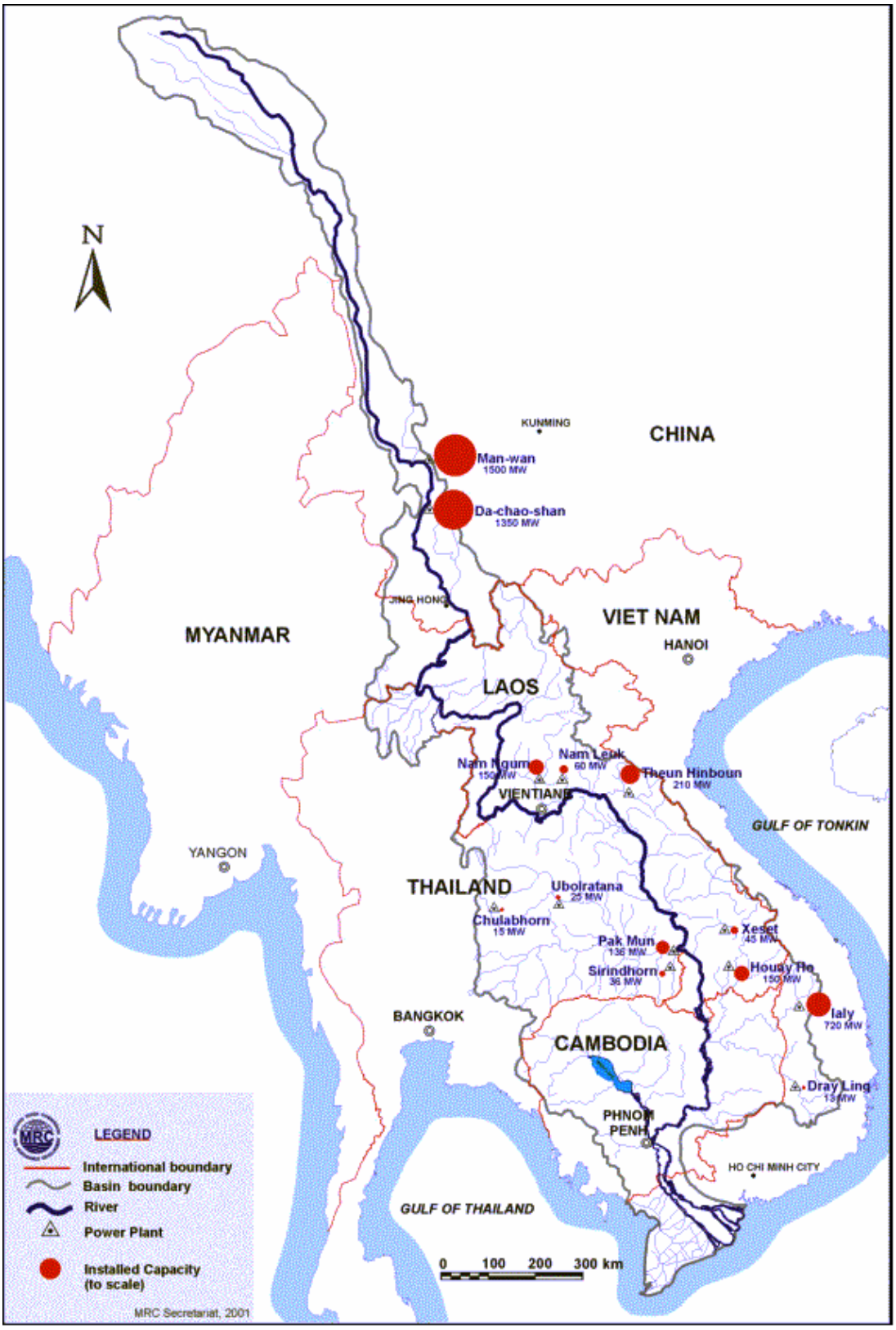


Table 5.2: Actual Electricity Consumption (1990-2000)

	Cambodia		Lao PDR		Thailand		Viet Nam	
Year	Energy demand (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%

Note: The above data for Cambodia are only for Electricité du Cambodge. Statistics were not available for the many generators that provide power on a small scale. Ref: ADB 2001 Indicative Master Plan on Power Interconnection in GMS Countries

Table 5.3: Actual Peak Load (1990-2000)

	Cambodia		Lao PDR		Thailand		Viet Nam	
Year	Energy demand (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%

Ref: ADB. 2001. Indicative Master Plan on Power Interconnection in GMS Countries

These tables show that in the four countries growth in demand was considerable (some 10 percent per year) except in Thailand in 1998 and 1999 when the Asian financial crisis drastically slowed the economy. Data on Cambodia indicate only the power that is currently supplied and not actual demand. It is generally assumed that the demand for electric power will continue to grow rapidly in Lower Mekong countries.

5.2 The power sector in Thailand

The Asian crisis brought an end to high growth rates, both in economic and in power terms, with power consumption stagnating or slightly falling during the years 1997-1999. In year 2000, consumption increases resumed and power demand grew by more than 7%, which is well below the rates during the first half of the 1990s. By the end of 2000 around 96% of the population reportedly had access to electricity.

Thailand's economy is on average projected to grow by 4.5 to 5% per annum over the forecasting period. This may be compared with an actual growth of 8.3% per annum over the ten-year period until the onset of the crisis.

Table 5.4: Thailand: Energy and Peak Demand Forecast

	2000	2005	2010	2020	Average annual change 2000-10	Average annual change 2000-20
Supply Requirements (GWh)	96,781	134,794	184,213	328,429	6.6%	6.3%
Peak Load (MW)	14,918	21,222	28,912	51,359	6.8%	6.4%
Consumption (kWh/yr/cap)	1,384	1,863	2,465	4,090	-	-

Supply requirements are projected to increase from 96,781 GWh in 2000 to 328,429 GWh in 2020, or by 6.3% per annum on average. Peak load is expected to more than treble to some 51,000 MW over the same period. The ten years pre-crisis growth rates were on average 13% per annum. Slackening demand growth is the result both of lower projected economic activity and a maturing power sector. Nevertheless, annual consumption per capita is expected to treble over the period, bringing it up to a level close to the present level of consumption per capita in South Korea.

The area-wise distribution of the country's requirements is summarized in terms of peak load in Table 5.4. The Central Region including the MEA Area continues to dominate Thailand's demand but its share is expected to be reduced from some 73% in 2000 to 68% of the total in 2020. The other areas show increasing shares, reflecting a lower degree of electrification and the Government's industrial decentralization policy.

Table 5.5: Thailand: Sub Regional Requirement, MW

Supply Area	2000	2010	2020	Share of Total Demand	
				2000 (%)	2020 (%)
Northern Area	1,394	2,874	5,385	9	10
Central and MEA Area	11,504	21,454	37,105	73	68
Northeastern Area	1,688	3,591	6,791	11	13
Southern Area	1,252	2,495	4,772	8	9

Thailand's power system uses a broad range of power sources including hydro, coal (lignite), oil and gas. The division of energy sources over installed capacity as of April 2001 is shown in Table 5.6.

Table 5.6: Thailand: Installed Capacity

Source	Installed Capacity (MW)	Share (%)
Hydro	2,886	13
Hydro Import	340	2
Lignite	2,625	12
Fuel oil	238	1
Gas	13,941	64
Diesel	230	2
Small Power Plants	1,613	7
Total	21,873	100

Thailand has developed only 25% of its hydro potential. Hydro is, according to EGAT, not presently viewed as an option for future expansion due to environmental and social resistance against further development. This is apart from the 2 x 250 MW Lam Takong and the 3 x 220 MW Kiridharn pumped storage schemes. Lam Takhong was commissioned in 2001, while commissioning of Kiridharn is planned in 2009-10 according to the EGAT PDP. The previously planned second 2 x 250 MW phase of Lam Takong is no longer included in the EGAT PDP. Increased use of lignite resources is unattractive because of environmental concerns. On this basis, future possible sources for Thai power system are:

- Hydro[ower imports from Lao PDR;
- Hydropower imports from Myanmar;
- Thermal plants based on imported coal;
- Hydropower imports from Yunnan Province of PRC; and,
- Combined cycle gas plants based on domestic and imported gas.

Transmission system

The transmission system in Thailand is divided into five operational regions and consists of 500 kV, 230 kV, 115 kV and 69 kV lines and substations. The five operational regions are: Metropolitan Area Grid, Central Region Grid, Northeastern Region Grid, Southern Region Grid and Northern Region Grid.

Northeastern Region Grid

This part of the grid consists of 230 kV, 115 kV and 69 kV lines and substations. Power from the largest generating plant in this area (Nam Phong CCPP) is transferred on 230 kV. The total generating plant in this area is 954 MW compared to a peak demand of 1,693 MW. With increasing loads, the power supply of this region will depend on power transferred from the Northern and the Central Regions. The degree of future grid reinforcements will depend on the implementation of local generating projects as well as possible power imports from neighboring countries such as Lao PDR, Cambodia and Viet Nam.

The highlight of EGAT's ongoing transmission projects:

- Transmission system extensions related to connection of Krabi Thermal Plant (300 MW) and Lam Thakhong Pumped Storage Project (2 x 250 MW units) to the grid; and,

- 500 kV TS Project for IPP. EGAT is constructing 500 kV lines along the Gulf of Thailand from Rayong to Nong Chok on the east coast, and from Bang Saphan to Chom Bung on the west coast (two routes of 500 kV double circuit lines on each coast). The purpose of the lines is to transfer power from the IPP power producers to the load center in Bangkok.

The highlight of Planned Transmission System Extensions

- Transmission system extensions related to connection of Surat Thani Combined Cycle Block 1 (300 MW) to the grid;

- TS Project No 10 is a package of sub-projects to be developed nationwide (except for the Greater Bangkok-Area); and,

- 500 kV TS Project for power import from Lao PDR. EGAT will construct two 500 kV transmission lines in separate routes from the Thai-Laos border, one to the Roi Et province and the second to Udon Thani Province.

EGAT's transmission extension plan comprises projects planned for implementation up to about stage 2010. So far, development plans for the period 2011 to 2020 have not been received.

5.3 The power sector in Lao PDR

High rates of growth in energy consumption were maintained through the crisis years in the Asian region despite lower overall growth of the economy (4-5% per annum) than in the preceding years of the decade (6-8% per annum). Increasing power exports from new hydropower schemes in recent years appear to only partly have compensated for lower growth in some of the other sectors, accompanied by a slowdown in reform efforts. The outlook is for relatively stable economic growth over the medium term, but the country's prospects for benefiting from further development of its vast hydropower resources depend on the competitiveness of hydropower generation compared to alternatives such as combined cycle plants in the prospective importing countries, and on the ability to attract foreign investment needed to develop these resources.

At present, 34% of the population is connected to one of the power grids, but consumption is highly concentrated. The power system in Lao PDR comprises four major networks, which are not interconnected: Central Area I, Central Area II, Northern Area and Southern Area. Central Area I accounts for 70% of consumption, and the municipality of Vientiane alone takes close to 60%.

Table 5.7: Lao PDR: Energy and Peak Demand Forecast

	2000	2005	2010	2020	Average annual change 2000-10	Average annual change 2000-20
Supply Requirements (GWh)	865	1,528	2,468	4,438	11.1%	8.5%
Peak Load (MW)	167	280	442	784	10.2%	8.0%
Consumption (kWh/yr/cap)	124	205	299	450	-	-

Domestic energy requirements are projected to increase from 865 GWh in 2000 to 4,438 GWh in 2020, or by 8.5% per annum on average. In comparison, supply in the 1990s on average grew by 12% per annum. Peak load is expected to increase by 4-5 times, to close to 800 MW over the same period. The main driver will be non-residential consumers among which there will be some relatively large schemes coming on line. Per capita overall consumption will still be modest at the end of the period under review at 450 kWh/year. The area-wise distribution of the country's requirements is summarized in terms of peak load in Table 5.7.

Table 5.8: Lao PDR: Sub Regional Requirement, MW

Supply Area	2000	2010	2020	Share of Total Demand	
				2000 (%)	2020 (%)
Northern Area	4.2	23.6	44.7	2	6
Central Area I	119.9	270.9	452.8	70	56
Central Area II	29.4	108.2	212.1	17	26
Southern Area	18.6	53.3	98.3	11	12

Central Area I with Vientiane and Luang Prabang will continue to dominate the country's demand but to a lesser degree, with a share of around 55% in 2020. The other areas show increasing shares, reflecting initial lower degree of electrification and the Government's electrification policy.

The existing system of Lao PDR is divided into four principle supply areas and a number of smaller isolated systems. The dominating generation source is hydropower, but a number of small diesel plants are used in the isolated systems. Some areas in the Central and Northern parts are supplied with imports from Thailand and Viet Nam at voltage levels between 22 and 115 kV.

Table 5.9: Lao PDR: Installed Capacity

Region	Load Centres	Hydro		Diesel	Total
		Domestic	Export		
Northern	Phonsaly, Lpang, Namtha			1.4	1
Central I	Vientiane, Luang, Prabang	212.2	210	11.1	22.5
Central II	Savannakhet, Thakek			1.0	1
Southern	Champassak, Savane	55	150	0.9	51
Total		268	360	14.4	642

The main power stations are Nam Ngum (150 MW) and Nam Leuk (60 MW) in the Central I region and Xeset 1 (45 MW) in the South. Hydro generation exceeds domestic demand most of the time and excess generation is exported to Thailand. An implication of this is that imports from Thailand to other areas in Lao PDR can be viewed as power wheeling. In addition there are two power stations dedicated for exports to Thailand: Theun Hinboun (run-of-river, 210 MW) and Houay Ho (storage, 150 MW). Lao PDR has a right to 1.5 MW from both plants, the Theum Hinboun right increasing to 10.5 MW in 2003. Table 3-4 provides an overview of generation candidates for export projects and domestic use respectively. The only thermal candidate in Lao PDR is the Hongsa lignite plant.

Table 5.10: Hydropower Alternatives Lao PDR (export projects)

Project name	Region	Capacity (MW)	Energy (GWh)
Nam Ngum 2	Central I	615	2,109
Nam Ngum 3	Central I	440	1,851
Nam Kong 1	Southern	238	802
Nam Mo	Central I	105	581
Nam Ngiep 1	Central I	366	1,429
Nam Ngiep 2	Central I	495	2,487
Nam Theun 1F	Central I	400	1,897
Nam Theun 2	Central I	1,088	5,500
Nam Theun 3	Central I	237	772
Xe Kaman 1	Southern	468	1,925
Xe Kaman 3	Southern	308	1,392
Se Kong	Southern	450	1,762
Se Kong 5	Southern	250	1,183
Xe Pian – Xe Nam Moy	Southern	390	1,995
Hong Sa (Lignite)	Southern	720	4,415

Table 5.11: Hydropower Alternatives Lao PDR (domestic projects)

Project name	Region	Capacity (MW)	Energy (GWh)
Huay Lamphan Gnai	Southern	60	354
Nam Bak 2	Central I	116	563
Nam Beng	Central I	51	217
Nam Ngum 4A	Central I	55	250
Nam Ngum 4B	Central I	56	254
Nam Ngum 5	Central I	100	425
Nam Kong 3	Southern	34	156
Nam Mang 3	Central I	35	134
Nam Pot	Central I	23	97
Nam Sane 2	Central I	62	279
Papheng (Takho)	Southern	30	215
Xe Katam	Southern	119	709
Xe Pon	Southern	74	301
Xeset 2	Southern	69	282
Xeset 3	Southern	16	85
Xe Xou	Southern	59	277

The following projects play a major role in the export strategy of Loa PDR:

Nam Mo (Viet Nam 2007)

The Nam Mo catchment is located in the province of Xieng Khouang some 200 km North-East of Vientiane on the border to Viet Nam. It was studied by Harza International Development Co. Ltd. to prefeasibility level in 1998. It comprises a mountainous area surrounded by high peaks. The proposed project is in the upper headwaters of the Nam Mo, where a small reservoir with an active storage of 264 million m^3 (84% of mean annual inflow) and a surface area of 11 km^2 would divert flows to a downstream powerhouse. The project involves an installation of 105 MW and an estimated annual generation of 581 GWh. Nam Mo is being investigated as an export project to Viet Nam. Little data is available about downstream social and environmental conditions in Viet Nam. Environmental effects seem to be moderate. The project has a low generation cost and a favorable location for export to Viet Nam.

Nam Theun 2 (Thailand 2008)

Nam Theun 2 involves the diversion of flows from the upper reaches of the Nam Theun from the Nakai Plateau to the Gnommalt plain below, using a head of approximately 300 m. The project was studied to feasibility by Snowy Mountain Engineering Corporation Limited (SMEC) in 1991. Additional studies have been undertaken by Worley/Lahmeyer in 1998. Social and environmental studies of the site have been carried out to EIA standards. Flows will be diverted to a powerhouse at the base of the plateau escarpment, from where a channel will be excavated to convey flows to the Xe Bang Fai. Two other hydropower facilities are currently being operated in the Nam Kading – Nam Theun Watershed: Nam Phao (1.6 MW) and Theun –Hinboun (210 MW), which diverts Nam Theun flows into the Nam Hinboun.

Development on Nam Theun 2 will reduce generation in Theun Hinboun, but this was anticipated when the latter project was developed. Several other projects are also under consideration, of which Nam Theun 3 and Nam Theun 1 are the most actual. According to the latest plans, installed capacity will be 1088 MW with an annual generation of 5,500 GWh. The project will have a reservoir of 3,210 million m^3, 42% of mean annual inflow. Reservoir creation will require the resettlement of some 800 families or 4,500 people within the Nakai Plateau. Nam Theung 2 is developed by NTEC and is at an advanced state of preparation. The impacts of the project are considerable, but they have been well investigated and adequate plans for mitigation have been made. Economically the project appears to be very attractive with the lowest cost per kWh of all projects proposed in Lao PDR.

Nam Ngum 2 (Thailand 2008)

The proposed Nam Ngum 2 project is located on the Nam Ngum River just upstream of the existing Nam Ngum 1 reservoir. It was studied by Electrowatt to feasibility in 1995. The project would involve inundation of 122 km^2 with a total volume of 3,950 million m^3 and an active storage of 2,400 million m^3 (39% of mean annual inflow). The project has an installed capacity of 615 MW and an annual generation of 2,109 GWh. The project will require a resettlement of approximately 5,800 people. As a large proportion of the Nam Ngum basin is covered by proposal for hydropower development, population and land pressure for resettlement is high. Economically the project appears attractive.

Electrowatt-Ekono suggests a reconfiguration of the project with two dams and two power station with respectively 160 and 185 MW installed capacity, considerably lower than the original plans. This would avoid most of the resettlement problems. It would also allow for a reconfiguration of the upstream Nam Ngum 3 project, allowing for a higher head and possibly a better solution.

Nam Ngum 3 (Thailand 2008)

This project is located some 30 km north of Xaisomboon on the Nam Ngum and 85 km upstream of the existing Nam Ngum reservoir. It was studied to feasibility level by SMEC/SEATEC (Thailand) in 1995. The project would create a reservoir extending approximately 80 km upstream into a steep and narrow valley. The reservoir has a total storage of 1,320 million m^3 and an active storage of 983 million m^3 (29% of mean annual inflow). Installed capacity is 444 MW and mean annual generation 1,851 GWh. The project's feasibility report indicates that the project would increase energy output of the Nam Ngum 1 and 2 projects with 3.5 and 5.3% respectively. Additional plans exist for upstream projects, Nam Ngum 4A, 4B and 5. These projects are on the list for domestic development in Lao PDR. Some studies suggest that resettlement will not be required, however, this appears to be uncertain. The cost of the project is relatively high. Electrowatt-Ekono proposes an extension of the headrace tunnel to increase the gross head of the project, increasing installed capacity to about 620 MW and a potentially better total project solution together with the proposed modification of Nam Ngum 2.

Hongsa Lignite (Thailand 2010)

The Hongsa Lignite is a thermal plant located in the Xianbouri province, based on lignite resources in the area. The proposed capacity is 720 MW. The project requires substantial resettlement, which however compares favorably with some of the hydropower projects, e.g. Nam Ngum 2 with a lower energy output and a higher number of persons to be resettled. Environmentally there are potential problems with air and water pollution. The project is more expensive than both gas fired and imported coal based generation in Thailand and many of the hydropower alternatives in Lao PDR, but could be selected to obtain fuel diversification in Thailand.

Xe Pian – Xe Namnoy (Thailand 2010)

The Xe Pian – Xe Namnoy project will exploit the hydraulic potential of a system of flows in the Bolovens Plateau in the provinces of Champassack and Attapeu in Southern Lao PDR. A feasibility study was completed by Electrowatt in June 1995. The flows of the Houay Makchan, the Xe Pian and its tributary Huay Liang and of the Xe Namnoy, all direct or indirect tributaries of the Se Kong River, will be impounded and diverted. The only completed project in the Se Kong Basin is Houay Ho. The Xe Pian – Xe Namnoy project will create a reservoir of 43.5 km^2, 979 million m^3 and an active storage of 919 million m^3 (68% of mean annual inflow). Installed capacity is 392 MW and estimated annual generation 1,995 GWh. Reservoir creation would require the resettlement of six villages supporting approximately 820 people. Economically the project is attractive.

Xe Kaman 1 (Thailand 2010)

Xe Kaman I is to be located on the Xe Kaman River approximately 85 km upstream of its confluence with the Se Kong River and the town of Attapeu. It was studied by HECEC to feasibility level in February 1995. The project involves construction of a 185 m dam in a

narrow gorge creating a large reservoir 224 km², 17,400 million m³ active storage (66% of mean annual inflow). The project has an installed capacity of 469 MW and a estimated annual generation of 1,925 GWh. Currently there are no other water resource developments on the Xe Kaman, but an upstream project, Xe Kaman 3 has also been proposed. Numerous other projects have been proposed in the Se Kong basin, but the only completed project is Houay Ho. With its large reservoir, Xe Kaman I will greatly alter downstream flows and reservoir inundation will require resettlement of over 800 people from ten villages. Economically the project is only moderately attractive.

Nam Theun 1 (Viet Nam 2012)

The Nam Theun 1 project is located in the Nam Theun River downstream of the existing Theun Hinboun project. The present project plan covers a relatively small reservoir with a 113 m high RCC dam and an active storage of 215 million m3, less than 2% of annual inflow. Installed capacity is 400 MW and annual generation ca. 1,900 GWh. With its small storage and the diversion of the mainstream low flows at Theun-Hinboun, the seasonality of the output is quite marked. Development of Nam Theun 3 would benefit the project. There are probably no resettlement problems with the current project plans, but there is some uncertainty related to this issue. Economically the project appears to be moderately attractive.

Nam Kong 1 (Viet Nam 2012)

This project is located on the Nam Kong River, a Southern tributary of the Se Kong River in the upland area which forms the South Eastern Lao PDR border with Cambodia. It was identified in the 1995 JICA Se Kong Master Plan Study and studied by Harclow to prefeasibility level in 1998. The scheme is within 20 km of the border and about 30 km south and west of the regional capital Attapeu. The project involves an 85 m high dam creating an 18.5 km2 large reservoir with a volume of 297 million m3 and an active storage of 271 million m3 (12% of mean annual inflow). Planned installation is 238 MW and estimated annual generation 802 GWh. No resettlement would be required as a result of the project. Economically the project looks doubtful.

Xe Kaman 3 (Viet Nam 2012)

The Xe Kaman 3 project is located on the Nam Paog-O, a tributary of the Xe Kaman in the Se Kong Basin. It was studied by Lahmeyer in 1998 (Hydropower Development Plan for Lao PDR) and by Halcrow to prefeasibility level in 1999. The proposed project is a storage project with a 128 m concrete dam creating a reservoir with an area of 12 km², a total volume of 467 million m³ and an active storage of 399 million m³ (35% of mean annual inflow). The proposed Xe Kaman 1 is downstream of Xe Kaman 3. No resettlement will be required for the reservoir. The project has an installed capacity of 308 MW and an estimated annual generation of 1,349 GWh. Economically the project appears to be moderately attractive.

Se Kong 4 (Viet Nam 2014)

Se Kong 4 is located on the Se Kong in Kaleum District Se Kong Province. It was studied to prefeasibility level by JICA in 1994 and Lahmeyer did an additional prefeasibility study in 1997. The project creates a 169 m high dam with a reservoir of 10 km², a volume of 8,350 million m³ and an active storage of 2,210 million m³ (39% of mean annual flow). Installed capacity is 451 MW and estimated annual generation 1,746 GWh. There are no other projects either upstream or downstream of the proposed Se Kong 4. The only existing

project in the same basin is Houay Ho, located in a downstream tributary. The Se Kong 4 project would have no impact on Hoyay Ho. Various other projects are proposed for the Se Kong basin, among them the upstream Se Kong 5, and several other export-dedicated downstream projects. Resettlement is estimated at 6,000 people, mostly ethnic minorities. Economically the project is among the least attractive of the projects proposed for export and viability is doubtful from a purely economic point of view.

Se Kong 5 (Viet Nam 2014)

Se Kong 5 is located upstream of the proposed Se Kong 4 site. It was studied by Lahmeyer/Hidrotechnica Portuguesa to inventory level in 1998. The project has a 205 m high dam, creating a large reservoir with a surface of 70 km2, a volume of 4,780 million m3 and an active storage of 2,200 m3 (81% of mean annual inflow). Installed capacity is 248 MW and estimated annual generation 1,183 GWh. Resettlement is estimated at approximately 1,000 people, including ethnic minorities. Economically the project is somewhat better than Se Kong 4, but also for this project economic viability is doubtful.

Nam Theun 3 (Viet Nam 2016)

Nam Theun 3 is located in mountainous country which rises eastwards up towards the Viet Nam border. The project was studied by ENEL S.P.S and ISMES S.P.A to feasibility level in 1995. The dam is on a big S shaped bend of the Nam Gnouang River, a tributary of the Nam Theun.

Planned installation is 236 MW with an annual generation of 772 GWh. The project involves a large reservoir with a total volume of 4,960 million m3 and an active storage of 2,870 million m3 (83% of mean annual inflow). The surface area of the reservoir will be 120 km2. Development of Nam Theun 3 would not negatively impact any of the other projects in the Nam Theun basin but by regulating flow would have some benefit on Theun-Hinboun and to a lesser degree Nam Theun 1. About 1,200 people would have to be resettled. Nam Theun 3 is a high cost project and is not economically viable as a stand-alone project. However, when the increase in dry-season generation in Theun-Hinboun and possibly Nam Theun 3 is taken into account, the project looks more attractive. Table 3-5 provides an overview over hydropower candidates including resettles number.

Table 5.12: Comparison of Planned Hydropower Projects

Name of Project	1[2]	2	3	4	5		6		7
	MW	GWh/a	N	km²	Per GWh/a	Rank 1	km² per GWh/a	Rank 2	
Northern Provinces									
Nam Long	11	53	na	na	-	-	-	-	-
Nam Sim	7	24	0	0.2	0.0	1	0.008	2	1.5
Nam Beng	54	175	na	12.0	-	-	0.069	5	-
Hongsa Lignite[1]	720	4,415	1,000	30.0	0.2	2	0.007	2	2.0
Moung Houn Lignite[1]	30	184	na	5.1	-	-	0.028	4	-
Nam Ngum Basin									
Nam Ngum 5C	100	430	500	14.6	1.2	4	0.034	4	4.0
Nam Ngum 5D	120	515	na	na	-		-		-
Nam Ngum 4A	55	250	1,740	14.4	7.0	6	0.058	5	5.5
Nam Ngum 4B	56	254	0	0.5	0.0	1	0.002	2	1.5
Nam Ngum 3	444	1,851	300	25.6	0.2	2	0.014	3	2.5
Nam Ngum 3E	580	2,654	500	25.6	0.2	2	0.010	3	2.5
Nam Ngum 2	615	2,109	5,778	86.0	2.7	5	0.041	4	4.5
Nam Ngum 2A	159	709	200	3.8	0.3	2	0.005	2	2.0
Nam Ngum 2B	183	830	1,000	7.5	1.2	4	0.009	2	3.0
Nam Bak 2B	116	536	0	4.8	0.0	1	0.009	2	1.5
Nam Mang 3	51	141	60	9.5	0.4	2	0.067	5	3.5
Nam Ngiep									
Nam Pot	23	97	0	6.1	0.0	1	0.063	5	3.0
Nam Ngiep 1 (FSL360)	360	1,905	5,200	148.2	2.7	5	0.078	5	5.0
Nam Ngiep 1 (FSL320)	240	1,349	1,600	73.9	1.2	4	0.055	5	4.5
Nam Mo	100	581	0	10.8	0.0	1	0.019	3	2.0
Nam Sane	62	279	6,190	121.8	22.2	6	0.437	6	6.0
Nam Theun Basin									
Nam Theun 3	236	772	1,220	126.0	1.6	4	0.163	6	5.0
Nam Theun 2	975	5,173	4,500	450.0	0.9	3	0.087	5	4.0
Nam Theun 2 S-538	900	4,169	4,000	313.0	1.0	3	0.075	5	4.0
Nam Mawan	137	695	0	120.0	0.0	1	0.173	6	3.5
Nam Mouan	84	445	na	120.0	-		0.270	6	-
Nam Theun 1F	600	2,824	330	44.0	0.1	2	0.016	3	2.5
Xe Pon	74	301	800	29.5	2.7	5	0.098	5	5.0
Xe Set									
Xe Set 2	69	252	0	1.5	0.0	1	0.006	2	1.5
Xe Set 3	16	72	0	1.3	0.0	1	0.018	3	2.0
Xe Kong (Upper)									
Xe Kong 5	258	1,183	980	70.0	0.8	3	0.059	5	4.0
Xe Kong 4	451	1,746	5,870	160.4	3.4	5	0.092	5	5.0
Houay Lamphang Gnai	60	354	0	3.5	0.0	1	0.010	3	2.0
Xe Katam	100	709	0	0.2	0.0	1	0.000	1	1.0
Xe Pian-Xe Namnoy	392	1,995	820	43.5	0.4	2	0.022	4	3.0

Name of Project	1[2]	2	3	4	5	6			7
	MW	GWh/a	N	km²	Per GWh/a	Rank 1	km² per GWh/a	Rank 2	
Xe Kong (Lower)									
Xe Kaman 3	308	1,348	0	12.0	0.0	1	0.009	2	1.5
Xe Kaman 1	469	1,925	800	220.0	0.4	2	0.114	6	4.0
Xe Kaman 1B	300	1,433	800	193.0	0.6	3	0.135	6	4.5
Xe Xou	59	277	500	112.9	1.8	4	0.408	6	5.0
Nam Kong 3	34	156	1,550	36.9	9.9	6	0.237	6	6.0
Nam Kong 1	238	802	200	12.1	0.2	2	0.015	3	2.5
Mekong									
Thakho (Phapheng Falls)	36	2,067	0.0	0.0	0.0	1	0.000	1	1.0

Source: ADB TA 3374-LAO, Power Sector Strategy Study Draft Final Rept Vol1, 09/03/01 Electrowatt - Hagler Bailly. Ranking by magnitude of environmental and socio-economic impact. (1) Installed capacity, (2) Energy produced, (3) Resettled person, (4) Reservoir area (5) Resettles, (6) Reservoir, (7) Overall Rank

1). mining area instead of reservoir area in the case of lignite fired thermal power plants

Thakho (Phapheng Falls)

South system is isolated from north and central system. This project targets an isolated area. The location is 150 km downstream from Pakse near the Cambodian border. Under the preliminary study done by Tokyo Electric Power Co. INC, Thakho power scheme is a run-of-the-river type on the Mekong main stream by the side of Thakho falls. Installed capacity is about 30 MW. Annual generation is about 230 GWh. Effective head and maximum discharge is about 20 m and 180 m^3/s respectively. Operation target is 2008. No relocation is required. Construction cost is about US$104 million.

Table 5.13: Small/Micro Hydropower Development Plans for Rural Electrification in Lao PDR

		kW				kW	
1	Nam Ngai	1,000	M. Phongsali	24	Nam Ken		M. Hongsa
2	Nam Hoy	200	M. Bountai	25	Nam Yang		M. Ngeun
3	Nam Pok	2,600	M. Samphan	26	Nam Nad	54	M. Kham
4	Nam Ngao	2,500	M. Nga	27	Nam Ka	800	M. Nonghet
5	Nam Ling	150	M. Gnot-Ou	28	Nam Peun	320	M. Khoun
6	Nam Sing	400	M. Sing	29	Tad Peun	35	M. Pek
7	Nam Tha-3	1,500	M. Nam Tha	30	Nam Yang	450	M. Viengthong
8	Nam Phak	12,600	M. Namo	31	Nam Ngou	60	M. Bolikhan
9	Huay Khieo	150	M. Paktha	32	Tad Xiengleu	800	M. Boualapha
10	Nam Meng	100	M. Paktha	33	Tad Salen	3,200	M. Xepon
11	Nam Gnon	460	M. Houayxay	34	Tad Keng	300	
12	Huay Phadam	200	M. Mueng	35	Nam Kokmak	40	M. Vilbouli
13	Tadnammeng	150	M. Mueng	36	Huay ilai	300	M. Ta-Oy
14	Nam Thoum	100	M. Nambak	37	Nam Phouang	150	M. Dakchung
15	Nam Khan	300	M. Nambak	38	Nam Fen	200	M. Xaisomboun

		kW				kW	
16	Nam Kuang	1,200	M. Viengkham	39	Tad Xong	3000	M. Thathom
17	Nam Chat	12	M. Houamuang	40	Nam Mang	200	M. Thathom
18	Nam Hao	5,100	M. Viengxai	41	Nam Pouan	20	M. Khamkeut
19	Nam Sim	2,700	M. Viengxai	42	Houaysing	20	M. Vangvieng
20	Nam Khuang	200	M. Xamtai	43	Nam Kheng	50	M. Kasi
21	Nam Houng		M. Xaignabouli	44	Houayhop	100	M. Viengkham
22	Nam Ham-2	2,000	M. Boten	45	Nampa 2	70	M. Phonxai
23	Nam Poui		M. Paklay				

Source: MIH, Department of Electricity Rural Electrification Division, 18 April 2000

Table 5.14: Small/micro Hydropower Projects Under Construction

		kW		
1	Nam Kai	500	95-	M. Khoua
2	Nam La	104	97-2000	M. Xamtai
3	Houay Kasen	75	97-2000	M. Pakbeng
4	Houay Samong	226	91 -	M. Sanamxai
5	Nam Sat	250	97 - 2000	M. Viengthong

Table 5.15: Existing Small/Micro Hydropower Plants

		kW		
1	Nam Boun	2 x 55	1996	M. Bountai
2	Nam Leu	1 x 46.2	1994	M. Luangnamtha
3	Huoay Khiboan	1 x 50	1998	M. Long
4	Nam Pa	1 x 16	1998	M. Louangphrabang
5	Nam Dong	3 x 336	1970	M. Louangphrabang
6	Nam Et	1 x 80	1988	M. Viengthong
7	Nam Long	1 x 20	1989	M. Sopbao
8	Nam Soplong	1 x 24	1989	M. Sopbao
9	Nam Hang	1 x 6	19..	M. Sam-nua
10	Nam Soy	1 x 12	19..	M. Sam-nua
11	Nam San	1 x 110	1995	M. Sam-tai
12	Nam Peun	1 x 36	1986	M. Houamuang
13	Nam Poun 1	1 x 96	1994	M. Viengxai
14	Ban Sop Ma	1 x 55	1995	M. Kham
15	Nam Tain	1 x 75	1995	M. Kham
16	Nam Poui	1 x 24	1986	M. Khoun
17	Nam Poung	1 x 5	1995	M. Khoun
18	Nam Ka1	1 x 12	1995	M. Phaxai
19	Nam Ka2	1 x 81	1995	M. Phaxai
20	Nam Ka3	1x5	1995	M. Phaxai
21	Ban Nong	1 x 40	1995	M. Khoun

		kW		
22	Ban Tan 1	1 x 5	1994	M. Khoun
23	Ban Tan 2	1 x 8	1995	M. Khoun
24	Nam Chat	1 x 100	1995	M. Mokmai
25	Houay Saloi	1 x 75	1996	M. Nong
26	Nam Ham	1 x 90	1992	M. Boten
27	Nam Khoun	1 x 5	19..	M. Bountai
28	Houay Kha	1 x 5	19..	M. Bountai
29	Nam Phao	2 x 800	1995	M. Khamkeut
30	Nam Ko	3 x 500	1996	M. Xai
31	Nam Poun 2	1 x 48	19..	M. Viengxai
32	Nam Noun	1 x 30	1999	M. Nale
33	Muangphoun Dam	1 x 200	1999	M. Phoun
34	Houay Champi	1 x 40	1985	M. Pakxong
35	Houaymen	1 x 24	19..	M. Xam-nua
36	Nam Mong	1 x 70	9/03/2000	M. Nambak

5.4 The power sector in Cambodia

Electricity supply in Cambodia is highly fragmented, with 21 separate power systems centred on the various provincial capitals and Phnom Penh. All but two of the 21 cities and towns are fully reliant on diesel power stations using imported high cost light diesel oil as fuel. Lack of a high voltage transmission system and the high cost of diesel fuel have led to Cambodia having one of the highest costs of electricity in the world (more than USc 30 kWh in some provincial areas, an average of USc 16 kWh in Phnom Penh). The high cost together with an unreliable supply situation due to lack of spare parts and maintenance has led many businesses to set up their own generating plants.

Per capita consumption is only about 35 kWh a year and less than 15% of households have access to electricity. Low per capita consumption reflects limited availability of supply, both geographically and in terms of hours of supply per day and the very high tariffs. Peak demand in Phnom Penh in 2000 was 64 MW with an additional 50 MW for the other provincial centres. It should be noted, however, that much of the private generation in the regions is of unknown quantity. Countrywide consumption increased by leaps and bounds during the latter half of the 1990s, at an average growth rate 26% up to 2000. The high growth partly the reflects substitution of private generation by EDC supply and a strong growth in demand in the larger load centres. The results of the forecast are summarized in the following table.

Table 5.16: Cambodia: Energy and Peak Demand Forecast

	2000	2005	2010	2020	Average annual change 2000-10	Average annual change 2000-20
Supply Requirements (GWh)	586	1,329	2,502	5,720	15.6%	12.1%
Peak Load (MW)	114	280	529	1,156	16.6%	12.3%
Consumption (kWh/yr/cap)	34	73	128	250	-	-

Supply requirements are projected to increase from 586 GWh in 2000 to 5,720 GWh in 2020, or by 12.1% per annum on average. Peak load is expected to reach 1,156 MW in 2020. Over the 20-year period, these figures represent a ten-fold increase. When considering such large increases the present low coverage and unit consumption as well as unregistered demand should be taken into account. Considerable uncertainty is attached to the forecasts. The distribution of the country's peak load requirements between the capital and the remainder of the country is summarized in Table 5.17.

Table 5.17: Cambodia: Sub Regional Requirement (MW)

Supply Area	2000	2010	2020	Share of Total Demand	
				2000 (%)	2020 (%)
Phnom Penh	64	281	567	56	47
Other regions combined	50	260	649	44	53

Apart from one 1 MW hydro plant and three small to medium-sized thermal stations in Phnom Penh, all generation is based on small diesel engines. Phnom Phen is presently supplied from five EdC power stations and two IPPs. The C2 steam plant is old and has low thermal efficiency. The GM diesels at the C3 plant are also inefficient and old and are mainly on standby duty when not required to support peak load conditions. The Jupiter IPP is an intermediate solution. Until recently a new 60 MW naphtha fuelled IPP2 was expected to be commissioned in 2000, but it has been difficult to close this deal satisfactory. Fuel costs are the largest component of total generation costs and the complete reliance on imported oil makes Cambodia vulnerable to changes in the international oil prices. The 11 MW Kirirom hydropower plant was commissioned in 1968 but destroyed in 1970. It is being rehabilitated as a Chinese BOT project together with the 130 km, 115 kV line to Phnom Penh.

Table 5.18: Cambodia: Hydropower Alternatives

Project name	Region	Capacity (MW)	Energy (GWh)	Comment
Stung Mnam 2	Western	90	466	Power plant in Thailand
Stung Meteuk 2	Western	210	384	Alternative to St Mnam 2
Kirirom	Western	11	63	Commissioned in 2002
W Kirirom Olateau	Western	13	70	
Battambang 1	Western	24	120	
Battambang 2	Western	36	187	
Stung Piphot 2	Western	25	140	
Kamchay CPEC	Western	128	558	
Kamchay HECEC	Western	47	133	
Stung Atay	Western	110	588	
Upper Stung Russei Chrum	Western	32	211	
Middle Stung Russei Chrum	Western	125	668	
Sturng Chlay Areng 2	Western	260	1,358	
Sambor CPEC	Eastern	465	2,800	

Project name	Region	Capacity (MW)	Energy (GWh)	Comment
Lower Se San 2D	Eastern	207	1,065	Downstream site
Lower Se San 2U	Eastern	112	546	Upstream site
Lower Sre Pok 2	Eastern	222	1,174	

5.4.1 Existing transmission system

The only transmission lines in Cambodia are constructed around Phnom Penh. A 115 kV single circuit transmission line strung on double circuit concrete poles links the three new substations GS1, GS2 and GS3 to a partial ring around Phnom Penh. These lines are redistributing power from the existing and new power stations to the existing and rehabilitated MV distribution system, which is now a uniform 22 kV system. The existing diesel/steam plants are connected to the 22 kV bus-bars in the substations: C2 to GS2, C3 to GS3, and C1, C5 and C6 to GS1. It is intended to add a second 115 kV circuit progressively in two to three years.

The 115/22 kV substations GS1, GS2 and GS3 have been established at the north, south and west of Phnom Penh. The new layout consisting of 115 kV lines and substations allows increased operational flexibility between the power stations. In other supply areas the local electricity production is delivered on local distribution networks.

5.4.2 Planned transmission system extensions

During the last few years four studies have been carried out on future transmission system developments in Cambodia:

- Mekong Integrated Transmission System Study
- Power Transmission Master Plan and Rural Electrification Strategy
- Feasibility Study for the First Transmission Link between Phnom Penh and the Southern Region of Cambodia
- Feasibility Study on Power Supply to Cambodia from Thailand

The generation and transmission system planning seem to be carried out in a continuous and iterative process. The Feasibility Study (Final Report) on 230 kV Interconnection Cambodia – Viet Nam was submitted in March 2001, and EdC planned to submit the Transmission Development Plan (Final Report) after that.

5.5 The power sector in Viet Nam

Power consumption increased on average by more than 13% per annum during the 1990s, with only one year (1999) below this average even after the onset of the Asian financial crisis. The main driver behind the increase so far has been household consumption. Industry is the other major consumer. The average elasticity of total power sales with respect to GDP during the decade was 1.8-1.9, indicating the strong need for more power along with an expanding economy. By the end of 1999, the national power grid had expanded to cover all

61 provinces and central cities. Close to 80% of the country's communes (villages) have access to grid supply and some 70% of the households are reportedly electrified.

During the two years (1998-1999) after the onset of the regional crisis, real economic growth was halved to around 4.5% per annum compared to the six-year period from 1992, an era of high growth driven by first-generation reforms, booming private consumption and foreign direct investment (FDI). In order to reach the Government's ambitious targets, a reversal of the present situation, characterized by a loss of reform momentum and declining FDIs is considered necessary. Since 2000, the economy has been showing signs of recovery. Long term economic growth of 7.5-8% is considered achievable if reforms are continued and macroeconomic stability is maintained. The result of forecast are summarized in Table 5.19.

Table 5.19: Viet Nam: Energy and Peak Demand Forecast

	2000	2005	2010	2020	Average annual change 2000-10	Average annual change 2000-20
Supply Requirements (GWh)	26,722	44,230	72,014	169,428	10.4%	9.7%
Peak Load (MW)	4,890	7,877	12,589	28,739	9.9%	9.3%
Consumption (kWh/yr/cap)	287	444	688	1447	-	-

Supply requirements are projected to increase from 26,722 GWh in 2000 to 169,428 GWh in 2020, or by 9.7% per annum on average. Peak load is expected to reach close to 28,800 MW by 2020, yielding a slightly lower growth rate due to the increase in load factor. In comparison, average growth rates during the 1990s were 11-12% per annum. Annual consumption per capita is expected to reach around 1,500 kWh which is slightly above the present level of consumption per capita in Thailand. The area distribution of the country's requirement is summarized in terms of peak load in Table 5.20.

Table 5-20: Viet Nam: Sub Regional Requirement (MW)

Supply Area	2000	2010	2020	Share of Total Demand	
				2000 (%)	2020 (%)
Northern Region	2,044	4,447	10,839	40	37
Central Region	572	1,578	3,515	11	12
Southern Region	2,435	6,687	14,629	48	50

Ho Chi Minh City in the south and Hanoi in the north are the major load centres and this is reflected in the regional distribution of loads. The Southern Region is expected to increase most, both in absolute and relative terms, whereas the smaller and less developed Central Region will show a moderate increase in its share of total demand. This is a continuation of a pattern of development already seen in the 1990s.

5.5.1 Existing generation system

The Vietnamese power system consists of three sub-systems North, Centre and South, with the major demand centres Hanoi in the North and Ho Chi Minh City in the South. The system uses a variety of fuel sources. Table 5.21 shows existing capacity in each sub-system.

Table 5.21: Viet Nam: Installed Capacity (MW) 2000

System	Hydro	Coal	Gas	Fuel Oil	Diesel Engine/GT	Total
North	2,038	645			50	2,733
Centre	183				190	373
South	1,070		1,338	573	551	3,532
Total	3,291	645	1,338	573	828	6,675
Share (%)	49	10	20	9	12	100

The older thermal plants are no longer fully available and as a result, available capacity is a few hundred MW lower than installed capacity. Of the fuel oil capacity, 375 MW is provided by the Hiep Phuoc IPP. Several power stations are presently converted from open cycle gas turbines to combined cycle plants.

3.5.2 Generation expansion candidates

In Viet Nam many alternatives for future generation are available: hydro, coal, oil and gas and geothermal heat. Viet Nam also contemplates the use of nuclear power in the last part of the planning period. Table 5.22 shows the most promising hydropower candidates. The majority of these are taken from EVN's WASP data set. A number of these projects are also under consideration in the National Hydropower Plan under preparation by Sweco International, Statkraft Engineering and Norplan.

Table 5.22: Viet Nam Hydropower Alternatives

Project Name	Region	River	Capacity (MW)	Energy (GWh)	Comment
A Vuong	Centre	A Vuong	170	760	
An Khe	Centre	Ba	165	694	
Bac Binh, B Loc, D Xuyen	Southern		159	536	
Bac Me	Northern	Lo/Gam	250	919	NHP
Ban Chac	Northern	Da	350	580	NHP
Ban La	Northern	Ca	300	810	NHP
Ban Mai	Southern		300	1,050	
Buon Kuop #	Centre	Srepok	277	1,346	
Can Don	Southern	Ba	72	291	Domestic BOT
Cua Dat	Northern	Chu	120	427	Mulyipurpose
Dai Ninh	Southern	Dong Nai	300	1,200	Concessional loan Japan
Dai Thi (Pac Ta)	Northern	Lo/Gam	300	899	NHP

Project Name	Region	River	Capacity (MW)	Energy (GWh)	Comment
Dak My	Central		200	751	
Dak R Thi	Southern	Dong Nai	105	468	NHP
Dong Nai 2	Southern	Dong Nai	90	309	NHP
Dong Nai 3 +4	Southern	Dong Nai	510	1547	NHP
Dong Nai 6	Southern	Dong Nai	180	768	
Dong Nai 8	Southern	Dong Nai	180	768	
Hua Na	Northern		275	982	
Huoi Quang	Northern	Da	300	847	NHP
Lai Chau B	Northern	Da	300	907	NHP
Na Le (Coc Ly)	Northern	Lo/Gam	100	392	NHP
Nam Chien	Northern	Da	131	542	NHP
Pleikrong	Central	Se San	110	766	
Rao Quan	Central	Rao Quan	80	268	Multipurpose
Se San 3 #	Central	Se San	273	1110	NHP
Se San 3A #	Central	Se San	100	401	NHP
Se San 4 #	Central	Se San	330	1,256	NHP
Se San 4A #	Central	Se San	140	530	
Son La Large	Northern	Da	3,600	11,800	NHP
Song Ba Ha	Central	Ba	210	895	
Song Tranh 2	Central	Tranh	200	720	
Srok Phu Mieng	Southern	Dong Nai	60	245	NHP
Thuong Kon Tum #	Central	Se San	260	654	NHP
Total			10,497		

5.5.3 Existing transmission system

The transmission system in Viet Nam consists of four voltage levels: 66 kV, 110 kV, 220 kV and 500 kV. In this sub-regional study the main focus will be on 220 kV and 500 kV. A 1,488 km long 500 kV line is interconnecting the northern, central and southern power systems.

5.5.4 Planned transmission system extensions

A Power Development Plan (PDR No. 4) for the period 2001-2010, with development outlook up to 2020 has been prepared. The PDR was approved by the Government at the end of June 2001. Information indicates that a Transmission System Study prepared by EVN, also exists. Moreover, a transmission system study on the second 500 kV line Plei Cu – Phu Lam showing among other things load flow and stability studies for stages 2000, 2005 and 2010 has been prepared by a consultant from Canada.

The PDP presents the planned transmission line projects (from substation, to substation), voltage level, number of circuits and line lengths, but no detailed information about planned conductor cross-section is given. For projects after 2005, no information about the planned commissioning time is given. Information about the planned future substations and transformer installations are given, but substation loads are lacking.

The PDP states that some of the near term 500 kV reinforcements are 1-2 years behind schedule. The 500 kV network is intended to satisfy three main goals:

- Power transmission from large-scale power plants such as the hydropower plants Hoa Binh, Yaly and Son La, and the thermal power plants Phu My, O Mon, Ca Mau and future nuclear power plants;
- Ensure a high supply reliability for the three largest load centres; and,
- Create power exchange possibilities in the GMS sub-region.

5.6 Hydropower development in Yunnan

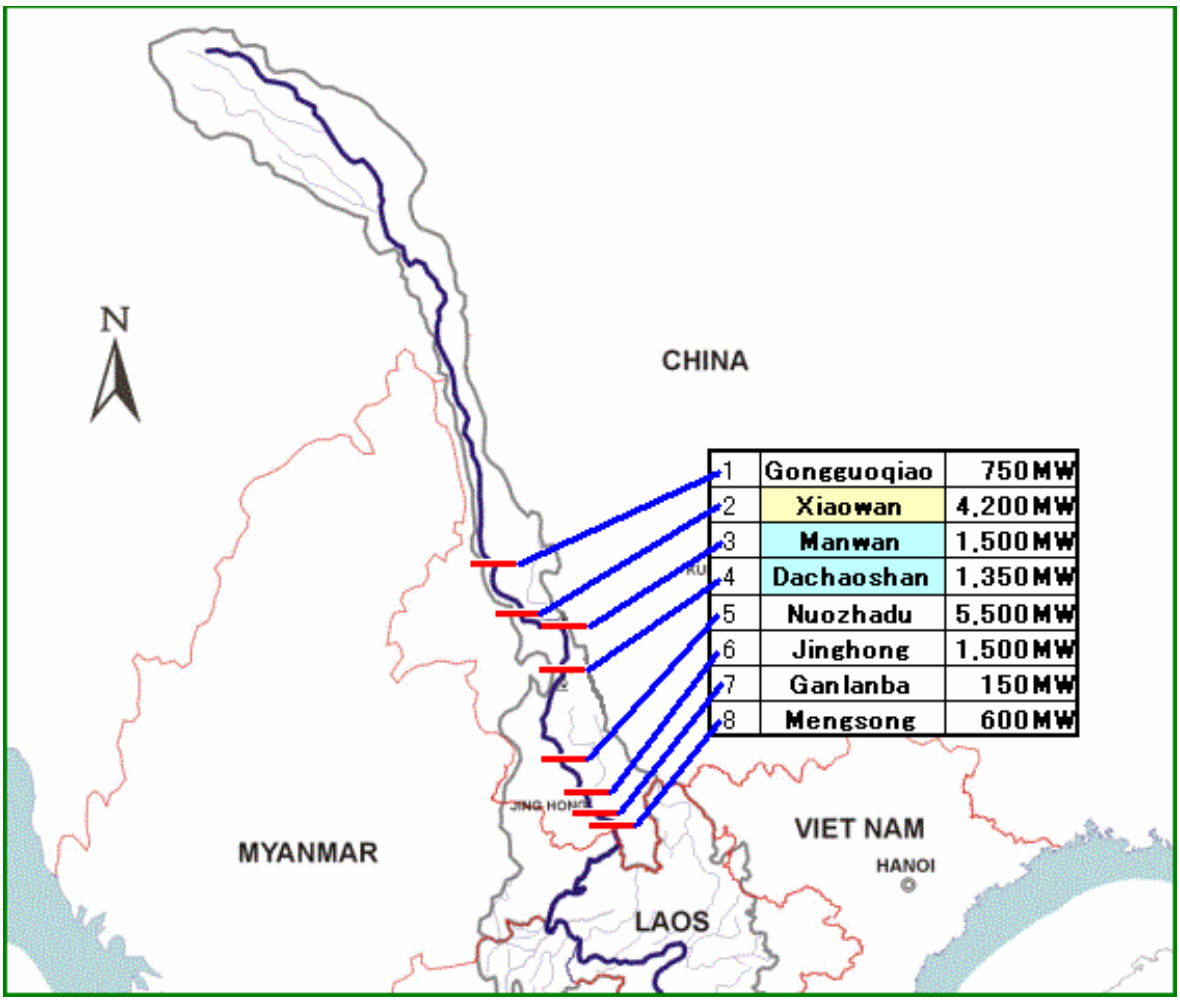
In Yunnan Province on the upper stream of the Mekong, China is implementing hydro projects on the mainstream without official consultation with the countries downstream. China currently has plans to construct eight dams and power stations, in addition to the two that are already operating. These projects 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 eight projects are presented in Table 5.23 and the location of the projects is shown in Map 5.2.

Table 5.23: List of Planned and Completed Hydropower Projects on the Mekong in China

Name of Project	Installed Capacity (MW)	Annual Generation (GWh)	Total Strage C. (million m3)	Catchment Area (km2)	Average Flow (m3/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				

Ref: Committee of Science and Technology. 1993. Study on Lancang River in Yunnan Province, China; ADB. 2001. Indicative Master Plan on Power Interconnection in GMS Countries

Map 5.2: Planned and Completed Hydropower Projects on Mekong in China



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 20January, 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 the river's flow pattern, blocking of sediment and impacts on the environment may have occurred. The impacts so far appear to be limited because these reservoirs could only change the flow pattern on a daily basis. The next two projects, Xiaowan and Nuozhadu, however, will have much large reservoirs and could change the river's flow on a seasonal basis.

To maximise the positive impacts and minimise the negative impacts from dams, these should be planned and operated in consultation with all countries in a river basin. In the

Mekong Basin, it is hoped that 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 which countries downstream from planned hydropower projects require 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, use of water for irrigation, domestic use etc.). 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 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. Through this cooperation, it is hoped that the river will be managed for the benefit of all the basin's peoples.

5.7 Interconnections

5.7.1 Overview

The power generation potentials indicate that Lao PDR, Myanmar and Yunnan have substantial surplus energy that could be exported to neighbouring countries for several years. The large future demand in Thailand combined with limited potential for increased generation based on domestic resources makes this country the largest single market for power. Increasing power demand also makes Viet Nam a net importer of electricity in the long run.

Although this is the long-term picture, the situation may be different in the short and medium terms. At present Thailand has a considerable net surplus caused by the slowdown in demand growth in 1998 and 1999. Another example is when a large power station is built in a small system (e.g. Cambodia), making export an attractive option in the first years after commissioning. Yet another example is the variability of annual generation from hydropower. Systems relying extensively on hydropower may have huge surpluses in one year and a deficit the next caused by changing hydrological conditions. A country may find it reasonable or economic to import power even if the long-term prospects are increased export. In fact, this is an important benefit of interconnections between power systems.

Some interconnections already exist between of the countries in the GMS sub-region, notably between Lao PDR and Thailand. However, these are transmission lines from power producers to consumers are not interconnections of countrywide grid systems which should be the definition of true interconnections to be considered as load increases and sub-regional power cooperation is being developed. In this study, only interconnections of 115 kv and above will be presented and only those transmission lines with some regional significance.

In general, all countries wish to have a certain degree of self-sufficiency of electricity. Some countries have formulated an energy dependency policy. In Thailand, the authorities have specified the maximum acceptable limits of power import to Thailand as follows:

- Dependency from one country: Maximum 13% of peak demand
- Dependency from two countries: Maximum 25% of peak demand
- Dependency from three countries: Maximum 33% of peak demand

With an increase load in Thailand, the acceptable amount of power imports will also increase. The following table gives an indication of power import limits:

Table 5.24: Acceptable Power Imports to Thailand

Year	Peak Load (MW)	Max. Permitted Dependency (MW) from		
		One Country	Two Countries	Three Countries
2000	14,918	1,939	3,729	4,922
2005	21,222	2,759	5,306	7,003
2010	28,912	3,759	7,228	9,541
2015	38,519	5,007	9,630	12,711
2020	51,359	6,677	12,840	16,948

5.7.2 Power exchange agreements Lao PDR – Thailand

Table 5.25: Power Exchange Agreements Between Lao PDR and Thailand

Power Plant / Interconnection	Max Transmission Capacity (MW)	Indicative Quantity	
		MW	GWh/yr
Nam Ngum / Nam Leuk	67 + 120	120	764
Xeset	120	20	138
Theun Hinboun	2 x 429	217	1,635
Huoay Ho	133	133	610
Total		490	3,147

Existing interconnections

Table 5.26: Existing Interconnection Between Thailand and Lao PDR

Interconnection From Lao PDR	To Thailand	# of Ckt	# in Bundle	Cross-section (MCM)	Length (km)	Capacity (MVA)	Comm. Year
230 kV							
Theun Hin Boun	Sakhon Nakhon 2	2	1	1,272	176	2 x 429	1998
Houay Ho	Ubon Ratchani 2	2	1	1,272	230	2 x 429	1999
115 kV							
Phonetong	Ubon. Line I	1	1	477	73	107	1971
Phonetong	Ubon. Line II	1	1	477	78	107	1971
Thanaleng	Nong Khai	1	1	95 mm²	11	60	1971
Bang Yo	Siridhon	1	1	477	60	107	1991
Pakxan	Bun Kan	1	1	477	11	30	1996
Thakhek	Nakorn Hnom	2	1	336.4	8	2 x 19	1997
Savannakhet Pakbo	Mukdahan 2	1	1	477	14	107	1997

Planned interconnections

Table 5.27: Potential Interconnection Between Thailand and Lao PDR

Interconnection From Lao PDR	To Thailand	# of Ckt	# in Bundle	Cross-section (MCM)	Length (km)	Capacity (MVA)	Comm. Year
500 kV							
Na Bon Collector	Udon Thani 3	2	4	795	124	2 x 2,832	2006
Savannakhet Collector	Roi Et 2	2	4	795	167	2 x 2,832	2006
Hongsa Lignite	Mae Moh 3	2	4	795	310	2 x 2,832	2008

5.7.3 Power exchange agreements Viet Nam – Cambodia

In June 1999 the governments of Cambodia and Viet Nam signed a Power Sector Cooperation Agreement. The objectives of this agreement were:

- To promote the power trade between the two countries;
- to reduce emission of greenhouse gases and other pollutants; and,
- to improve the power sector efficiency and reduce electricity costs by linking the power grid systems of the two countries.

Under this agreement Viet Nam will supply power to Cambodia at two voltage levels. The medium voltage feeders will supply small loads close to the border, while the high voltage interconnections will be used for bulk supply of power. In July 2000 a Power Trade Agreement and a Power Purchase Agreement were signed, describing principles of power cooperation, technical, commercial and operational arrangements required.

Existing interconnections

There are no interconnections between Viet Nam and Cambodia.

Planned interconnections

A feasibility study has been carried out for the first transmission link between Phnom Penh and the Southern Region of Cambodia. EVN carried out a series of preliminary studies, and concluded that a 220 kV interconnection from Thot Not and Chau Doc substations in Southern Viet Nam to Takeo substation and Phnom Penh in Cambodia was the preferred interconnection option. EVN will provide to EdC the following available firm capacity at the interconnection point:

- Phase 1: 80 MW during 2003-2005
- Phase 2: 200 MW after year 2005

In the Master Plan for Electric Power Development 2001-20020 in Viet Nam and Power Development Possibilities up to 2020, the possibility of power imports from Sambor and Stung Trang hydropower projects in Cambodia is also mentioned. A double-circuit 500 kV line from Sambor to Tanh Dinh substation (Ho Chi Minh) is indicated, with commissioning after 2010. So far no agreement on power development of Sambor has been made between Viet Nam and Cambodia.

5.7.4 Power exchange agreements Thailand – Cambodia

An MOU is signed between the governments of Cambodia and Thailand on power supply from Thailand to western parts of Cambodia. A Power Purchase Agreement is prepared and is expected to be negotiated soon.

Existing Interconnections

There are at present no interconnections between Cambodia and Thailand.

Planned Interconnections

The master plan for generation and transmission development of Cambodia describes that the western parts of Cambodia namely, Banteay Meanchey, Siem Reap and Battambang will be connected to the Thai grid. EGAT has undertaken a power interconnection feasibility study with the main objective of identifying the optimal transmission system configuration and to indicate the wheeling charge for power transmission. In this connection a power supply survey and demand forecasting was also carried out. The load forecast indicates a load of 88 MW at stage 2016.The study recommends a 115 kV single-circuit interconnection from EGAT's Watthana Nakhon substation to Banteay Meanchey, Siem Reap and Battambang in Cambodia. The line is planned for commissioning in 2004. The lengths of the 115 kV lines are:

- Watthana Nakhon – Border 42 km
- Border – Banteay Meanchey 46 km
- Banteay Meanchey – Siem Reap 101 km
- Banteay Meanchey – Battambang 56 km

5.7.5 Power exchange agreement Lao PDR – Viet Nam

The current agreement between the Government of Lao PDR and the Government of Viet Nam (signed in 1998) provides for a possible export of 1,000 MW to Viet Nam during the next ten years, increasing to 2,500 MW in 2010. The generation and transmission system planning of the two countries is currently based on the availability of this capacity at a competitive cost.

Existing Interconnections

So far the power systems of the two countries are not interconnected. The only cross-border lines between Lao PDR and Viet Nam are two 35 kV feeders from Viet Nam supplying Huaphanh Province and center of Savannakhet Province of Lao PDR.

Planned Interconnections

The hydropower candidates for export to Viet Nam have not yet been conducted. Lao PDR has recently prepared the following list of export candidates to Viet Nam:

- Nam Mo 105 MW in 2007
- Nam Theun 1 F 400 MW in 2012
- Nam Kong 1 240 MW in 2012
- Xe Kaman 3 218 MW in 2012
- Se Kong 4 440 MW in 2014
- Se Kong 5 253 MW in 2014
- Nam Theun 3 236 MW in 2016

The above list gives a total capacity of 963 MW by 2012, increasing to 1,656 MW by 2014 and to 1,892 MW by 2016. After subtracting the assumed 5% power takeoffs for domestic purposes in Lao PDR, 915 MW would be available for export by 2012, 1,575 MW by 2014 and 1,800 MW by 2016. EVN is interested in a 500 kV interconnection between Nam Theun 2 and Ha Tinh to provide support to its 500 kV system at an early stage. Moreover, because the load growth is higher in Southern Viet Nam than in the northern and central regions, a 500 kV interconnection between Ban Sok and Plei Cu could come in parallel with developing export projects in Southern Lao PDR for export to Viet Nam.

The present plans include only one new 230 kV interconnection between Lao PDR and Viet Nam. If Nam Mo (105 MW) is developed, the plant may be connected via a 230 kV line to the Vietnamese system at Ban Mai, a future hydropower project located northwest of Vinh and planned for commissioning in 2008-9

Table 5.28: Potential Interconnection between Viet Nam and Lao PDR

Interconnection		# of Ckt	# in Bundle	Cross-section (MCM)	Length (km)	Capacity (MVA)	Comm. Year
From Lao PDR	To Thailand						
500 kV							
Nam Theun Collector	Ha Tinh	2	4	795	190	2 x 3,000	2008-12
Ban Sok Collector	Plei Cu	2	4	795	178	2 x 3,000	2012
230 kV							
Nam Mo hpp	Ban Mai hpp	1	1	795	85	350	2007-09

5.7.6 Power exchange agreements Yunan – Thailand

In 1998 a MOU on the Power Purchase Program from China was signed by the governments of China and Thailand. In this MOU Thailand has expressed a wish to purchase 3000 MW of power from Yunnan by the year 2017.

The China – Thailand Yunnan Jinghong Hydropower Station Consulting Co., Ltd was established jointly by YPEPC and MIDX of Thailand for investing in a feasibility study of the Jighong project. The feasibility study report was approved in March 1999.

In September 2000 an agreement on joint investments in development of Jinghong hydropower station between Chinese and Thai Investors was signed. In this agreement it is stated that Thailand will purchase 1500MW by 2013 and additional 1500 MW by 2014, in total 3000MW from China in accordance with the MOU. It is also agreed that the Jinghong Hydropower Project should be the first project to be built on the cooperation basis. In this agreement the parties also established the China – Thailand Yunan Jinghong Hydropower Co., Ltd. With the main objective to develop, construct and operate the Jinghong hydropower plant. In addition, the Company was given the objective of participating in the development, construction, operation and management of any other hydropower projects located within the Lancang River basin in the light of the actual situation in the future.

The Jinghong hydropower project has an installed capacity of 1500 MW (five units, each 300 MW), with a construction cost of Chinese RMBY 7.937 billion (static investment) and a construction cost, including interest during construction, of Chinese RMBY 10.044 billion (dynamic investment). It is stated that all of the power and energy generated from Jinghong hydropower station will in principle be sold to EGAT.

Since Jinghong can provide only 50 % of the agreed 3000MW power export to Thailand, it is planned that the remaining 1500 MW will be exported from the Nuozhadu Hydropower Project (5500MW) located some 90 km north of Jinghong.

Existing interconnections

At present there are no interconnections between Yunnan and Thailand.

Planned interconnections

A Feasibility Study has been carried out on power transmission of 3000MW from Jinghong and

Nuozhadu hydropower projects in Yunnan to Lopburi, north of the Bangkok area in Thailand. Due to the large amount of power to be transferred and the 1045 km long distance, the study has concluded that an HVDC line is least-cost. The scheme is presented Figure 2-20 – Figure 2 – 22 showing the proposed line route, location of converter stations and the key data, including the cost estimates.

The transmission scheme consists of 500 kV HVAC lines between the power plants and the Converter station Meng Yang in Yunnan, and 500 kV HVDC lines to the Tha Wung converter station (Lopburi) north of the Bangkok area.

We have understood that EdL wants to have the converter station located in Northern Laos instead of southern Yunnan, making it possible to connect future hydropower plants in Northern Laos to the converter station and in this way export power on the HVDC line

towards Bangkok. This will imply longer HVAClines from the power plants in Yunnan to the converter station. The feasibility study has concluded that this alternative is more expensive for the Yunnan to Thailand power export scheme.

5.7.7 Power exchange agreements Yunan – Lao PDR

A power Purchase Principle Agreement between Yunnan and EdL, Laos also exists. This agreement is dated 30 January 1999, and describes a possible power export from Yunnan to the three northern provinces (i.e. Luang Namtha, Phong Sali and Oudomxai) of Lao PDR. The duration of the agreement is up to end of year 2020, and the power export is limited to maximum 30 MW.

Existing interconnections

At present there are no power interconnections between Yunnan and Lao PDR.

Planned interconnections

In reference L-6 the power supply of the three northern provinces of Lao PDR from Mengla 110 kV substation in Yunnan has been studied. The financial and economic analysis concluded that supply to the load clusters in Luang Nam Tha and Oudomxai provinces should be established, but not to Phong Sali.

The supply scheme (final stage) consists of

- a 115 kV overhead line of a total length of 88 km (of which 47 km are located in Laos)
- a new 115/22 kV substation at Namo Tai (Nam Xe) with one 12.5 MVA transformer in First Stage and one 27 MVA transformer in Second Stage
- 545 km of 22 kV lines to distribute the power in the northern provinces

The proposed tariff on power import to Lao PDR has been set to USc 6.5 per kWh from 2001. So far this agreement has not become effective. EdL is considering grid extensions within Laos as an alternative to power import from Yunnan. A second alternative could be development of local hydropower sources in the northern provinces.

5.7.8 Power exchange Yunan – Vietnam

Even if the distances between the power systems of the two countries are relatively short, there is no interconnection between Yunnan and Vietnam. However, in the long term 220 kV as well as 500 kV interconnections are considered realistic. The possibility of hydropower development in Yunnan Province after 2010 for export to the Hanoi load centre in Northern Vietnam is mentioned. A quantity of 2000 MW power import on 500 kV transmission lines is indicated.

In Yunnan the possibility of development of Malutang hydropower project (460MW) located 13 km from the Vietnamese border has been mentioned.

Other interconnections between Myanmar/Thailand and Thailand/Malaysia are planned.

Further study is necessary as the data is national based and requires the following Mekong Basin Reservoir information:

- Location including type of stream (mainstream/tributary), reservoir type, reservoir area and capacity, total installed power capacity;
- flow regime analysis: operation of the reservoir, impact on flow regime for wet and dry season;
- Economic analysis: cost/benefit analysis of power generation, distribution of benefits;
- Downstream impacts: impact on fisheries, flood recession agriculture, flow regime for wet and dry seasons, flood control, creation of environmental flow; and,
- Local impacts: will people be displaced? How many? To where? What ecosystems will be flooded? Effect on fisheries of new reservoir?

5.8 Dams in the Se San and Sre Pok Basins

(from Mekong Regional Environmental Governance: *Resources Policy Support Initiative*)

Se San 3 is controversial and has received much criticism. For instance, in October 2000 a review of the "Se San 3 Hydropower Project Feasibility Study" by Probe International, found that "sensitivity analysis of the study indicates that the project [Se San 3] is not economically viable and the study does not address downstream effects that may extend across national borders" (White, 2000). The report also indicates that the study carried out by SWECO overestimates the value of Se San 3 as an electricity producer. The SWECO study understates, it argues, the project cost by ignoring the interest charges during the year of construction. The critical report concludes that the SWECO study should not be the basis for investment decision-making.

The Se San 4 is the furthest downstream of the Se San mainstream schemes in Viet Nam. This dam is located approximately 8 km from the Cambodian border. It is the one most likely to follow after the Yali Falls and the Se San 3. The Se San 4 was recommended as one of the six priority projects in the SKSSNT study. The project was recommended for medium-term development by SWECO (1999).

The Upper Kontum scheme is located on the Dak Nghe River, an upper tributary of the Se San in Viet Nam. The dam site is about 40 km northeast of Kontum town. This dam would divert water from the Dak Nghe River, an upper tributary of the Se San River in Ko Plong District, Kontum Province, into the Dak Lo River through a two-stage transfer scheme. The Dak Lo flows into the lowland zone of the Vietnamese coastal plain, outside of the Mekong Basin. This is an inter-basin water diversion project which would radically alter water flow both in the Dak Nghe and Se San Rivers.

The upper Kontum Dam was the other priority hydropower project proposed for the Se San Basin in Viet Nam by the SKSSNT study despite the fact that severe hydrological impacts were identified. It was also listed as a priority project for medium-term development by SWECO. The regulation on inter-basin transfer of water in the MRC Agreement, and its inherent complexity, has been little regarded.

Apart from the dams envisaged for the Se San River Basin in Viet Nam, a small number of projects have also been proposed for the Se San Basin in the northeast of Cambodia. These include the Lower Se San 2 and the Lower Sre Pok 2. Two different locations were proposed for the Lower Se San 2, but the second was subsequently rejected for economic reasons (ADB 1998). Although the economic feasibility of the proposed dam is questioned it is still included as a priority project, possibly due to the pressure to include two priority dams for each of the three countries. The scheme, which is in the lowest part of the Se San River catchment, would receive partially regulated water flows from proposed upstream schemes including Upper Kontum, Plei Krong, Se San 3 and Se San 4, and the Yali Falls. The Lower Se San 2 scheme is located just below the town of Veun Sai, which would be inundated, as would the river and surrounding lands all the way up to Vietnamese border.

The Lower Sre Pok 2 shares many characteristics and potential impacts with the Lower Se San 2. Both dams would have large, shallow reservoirs with low heads and both would obstruct fish migration in an important tributary of the Mekong system. The Lower Sre Pok 2 would require a major resettlement plan and it is also not believed to be commercially viable (Halcrow 1998). Somewhere between 1,000 and 3,000 people would have to be relocated if the dam was completed.

6 Navigation

6.1 Summary

Navigation and water transport issues are best considered at a regional level. A report being prepared by the Navigation Section in MRC Secretariat (assessment of trends in the transport sector of the Lower Mekong Basin with special emphasis on waterborne transport) will provide a comprehensive overview of navigation covering:

- Domestic and international trade
- national traffic profiles, including (i) navigable length of rivers, lakes, canals; and (ii) maritime transport in the Mekong and Bassac
- type, volume and value of cargo; passenger numbers
- international agreements and standards governing trade
- development status and trends in inland waterway transport
- navigation infrastructure (ports, bank protection, dredging etc.)
- physical and non-physical barriers to maritime and inland water transport in LMB
- the importance of water transport and trade, and how it relates to regional transport routes

Additional information required for the BDP includes:

- Role of water transport in tourism
- proposed infrastructure developments
- impacts on environment of river works for access.
- impacts on economy, environment of increased traffic
- projected future value of maritime and inland water trade
- potential impacts on access due to changes in water flow from withdrawals (hydropower, irrigation)

In addition, MRCS holds hydrographic charts at a scale of 1:20,000 for the Lower Mekong (digitized for Viet Nam; digitizing for Cambodia, Lao PDR and Thailand will start in mid 2002).

Information gaps include:

- Opportunities for tourism and water transport
- impacts on economy and environment of increased traffic
- impacts on environment of river works for access.

6.1 Introduction

The greater operating efficiency and lower costs of inland waterway navigation compared with other forms of transport are widely recognized. Yet, the advantages offered by IWT do not appear to have been reflected in greater use by passengers or for cargo, nor in the evolution of government plans, policies and spending priorities in such a way as to encourage its greater use. Four main factors influence the extent to which the Mekong River and its tributaries are used for transportation: economic and trade growth; the non-physical (or institutional) barriers to international navigation; the strength of competition from other transport choices (most notably from road transport) and physical restrictions such as limitations on vessel draft imposed by the maximum available water depth during the dry season or, in the case of the estuarine region, at low tide.

One of the purposes of this chapter is to provide a measurement of the value of navigation on the Lower Mekong River and its tributaries to a diverse community of users, ranging from the inhabitants of small villages to large trading and ship operating organizations. Other issues covered include the status of navigational channels and inland ports, environmental protection measures for IWT, conditions for increased international navigation, contribution of river transport to poverty alleviation, passenger and cargo traffic, IWT vessel fleets, government transport policies related to IWT development and modal shares of inland waterway transport versus those of competing transport.

6.2 Importance of inland waterway transport in LMB member countries

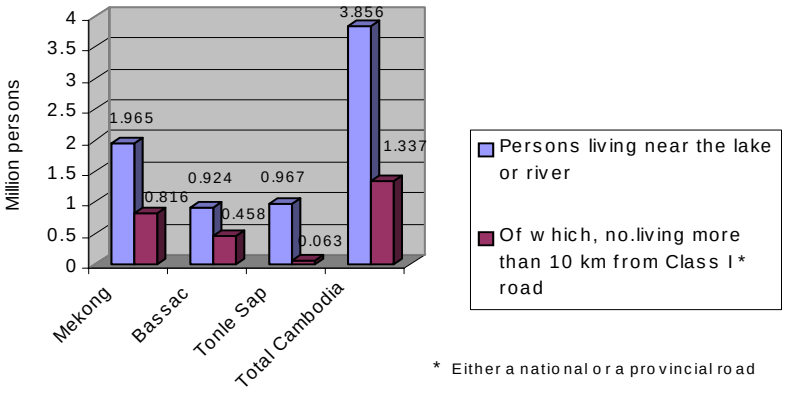
The importance of the Mekong River and its tributaries as a transport artery for member countries may be assessed in terms of the access it provides for poor communities, which would otherwise have no year-round transport to markets, or health and education services which are usually located in district or provincial centres. It may also be assessed in terms of volume and value of the foreign trade flows made possible by river transportation.

6.2.1 The river as the sole practical means of transport

For many small communities located along the Mekong River and its tributaries, small boats still provide the only practical means of traveling to district or provincial towns and market centres, especially during the monsoon season, when many roads become impassable. While the dependence of riverside communities on inland waterway transport is gradually being reduced as a result of the on-going construction of new roads throughout the Lower Mekong Basin, more than one-third of the riverside populations[172] of Cambodia and of the Mekong tributaries in Lao PDR live further than 10-11 km from a road which can be used all year-round, as may be seen in Figures 1 and 2. For such communities, the river is the only option they have as a basic means of transport.

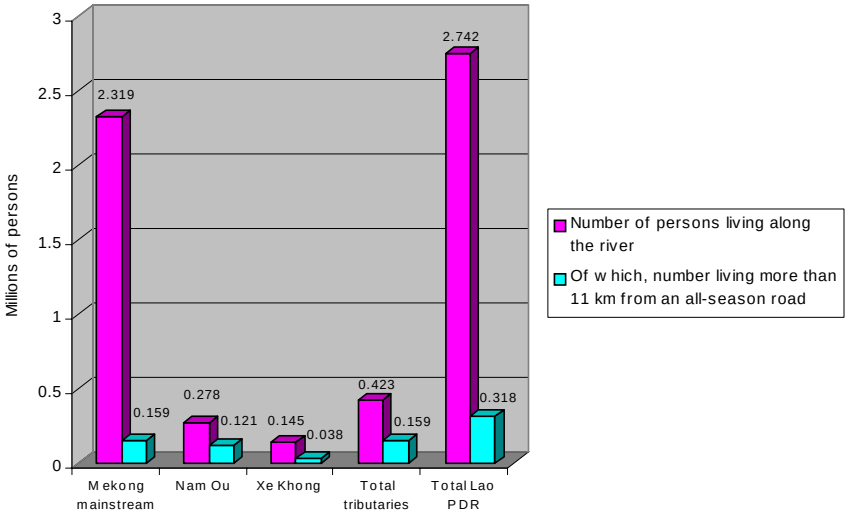
Figure 6.1: All-season road access for river populations in Cambodia

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



Sources: 1. UN World Food Programme and Mekong River Commission, GIS databases. 2. Cambodia National Population Census 1998 and Cambodian Socio-Economic Survey, 1999

Figure 6.2: All-season road access for river populations in Lao PDR



Sources: 1. UN World Food Programme (Lao PDR), GIS database. 2. Agricultural Census, Lao PDR, 1998

Dependence on inland waterways in Cambodia can be seen to be greatest along the mainstream of the Mekong River, rather than 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 in Cambodia, housing 1.36 million people, are estimated to be totally dependent on inland waterways for transportation.

By contrast, data provided by the UN World Food Programme in Vientiane suggest that 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 in Lao PDR.[173] Road access for communities located along the Mekong tributaries in Lao PDR 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 a major part of the year is estimated at 915, with a population of about 320,000.

While road access data for the Mekong Delta region of Viet Nam were not available for this review, the IWT dependence of communities in the 12 main provinces comprising this region is demonstrated by modal share data indicating that the inland waterway mode carries about 73 percent of the region's cargo tonnage and about 27 percent of its passengers annually.[174] In addition, the relatively short average passenger trip distances for inland waterways in this region (only 15 km) suggest that the waterways are satisfying a crucial need of local communities for intra-district transportation. While it is likely that road building projects already underway in the region will result in a diminished passenger transport task for IWT in the region, this is unlikely to be the case with the IWT cargo, which is dominated by rice export and other agricultural commodities, requiring high capacity bulk transport and transfer facilities of a type not provided by road operators. 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 noted that although the communities which benefit most from river transport are those which have no, or very limited, year-round access to other modes, 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.

6.2.2 Contribution of river transport to poverty alleviation

The available evidence suggests that the poorest communities in each member country are unlikely to be located along the Mekong River and its tributaries. In Cambodia, for example, the Mekong River and its tributaries, with the notable exception of the Tonle Sap River and Lake, is bordered by communities in which it is estimated that poor households comprise no more than 40 percent of the total (with the average range being 25-40 percent).[175] By contrast, the poorest areas (which dominate the Cambodian land mass) are those estimated with greater than 40 percent of their households poor.[176] The communities bordering the Tonle Sap River and Lake have been identified within this category.

Another way of looking at this evidence is that the communities bordering the river and its tributaries have already benefited economically from the river's attributes, whether they be

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[173] UN World Food Programme in collaboration with the National Statistics Centre and State Planning Committee, Lao PDR, Poverty Indicators, May 2001.

[174] 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.

[175] 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.

[176] UNWFP et al (February 2001), page 47

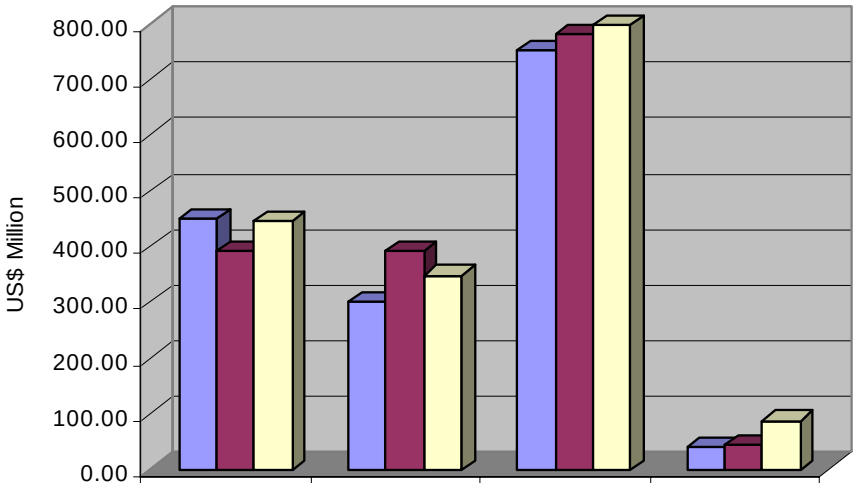
related to water for irrigation, to fishery resources or to transport uses, and that as a result they are considerably less poor than they would have been had they been remote from the river. While it is practically impossible to separate the benefits provided by these attributes, there is little doubt 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 realizing 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), appropriate measures must be adopted to ensure that they realize these benefits in future. Such measures can be expected to range from infrastructure improvements to reducing the burden of taxes and charges on boat operation.

6.2.3 Trade benefits of river transportation

In 2001, trade valued at an estimated US$4.7 billion was distributed by inland waterway transport on the Lower Mekong River and its associated waterways. This was comprised of trade: between Thailand and Lao PDR amounting to US$350 million; between Thailand and China (Yunnan Province) US$88 million; Cambodia US$235 million; and the Mekong Delta of Viet Nam (excluding trade with Cambodia) US$4 billion.[177]

Figure 6.3: 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

[177] 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).

As the only land-locked LMB member country, Lao PDR has realized substantial benefits from using the Mekong River as the principal conduit for its international trade. In 2001, the value of exports, imports and transit trade through river checkpoints opposite Thailand is estimated to be US$348 million, or 44 percent, out of a total trade of US$795 million (Figure 6.3).

River checkpoints account for an even higher share of the value of Lao PDR's exports – about 64 percent – since exports tend to be dominated by logs, timber products and other agricultural commodities - all of which are well adapted to transport by river. In fact, these commodities, if carried on roads, can cause substantial damage to pavement.

Four river 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 the river checkpoints of Lao PDR. However, 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.

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 the 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 the use of the river to transport a growing proportion of its bilateral trade with Yunnan Province of China, mostly through the ports of Chiang Saen and Chiang Khong. In a single year, the value of this trade more than doubled, from US$43 million in 2000 to US$87 million in 2001.[178] It is likely that the implementation by the Upper Mekong countries of an Agreement on Commercial Navigation in April 2001 had a major influence on this trade expansion , which serves to demonstrate the speed and extent of benefits flowing to countries willing to make the necessary institutional adjustments to remove trade barriers.

In Viet Nam, some 90 percent of the export tonnage of rice and 60 percent of fruit and vegetables (fresh and processed) originates in the Mekong Delta and is transported at least as far as Ho Chi Minh City by inland waterway vessels. The tonnage and value of rice exports transported in 1999 is estimated at approximately 4.06 million tonnes worth US$1.8 billion.[179]

Corresponding estimates of the volume and value of fresh and processed fruit and vegetable exports in the same year are 63,000 tonnes worth US$63 million. The combined value of agricultural exports moved by inland waterway vessels in the Mekong Delta is estimated at nearly US$2 billion annually. If this figure were augmented by the value of other exports and by the value of the sizeable import volumes, it is not inconceivable that the total value of the trade being moved annually on the waterways of the Mekong Delta could amount to US$4 billion, or nearly 20 percent of the country's overall foreign trade.

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

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

6.3 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 at 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.

Table 6.1: Navigable lengths and vessel size restrictions on waterways of Lower Mekong Basin

River Section	Length (km)	Year-round navigation possible?	Vessel Size Restriction	
			Low water	Mean-high water
Mekong Mainstream				
Golden Triangle Luang Prabang	362	Yes – but is limited by rocky passages and strong currents		60 DWT
Luang Prabang Vientiane	425	Yes – but requires small boats and skilled pilots during dry season	15 DWT	60 DWT
Vientiane Savannakhet	459	Yes	200 DWT	500 DWT
Savannakhet Pakse	261	No "high water" only navigation possible	Less than 10 DWT	50 DWT
Pakse Khinak	151	Yes	50 DWT	
Khinak Veune Kham	14	No – navigation not possible at any time due Khone Falls		
Veune Kham Stung Treng	30	Yes – with size limitations at low water	15 DWT	50 DWT
Stung Treng Kratie	128	Yes – with size limitations at low water	20 DWT	50 DWT
Kratie Kampong Cham	121	Yes	80 DWT	400 DWT
Kampong Cham Phnom Penh	100	Yes – navigable by sea-going ships	2,000 DWT	
Phnom Penh Junction of Vam Nao Pass	154	Yes – navigable by sea-going ships	3-4,000 DWT	5,000 DWT
Vam Nao Pass South China Sea	194	Yes – navigable by sea-going ships	3-4,000 DWT	3-4,000DWT
Bassac River				
Phnom Penh- Junction of Vam Nao Pass		Yes – but not possible by sea-going ships	20 DWT	50 DWT
Vam Nao Pass South China Sea	188	Yes – navigable by sea-going ships	5,000 DWT	5-6,000DWT
Tonle Sap (Cambodia)				

River Section	Length (km)	Year-round navigation possible?	Vessel Size Restriction	
			Low water	Mean-high water
Phnom Penh 5 km south of Kompong Chhnang	94	Yes – navigable by sea-going ships	1,000 DWT	2,000 DWT
Kompong Chhnang Chhnoc Trou	46	Yes – with size limitations at low water	20 DWT	150 DWT
Chhnoc Trou Chong Kneas	109	Yes – with size limitations at low water	20 DWT	150 DWT
Mekong Delta Waterways				
Dense network of canals, natural creeks and tributaries, with a total navigable length of 4,785 km	4,785	Yes – vessel size restrictions within this network vary from 10-300 DWT		
Nam Ou Mekong tributary (Lao PDR)		Yes – by very small boats as far as Muong Khoa, where goods in transit for Viet Nam are transferred to road vehicles		
Se-Kong/Mekong tributary (Lao PDR and Cambodia)		Yes – this waterway is navigable between Lao PDR and Cambodia, providing an alternative international transit corridor to the Mekong which is non-navigable through the Khone Falls		

Source: Mekong River Commission, Updating the Strategy and Programme for Navigation Development and Coordination in the Lower Mekong Basin, July 2000

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 DWT, and several other sections are navigable at low water with lesser (but still severe) restrictions on vessel size.

6.4 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 to purpose-built concrete quay structures equipped with modern cargo handling technology. Port infrastructure is at its most sophisticated 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 Ho Chi Minh City the task of consolidating and dispatching 90 percent of Viet Nam's annual rice exports. Among these is Can Tho Port (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.

Map 1 shows the locations of 25 major ports throughout the Lower Mekong Basin (four in Thailand, eight in Lao PDR, six in Cambodia and seven in Viet Nam). All, with the exception of two on the river section between Vientiane and Luang Prabang, are connected to main roads. However, the density of road networks in the vicinity of the ports varies widely within the LMB. It is densest in Thailand and least dense in Lao PDR and Cambodia. In the Mekong Delta region of Viet Nam, the low-lying and swampy nature of the terrain has up until recently imposed a barrier to the expansion and improvement of the main road network. This has been recognized as a major impediment to the development of rural and industrial communities in the Delta. A World Bank-funded project is now underway, with the objective of removing this impediment by upgrading segments of Highway 1, as well as national and provincial roads in the Delta provinces.[180] This project may be expected to contribute significantly to improving the intermodal linkages of several Delta ports, including Can Tho.

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

Map 6.1: Modal Linkages in the Lower Mekong Basin

6.5 Growth and composition of inland waterway vessel fleets

Much of the available data on the growth and composition of the IWT vessel fleets of the LMB member countries were incomplete, inconsistent and unreliable. In Cambodia, the lack of any central control over boat licensing, meant that it was not possible to identify in national statistics the fleets of small boats registered and licensed in the provinces.[181] Notwithstanding the data deficiencies, it was possible to develop a limited picture of fleet growth and composition in four LMB member countries.

At the end of 2000, the IWT fleet of Lao PDR totaled 1,098 boats, of which 405 (37%) were cargo or multi-purpose boats and 693 (63%) were passenger-carrying boats. Over the past five years, there was 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 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.

Thailand's Lower Mekong Basin fleet has been stable for the past five years, numbering 110 vessels (55 passenger, 35 cargo and 20 multi-purpose passenger and cargo). The majority of vessels are of less than 30 DWT, but several large flat-topped barges 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 fleet reflects the negligible use of the river for domestic transport.

In Cambodia, the number of centrally registered vessels totaled 593 (30 November 2001). These included 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.

On 30 April 2002, the registered inland waterway fleet of the Mekong Delta in Viet Nam numbered 57,791 vessels. The fleet was reported to have nearly doubled in size since 1997.[182] More than three-quarters of the fleet comprised motorized or non-motorized barges in the range of 200-1,500 DWT. Passenger vessels (licensed to carry from 20-150 passengers) numbered 7,519, or 13 percent of the registered fleet. Not included in the fleet data provided by VIWA 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 registrations are decentralized and it is understood that only 45 percent of the fleet is in fact registered.

[181] 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.

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

6.6 IWT traffic and modal share analysis

The almost universal absence throughout LMB line agencies of comprehensive and up-to-date records of passenger and cargo traffic plying the river and its associated waterways meant that estimates of traffic volumes had to be made from a variety of sources. In some member countries (notably in Lao PDR and Cambodia), much of the authority for vessel licensing and port operation has been decentralized to provincial offices and with it the responsibility for record keeping. In most cases, records are maintained manually 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 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 taken 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 for road traffic are likely to understate significantly the actual volumes of passenger traffic moving on the road system.[183].

Table 6.2 contains estimates of passenger and cargo traffic volumes and modal shares for all transport operating in the Lower Mekong Basin. They 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. Recently, however, IWT passenger and freight volumes in Lao PDR have begun to trend upwards, albeit from a low base. The declining trend in IWT passenger volumes for all countries except 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 on-going 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 of Lao PDR).

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.

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 LMB 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 Thailand 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 Lao PDR. The share of road transport in this cross-border traffic will inevitably increase as soon as the

[183] 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).

planned bridge connecting Mukdahan with Savannakhet is available for service from 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.

Table 6.2: Traffic flows in the Lower Mekong Basin

Traffic category and country	Volumes						Shares (%)				
	IWT Vol.	Average annual growth %*	Road	Rail	Air	Total	IWT	Road	Rail	Air	Total
Passenger traffic											
Million passengers -2001											
Lao PDR, domestic	1.8	9.1	19.1	-	0.5	21.4	8.4	89.3	-	2.3	100.0
Thailand-Lao PDR –Thailand	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
Million passengers-km -2001											
Lao PDR, domestic	72.8	11.2	1,423.7	-	178.3	1,674.8	4.3	85.1	-	10.6	100.0
Thailand-Lao PDR-Thailand	0.5		3.3			3.8	13.2	86.8			100.0
Cambodia	54.3		2,365.3	32.4	48.7	2,500.7	2.2	94.6	1.3	1.9	100.0
Viet Nam (Mekong Delta)	12,92.1	-1.5	6,049.0	-		7,341.1	17.6	82.4	-	-	100.0
TOTAL - LMB	14,19.2		9,838.0	32.4	227.0	11,520.4	12.4	85.3	0.3	2.0	100.0
Cargo traffic											
Million 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
Thailand-Lao PDR -Thailand	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
Million 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
Thailand-Lao PDR –Thailand	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)	2,316.5	7.5	652.0	-	-	2,968.5	78.0	22.0	-	-	100.0
TOTAL - LMB	2,631.5		1,305.8	108.3	0.6	4,046.2	65.0	32.3	2.7	-	100.0

Sources: 1.MRC missions to member countries, April-May 2002 2.National statistical yearbooks.

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.

6.7 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.[184] These conclusions were reinforced by other studies undertaken in the United States during the 1970s and 1980s, which found even greater margins of advantage for inland waterway transport in terms of energy consumption.[185]

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 advantages over its land transport competitors as those 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 suggests that in some cases charges made by IWT operators in Lao PDR are three times 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 cost of road infrastructure provision from truck operators, while also penalizing boat operators who are obliged in all LMB countries to contribute to road development funds, through their payments of fuel tax.[186] Boat operators in some LMB countries, notably in Lao PDR, may also be prevented from realizing maximum commercial advantages from their operations, by having to operate, during the low water season, 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 recognize 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 are available, shows that in three of the four member LMB member countries, inland waterways attract less than 1.5 percent of all expenditure on both modes. This comparison is shown in Table 3.

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

[185] 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.

[186] In the Lao People's Democratic Republic, for example, the government tax take represents 28 percent of the pump price of diesel fuel in Vientiane (about 2,635 Kip or about US$0. 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 6.3: Five-year capital and operating expenditure allocations by governments

Country	Inland Waterways		Roads		Total	
	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

Sources: 1. National Statistical Yearbook, Viet Nam, 2000. MRC missions to LMB member countries, April-May 2002. Notes:1. Cambodia data are for the five-year period 1997-2001. 2. Lao PDR data are for the five-year period 1996-2000 (fiscal years commencing 01 October) 3. Viet Nam data are for the five-year period, 1995-1999, but purport to include only capital expenditures.

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 a negligible 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 LMB level.

Nevertheless, it might be reasonable to conclude that the Mekong River in Thailand attracts an expenditure share of 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 6.3 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.

Table 6.3 shows that not only are expenditure allocations disproportionate to the economic worth of IWT, but also that they are disproportionate to the IWT share in the national transport task of all LMB member countries. 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 governments are prepared to commit a more realistic level of funding for essential river works, especially for dredging of some hot spots, bank protection and for port improvement, and access improvements such as installation of aids to navigation, and actually starting navigation training, it will be difficult for the IWT sector to maintain its significant role in cargo transport, within the LMB. Similarly, a more realistic funding approach, which in reality requires nothing more than a re-ordering of mode funding priorities, would be necessary for the sector to establish a significant role in passenger transport (especially in tourist transport) within the LMB.

6.8 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, is funding the improvement of two international highway links:

- Highway 9, forming part of the GMS East-West Corridor linking Northeastern 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 US$67 million); and

- 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 US$125 million).

Coupled with ADB support for rural road improvement projects in Lao PDR and in 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.[187] Rehabilitation of Phnom Penh Port has been carried out because of deterioration of facilities. Rehabilitation Project No.1 and No.2 have completed in 1996 by World Bank (IBRD) assistance and Japan's Grant Aid respectively.

Four ports of Thailand, such as, Chiang Kong, Nong Kai, Nakhon Phanom and Mukdahan are under rehabilitation by the soft loan of JBIC (Japan Bank of International Cooperation), which is sub-project of east-west corridor. 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 of the Bassac River estuary. This project is being implemented over the period April 1997- June 2003, at a cost of about US$85 million.

- The Mekong Transport and Flood Protection Project, in Viet Nam, involving, among other things, upgrading of 180 km of Highway 1 between Can Tho and Ca Mau and of another 182 km of national and provincial roads throughout the Mekong Delta. The estimated cost of this project is US$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 US$69 million and US$28 million.

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

- 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 a cost estimated at US$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-Kien Luong and Ho Chi Minh City-Ca Mau are being dredged to provide 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 (including container) handling equipment.

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 three metres of the high tide allow for vessels of 6,000 -7,000 DWT to enter. The Government of Viet Nam is however committed to improve 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.

6.9 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 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 operational 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).[188]

There will inevitably be other such opportunities throughout the Lower Mekong Basin, and it is strongly recommended that they should be followed up by the MRC, in co-operation with the relevant national line agencies.

6.10 Potential for increased international navigation

The adoption during 2001 of a harmonized system of aids to navigation on the Mekong River and its associated waterways (developed jointly by 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 failure of both countries to agree 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 from China, Japan, Taiwan, the Republic of Korea and Viet Nam. If such traffic is to be distributed instead through Sihanoukville Port, distance and time penalties of 280 km and one day will be incurred, the latter assuming that border crossing delays between Viet Nam and Cambodia, via the river route, can be minimized.

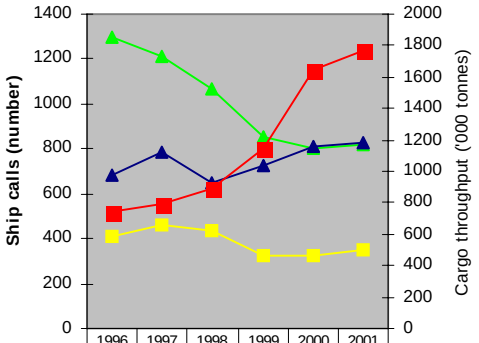
Yet, as may be observed in Figure 6.4, the robust traffic growth of Sihanoukville over the past five years (+3.8% per year for ship calls and +18.9% per year for cargo throughput) is in stark contrast with the declining traffic growth registered by Phnom Penh over the same period (-8.7% for ship calls and –3.0% 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 as to the list of prohibited transit goods in the protocol, the agreement has yet to be put into

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

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.

Figure 6.4: 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

It has to be noted that more effective use of the Mekong river system as an international transit route will only materialize if both countries see that they will benefit. One of the factors influencing them will be the strong possibility that international shippers will make greater use of the economic trade range formed by the triangle Ho Chi Minh City – Phnom Penh – Can Tho.

6.11 Navigation and the environment

Of the four governments of the Lower Mekong Basin, only Thailand appears to have applied 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 spillage of foreign matter into waterways. However, given that a number of ports along the Thailand side of the Mekong are not owned and managed by the Harbour Department, but by provincial government authorities, it is questionable whether the department would have the power to prosecute any infringements by these authorities or their contractors.

While none of the line agencies visited during the course of MRC missions to LMB member countries during April and May 2002 reported recent cases of major spills, it was clear that no agency had the possibility of rapidly mobilizing the trained personnel and specialized 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.

In Viet Nam, all new projects involving dredging or development of infrastructure, in and beside waterways, are now required to undergo Environmental Impact Assessment (EIA). In Thailand, EIA's are required only 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 EIA's 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 specialized port facilities would eliminate the risks involved in the beach landings of petroleum tanker barges where no such specialized facilities exist. In addition, the introduction of common rules and regulations will reduce the frequency of collisions and with it the pollution risk.

6.12 Critical issues requiring resolution

There remain to be resolved a number of issues affecting the use of the Lower Mekong and its associated waterways for transportation. The three most critical of these are:

1 The need for the responsible government agencies (especially ministries of transport) to recognize the economic advantages of supporting the development of inland waterway transport, by committing an adequate level of funding for the provision and maintenance of navigating channels and landing facilities. In most cases, this will require a new approach by governments to establishing transport expenditure priorities, on the basis of a realistic assessment of the relative economic benefits of individual transport modes;

2 The removal of all remaining institutional barriers to the freedom of international navigation. In particular, this will require early implementation of the Agreement between the Royal Government of Cambodia and the Socialist Republic of Viet Nam on Waterway Transportation, together with its associated protocol; and

3 The introduction, by all LMB member governments, of comprehensive and effective regulations to ensure that inland navigation operates in harmony with the environment. In particular, member governments need to enforce regulations, which will deter boat and port operators from discharging waste into waterways, as well as requiring them to bear at least part of the clean-up cost, following spillages.

7 Tourism

7.1 Introduction

Following a brief review of the main types of tourism in the Lower Mekong Basin (LMB), this chapter will focus on water-based and ecotourism. Where relevant, additional information on the policies, strategies and investments in individual countries will be provided. Readers should refer to the national sector overview of tourism for each country for further detail.

In Cambodia, Lao PDR and Viet Nam, the return of political stability, the re-establishment of political and economic contacts with other countries and liberalization of national economies has led to a rapidly developing tourism industry since the early 1990s. The tourism industry in Thailand has played an important role in national economic development for many years. The traditional tourist destinations in Thailand and the other LMB countries have included:

- Sea, sun and sand destinations (the classic definition of tourism destinations).
- Cultural, religious, historical and archaeological sites that allow visitors to see, experience and learn about the history and traditions of the country.
- Major cities and regional urban centers that offer shopping, conference/convention facilities and other modern entertainment, as well as cultural, religious and historical sites.

Some of these traditional tourist products have focused attention on water-based activities as part of the package. For example, water festivals and longboat races are common cultural traditions and attract increasing numbers of domestic and international tourists. From locations such as Luang Prabang, tourists can easily visit the waterfalls and caves that are upstream on the Mekong. Travel by boat from Phnom Penh to Siem Reap is often part of the tourist experience of Angkor Wat.

Ecotourism has recently become the fastest growing sector of the tourism industry worldwide (The Economist 1998), including increased interest in the LMB countries. Ecotourism is defined as tourism and recreation that is nature-based and ecologically sustainable and targets activities that teach people about the environment. It can combine one or more of the following types of activities:

- Adventure tourism such as trekking, white water rafting or cycling in remote areas.
- Village-based tourism offering opportunities to visit rural villages and learn about indigenous lifestyles and handicrafts.
- Nature-based tourism that focuses on sites of natural ecological and scientific interest, e.g. rain forests, protected wildlife areas and parks.
- Water-based tourism including active sports such as canoeing, kayaking and rafting on rivers and streams, as well as more passive cruises and live-aboard experiences on inland waterways.

Water-based ecotourism in the LMB includes visits to floating villages and the flooded forests of Tonle Sap as part of a trip to Angkor Wat. Other ecotourism activities currently

being promoted in LMB countries include the following tour packages from the Visit-Mekong website:

Table 7.1: Tour packages in the Lower Mekong Basin

Tour Package	Description
Mekong 2002	A two-week groundbreaking hovercraft expedition through six countries. This trip is a one off, and has never been done before!
Southern Laos Cruise	From Pakse to the Cambodian border. Wat Phu, 4,000 islands and the Phakeng Falls. Accommodation on board.
Kayaking South Laos	10 days exploring the southern reaches of the Mekong in Laos and its tributaries. A tourist free zone!
Kayaking Vientiane's Rivers	7 days exploring the tributaries of the Mekong River near Vientiane by kayak and raft.
Northern Laos Cruise	From the border with Thailand to Luang Prabang. Overnight at a nature lodge.
Golden Triangle Hill Tribe Experience	3 days of trekking, rafting, elephants and ethnic minorities – lots of fun!
Mekong Dolphins	4-day trip that includes a trip to see the rare Irawaddy Freshwater Dolphin.
Floating Markets	3 days from Ho Chi Minh City in the Mekong Delta.
Mekong River Highlights	4 days meeting the locals and exploring Isaan.

These types of tourism tend to be small-scale and dispersed throughout the region in contrast to mass tourism products that are larger-scale and concentrate in particular areas (e.g. Phuket, Angkor Wat, Luang Prabang, Dalat). Many rely on water, while others interact with water-related natural resources such as forests, uplands of watersheds and cultural resources.

7.2 Economic and social value of tourism

At a national level in the LMB, tourism is a major source of foreign exchange earnings and foreign direct investment. It is emerging as a major component of the economic structure of the region . Tourism has been a principal component of the service sector in Thailand for a number of years. In 2001, it represented 13 percent of total GDP. The potential of tourism is increasingly being recognized in the economic development policies of the other LMB countries, targeting both domestic and international demand. In 2001, it contributed more than 9 percent of total GDP in Cambodia and Lao PDR, and nearly 7 percent in Viet Nam.

The importance of tourism derives from the direct, indirect and induced economic benefits that it generates. Spending by tourists for goods and services (e.g. hotels, food, transportation, souvenirs) generate direct benefits in the form of job creation and income, as well as business receipts and government receipts (fees, taxes). Indirect benefits come from domestic inter-business transactions such as the supply of food and beverages to hotels and restaurants and create additional employment and income in other sectors such as agriculture, construction and manufacturing. Induced benefits result when employees in the tourism and other sectors spend money in the local economy.

The economic impact of tourism in each of three of the four LMB countries is larger than for the entire region of Southeast Asia. The following table summarizes current data and

projections of the contribution of tourism to GDP and the creation of employment, including direct, indirect and induced benefits.

Table 7.2: Significance of tourism

		2001	2002 estimate	2012 projected
GDP Contribution (%)				
	Cambodia	9.18	9.27	11.51
	Lao PDR	9.73	9.35	12.69
	Thailand	12.95	11.95	12.04
	Viet Nam	6.71	6.49	7.38
	Southeast Asia	8.51	8.15	8.93
Total Employment (%)				
	Cambodia	10.28	10.39	12.91
	Lao PDR	8.26	7.94	10.78
	Thailand	10.13	9.35	9.42
	Viet Nam	5.30	5.13	5.83
	Southeast Asia	7.80	7.29	7.59

The value of tourism is also the increased levels of infrastructure and services available to the host populations of LMB countries. Improved roads and transportation facilities benefit local people, as can the availability of new facilities and services (water supply systems, sanitation). The strong potential of the tourism sector to create employment and income is a primary reason why governments are targeting it as an instrument of poverty reduction and broad-based economic growth.

Ecotourism, for example, has the capacity to create jobs in remote regions that have high levels of poverty. Although ecotourism activities tend to be developed on a small scale and will not provide the levels of employment and income afforded by mass tourism, in rural areas even a few jobs can make a big difference. The Poverty Reduction Strategy in Cambodia estimates that a visitor spending US$500 per day can help to feed two people for one year. Ecotourism by focusing on natural attractions that are located away from urban areas has the potential for promoting regional economic development and revitalization. The revenues from ecotourism can also provide the economic basis for conservation and protection of natural areas.

However, some cautions are required. The value of tourism will vary from region to region, and may incur social and economic costs. Some of the potential costs include: i) seasonal employment that may contribute to underemployment; ii) low paying jobs with low social status; iii) inflation and increased costs from land, housing and food; iii) increased crime; iv) increased taxes; and, v) "leakage" of revenues through purchase of imported goods or export of profits. The profit margins from ecotourism activities are often very small, as a consequence of the nature of these activities (small scale, dispersed locations, etc.).

Moreover, tourism is very susceptible to a number of factors. Tourist demand is highly seasonal and can be easily influenced by weather. Demand is also influenced by changes in price and income, as well as supply-side problems. Natural disasters and political instability

are major events that can seriously curtail tourism demand. As a consequence, over-reliance on tourism can significantly increase economic vulnerability within a region or country.

7.3 Characteristics and impacts of water use

One of the most important requirements for the development of tourism facilities is an adequate and continuous supply of safe water for drinking and other domestic and recreational uses. Detailed data on per capita water use for tourism are hard to obtain. However, by way of example, per capita water use in the town of Luang Prabang in 2000 was approximately three times greater than in most other provincial towns in Lao PDR. This is likely due to the high number of tourists visiting the town. In general, issues related to water use in the tourism sector include:

- A tendency towards extravagance in water use by tourists;
- increased levels of water use in food and drink preparation in remote locations; and,
- excessive use of water to maintain sites in areas that experience high levels of tourist visitation (cleaning public areas, maintenance of gardens.).

The principal issues related to in-stream water use, for example, for river-based tourism and navigation related to tourism, are the potential for negative environmental impacts.

7.4 Environmental, social and socio-economic issues

Eco- and other forms of tourism in the region depend on the beauty and integrity of natural, social and cultural resources. The pressures from tourism – the numbers of people, poorly planned development and poor management – can damage environmental resources and social systems which can reduce the potential for future tourism development. Some of these issues, particularly related to ecotourism, include:

Environmental degradation: There are serious risks for deterioration in the ecological health and integrity of natural resources. Some of the potential impacts include: soil erosion, soil degradation, damage to sensitive terrestrial and wetlands ecosystems including loss of biodiversity and damage to wildlife habitats.

Water-related environmental impacts: The use of rivers for tourism, transport and other activities (floating restaurants) can increase the risks to water quality, aquatic species and habitats as a result of the operation of port facilities and boats (e.g. noise pollution caused by the boat engines); accidental spills of toxic substances (e.g. fuels); and disposal of solid and sanitary wastes. The construction of ports, hotels or other tourist-related facilities along waterways can produce long-term environmental impacts in ecologically sensitive areas.

Environmental impacts of increased access to remote areas: Ecotourism activities are frequently located in remote areas. Increased human activity in remote areas may heighten the risk of damage and environmental degradation of natural resources and ecosystems that have not previously been damaged. Greater accessibility into remote areas may also lead to indirect environmental impacts related to increased logging, agriculture on cleared land and increased use and exploitation of sensitive environmental resources.

Social and socio-economic benefits: Ecotourism can create employment opportunities in remote rural villages and provide increased household income, directly or indirectly related to the tourism activities. It can also promote the production of indigenous handicrafts and the preservation of these traditions. In some instances, income from tourism may help to reduce hunting pressures on exotic and other wildlife, or other threatened natural resources. In the case of village-based tourism, entrance fees, interpretation centres or other facilities may be a source of income for the community.

Social impacts: The development of ecotourism activities in remote areas has been associated with a number of significant social impacts. Rapid tourism development followed by economic growth in remote areas has contributed to accelerated change in traditional ways of life. This can lead to the erosion of cultural traditions and habits, accompanied by the breakdown of social structures. The use of cultural traditions and communities as tourism products can lead to economic and social exploitation of the people. The development of village-based and other forms of tourism without a full partnership with the local community in planning and managing these activities can further marginalize remote, indigenous communities from the benefits of tourism. Some of these products can reinforce prejudices about indigenous people or the subservient role of women. The character of communities and regions can be altered through inappropriate physical design and development. This can lead to the loss of quality of life, as well as the loss of community character and "sense of place." Inappropriate tourist behaviour and poor management, particularly at sites of historical or religious significance, can damage the spiritual value of these sites for local people.

7.5 Trends and issues

Southeast Asia – and the Mekong Basin in particular – is one of the fastest growing tourism destinations in the world. To date, tourism activities are largely restricted within the geographical boundaries of each LMB country, although national tourism products are complementary to one another. Tourism authorities would like to offer the region as a 'single destination' and countries are discussing plans to integrate visa policies. Ecotourism and sustainable development of tourism are regional priorities. A number of trends can be identified that will affect tourism in the LMB.

Tourism is increasingly multi-country with national and regional initiatives to promote the Mekong region as a single destination. For example, with more integrated air access, people are able to travel to several countries during a visit to the region. In line with worldwide trends, there is an increased regional and national demand in the Mekong region for different types of ecotourism – nature-based, cultural and water-based tourism.

Sustainable development of tourism will assess economic opportunities in the context of the carrying capacity of natural and cultural resources to support tourism, as well as greater emphasis on equitable distribution of economic benefits. Approximately 70% of tourism activity in the LMB will be people from the region who travel in their own or neighboring countries. International tourists, mainly from North America and Europe will account for 30% of visitors to the region.

Regional and international tourists have different preferences and objectives, requiring the development of different tourism products. Increasingly, tourism will be driven by issues of security, sanitation and satisfaction; replacing "sun, sand and sea" as the 3 'Ss' of tourism.

Despite these trends, there are still significant obstacles to tourism development in the region at the national and regional levels. There are now initiatives to address some of the issues but further work is required to fully support tourism development. Principal issues include:

- Different forms of governance in the countries of the region and differing levels of capacity of national tourism agencies make it difficult to develop integrated regional plans and policies;
- varying levels and quality of service provided by the tourism industry in different countries;
- insufficient infrastructure such as public facilities, electricity and water supply;
- limited land transport systems throughout the region, except in Thailand;
- inadequate standard of water transportation services;
- varying levels of tourist safety and security; and,
- lack of a common visa policy.

7.6 'Hot spots' and transboundary issues

In general, the reliance of ecotourism on the natural and cultural resources of LMB and its people makes it essential that tourism is based on the sustainable use of water and water-related resources. Sensitive environmental resources and cultural traditions can be easily damaged by rapid, poorly planned tourism that does not involve local communities as partners. In that sense, there is a high potential for localized hot spots associated with tourism development.

From the perspective of a regional analysis, the ADB-GMS Strategic Environmental Framework (SEF) Project has identified five environmental hot spots in the Mekong Basin, four of which are in the Lower Mekong Basin. These include:

- Central GMS: one of the most important wilderness areas left in Southeast Asia and supporting a series of eight protected areas. Within the LMB, this area includes part or all of Vientiane Municipality and the provinces of Xieng Khouang, Xaysomboun S.R. Bolikhamsay, Khammouane and Savannakhet (Lao PDR), as well as part of Quang Tri province in Viet Nam. This area includes the mainstream of the Mekong and major tributaries in central and southern Lao PDR.
- Golden Quadrangle: a merger of the Golden Triangle and the Economic Quadrangle, covering the provinces of Chiang Rai (Thailand), Bokeo and Luang Namtha (Lao PDR), as well as parts of Myanmar and Yunnan Province. This area includes the mainstream of the Mekong River in the northern part of the LMB.
- Se San/Se Kong: the area of the watershed including part or all of the provinces of Gia Lai and Kon Tum (Viet Nam); Kratie, Mondulkiri, Stung Treng and Rattanakiri (Cambodia); and Champassak and Attapeu (Lao PDR). The Se San/Se Kong is the second largest watershed in the Mekong Basin.

- Tonle Sap: The greater watershed area including the provinces of Kampong Chhnang, Battambang, Kampong Thom, Banteay Meanchey and Siem Reap. This hot spot concentrates on the Tonle Sap Lake area.

These hot spots have been identified in the context of proposed GMS transportation and energy sector projects as development stressors. They are defined using criteria of highly valued environmental areas (protected areas, areas of outstanding biodiversity, forested areas and wetlands); socially vulnerable groups (the poor, ethnic minorities); and the risks associated with development stressors.

Development 'stress' can generate different levels of risk. Nonetheless, the environmental and social criteria used in determining hot spots are relevant to issues of sustainable tourism. Therefore, the SEF hot spots provide an initial assessment of potential regional hot spots related to various types of ecotourism development. The significance of known and potential hot spots should be confirmed through the more detailed sub-area analysis process of BDP.

Transboundary issues related to the development of ecotourism and other tourism activities in the LMB may be more positive than negative. Due to the nature, scale and dispersed location of many ecotourism activities, the downstream negative effects will generally be localized with reduced risks for cumulative impacts in the region. Water-based tourism on the Mekong and major tributaries that does not seriously damage aquatic habitat resources (e.g. fish spawning areas) will generally have localized effects with little cumulative effect. On the other hand, development of a network of tourist experiences related to the river and the access it provides to other land-based sites are increasingly being considered of mutual benefit to some (all) of the riparian countries.

7.7 National tourism initiatives in the lmb

Each country places a high importance on tourism policies and development. This reflects the significant expansion of tourism and the hope that tourism will contribute to overall economic growth. This section summarizes some of the readily available information.

Cambodia: In 2000, nearly 500,000 international tourists visited Cambodia , an increase of 27% over the previous year. A total of 1 million Cambodians also made visits as tourists to sites throughout the country. Much of this activity, however, was concentrated in Phnom Penh and to a lesser extent, in Kampong Som and Siem Reap.

Tourism accounted for nearly 30,000 full-time equivalent jobs in 2000 and added US$650 million to the national economy. Land and boat transportation created employment for 3,500 full-time equivalent positions in 2000. Ministry of Tourism projections estimate that by 2003 total employment related to tourism will increase by over 30% and GDP contributions will exceed US$1 billion.

In 2001, the Royal Government of Cambodia announced the preparation of a Tourism Master Plan to set policies for development over the period 2001-2010 that will maximize and distribute equitably the benefits from a rate of tourism growth that is consistent with the protection of natural, built, social and cultural environments. A number of areas have been recognized with tourism development potential and constitute priorities for development: central Cambodia and the portion of the delta that lies within Cambodia's borders, including nature and river-based tourism on the Mekong and Tonle Sap Rivers, fishing, floating villages, rural exploration, wildlife and cultural sites; northeast Cambodia (Mondulkiri and Rattanakiri) including village-based, nature-based, adventure and river-based tourism; northern Cambodia including nature-based, adventure and village-based tourism and cultural

and heritage sites at Preah Vihear; as well as Siem Reap and Angkor Wat; Phnom Penh and the surrounding area; and the coastal areas of Kampong Som and Koh Kong.

Ecotourism is a major focus of RGC plans to develop tourism in Cambodia, including provincial tourism plans such as in Rattanakiri and Mondulkiri. To support ecotourism initiatives, the RGC intends to improve infrastructure such as: open water routes with neighboring countries to use the potential ecotourism attraction of the upper and lower Mekong; cooperation under the ADB-GMS to develop tourism, particularly along the East-West Economic Corridor and the Southern Coastal Corridor; and rehabilitation of airports and roads accessing the northeastern provinces and access roads to other major ecotourism sites. To ensure the sustainability of ecotourism, development will be based on assessments of carrying capacity and infrastructure, as well as evaluation of the economic, social and environmental benefits.

Lao PDR: Since 1995, the flow of tourists to Lao PDR has nearly doubled, with the number of international tourists more than quadrupling from just 31,000 in 1995 to 129,000 in 2000. However, regional tourists from other Southeast Asian countries outnumber international tourists four to one. Revenue from tourism reached over US$110 million in 2000, making it the country's leading source of foreign earnings. Foreign investment in the tourism sector has also increased significantly in recent years and represented 9% of total foreign investment in the period 1988-1998

In 1995, the Lao National Assembly identified tourism as one of the nation's eight priority development areas. Tourism development is based on the extensive natural and cultural resources of the country: 20 National Biodiversity Conservation Areas (NBCA) that cover 12.5% of the land area of Lao PDR, numerous significant historical sites and the culture and traditions of nearly 50 ethnic groups. An important piece of legislation is the 1997 Presidential Decree of the Preservation of Cultural, Historical and Natural Heritage.

The tourism policy of the Government of Lao PDR focuses, among other issues, on the following: consolidation of tourism along the Mekong River, along National Road No. 9 in conjunction with the ADB-GMS East-West Economic Corridor and village tourism; integration of tourism with the development of regional and international tourism; the development of Luang Prabang as a regional tourism center; and the equitable distribution of tourism benefits to various geographic regions and to the poor. The growth in the number of tourists is projected to growth at 15% per year.

The UNDP has assisted with tourism policy and planning: the preparation of a national tourism master plan and the organization of the National Tourism Authority (NTA). UNESCO has also been involved in developing and managing cultural tourism. Regional master plans have been implemented for historical sites of Luang Prabang and in Champassak.

Ecotourism is an important aspect of tourism in Lao PDR. The NTA in collaboration with UNDP has proposed a strategy based on an ecotourism accreditation system and an ecotourism network that will improve coordination among government, ecotourism operators and potential investors. Lao PDR has established broad guidelines for the development of ecotourism. The NTA has developed two ecotourism projects in cooperation with international partners4: the Nam Ha project developed with UNESCO and the Forespace Ecotourism Project in the Nam Kan/Nam Nga Protected Area.

Regional cooperation is seen as an important strategy to promote regional tourism. For example, Lao PDR reached an agreement with Myanmar to promote tourism within the Golden Triangle and is a member of the PATA Mekong Tourism Forum Tourism. They are

also a partner in a trilateral economic development zone being proposed under the auspices of ASEAN that will target tourism development.

Thailand: In 1999, there were 8.3 million tourist arrivals in Thailand. Tourism created about 11% of total employment in 1999. Economic activity related to tourism contributed nearly 13% to GDP. In addition to jobs and foreign exchange, tourism contributes to the growth of regions outside Bangkok.

In 2001, the Cabinet approved the preparation of a Tourism Master Plan for the period 2001-2010, aimed to establish Thailand as a 'world-class destination' and as a gateway to the other countries in the region. Under this Plan, the Tourism Authority of Thailand (TAT) is the coordinating body for tourism-related policies and programs implemented by the various ministries in Thailand. The Plan covers eight issues, including the following of potential relevance to BDP: develop new tourist attractions and provide better maintenance of existing attractions; ease immigration regulations; take steps to ensure greater visitor security, including in provincial areas; and collaborate with GMS countries, as well as Malaysia and Singapore, to promote tourism.

The Tourism Authority of Thailand (TAT) has carried out a study on river cruise opportunities on the Mekong River. TAT also promotes Mekong River Exploration on its website including cross border package river tours between Yunnan Province and North/Northeast Thailand.

Thailand is a partner with Cambodia in a proposed bilateral economic development zone that would also target tourism. Northeast Thailand is also being promoted for various ecotourism activities.

Viet Nam: Tourism has grown very rapidly in Viet Nam since the beginning of the Doi Moi policy in the late 1980s. From 1990 to 1997, the number of international visitors increased from 250,000 to 1.7 million. About 130,000 persons work in tourism and many more work for businesses related to tourism. From 1997 to 2000, the average annual contribution of tourism to GDP was 5.8%. Projections in the Tourism Master Plan (1994) anticipated 3.5 to 3.8 million international tourists in 2000, and about 9 million in 2010. Domestic tourists were projected to be 11 million in 2000 and 25 million in 2010. The economic impact of tourism was projected as 9.6% in 2000 and 12% in 2010.

Much of the tourism in Viet Nam is concentrated along coastal areas, for example, Ha Long, Danang-Hue, Nha Trang and Vung Tau. About 70% of tourist destinations are located in coastal areas, drawing 80% of all tourist visits. Information available in the preparation of this regional sector overview suggests there has been some development of ecotourism activities in the Mekong Delta (e.g. river boat cruises on the Mekong). However, there is little tourism development in the Central Highlands, due to security issues.

The Viet Nam Tourism Master Plan 1995-2010 as well as the Five-Year Socio-Economic Development Plan 2001-2005 are targeting further growth of the tourist sector. The Master Plan identifies seven priority regions, five of which are the major coastal areas: Ha Long Bay, Danang-Hue, Nha Trang, Vung Tau and Phu Quoc. The other two are the Hanoi and Ho Chi Minh City regions. The Ho Chi Minh City region extends to the Mekong Delta provinces adjacent to Cambodia and Lao PDR, the site of a proposed tri-lateral project under the auspices of ASEAN.

The Socio-Economic Development Plan prioritizes the development of domestic tourism, although it acknowledges the importance of international cooperation to promote international tourism. A program for tourism infrastructure targets development of four

comprehensive national tourism areas and 16 special tourism areas. Further information is required to identify the location of these areas and the proposed initiatives.

7.8 Regional tourism initiatives in the LMB

National governments are exploring multi-country initiatives that include tourism opportunities. Regional initiatives are being proposed by donor agencies and regional and international organizations. The private sector is directly involved in the development of the regional tourism industry.

Multi-country initiatives: All of the riparian countries are involved in one or more multi-country initiatives for development that includes tourism.

Thailand-Cambodia Economic Cooperation Plan: The two countries have prepared a draft 10-year plan to promote bilateral economic cooperation. Cross-border economic zones are proposed at Trat-Koh Kong and Aranyaprathet-Poipet. Tourism, as well as labor-intensive manufacturing, agro-industry and infrastructure sectors are being considered. The joint development of infrastructure such as road and train systems would enhance economic cooperation.

ASEAN: In 1996, the ASEAN members agreed to a Basic Framework of ASEAN-Mekong Basin Development Cooperation. The objectives of this cooperation are: to promote economically sound sustainable development of the Mekong Basin; to encourage dialogue leading to economic partnerships; and to strengthening economic linkages between ASEAN member countries and the Mekong riparian countries. Tourism is a key sector of cooperation, along with infrastructure, trade, agriculture, forestry resources and industry.

Cambodia-Lao PDR-Viet Nam Development Triangle: These countries have proposed a development triangle to increase regional and international economic integration. The proposal falls within the framework of the Mekong Basin Development Cooperation Program of ASEAN. The development triangle will initially encompass seven provinces: Rattanakiri and Stung Treng (Cambodia); Attapeu and Se Kong (Lao PDR); and Kon Tum, Gia Lai and Dac Lac (Viet Nam). Among other initiatives, trade and tourism will be promoted under the motto "Three countries: One destination."

ADB-GMS: The ADB-GMS Strategic Framework 2001-2010 has identified GMS Tourism Development as a 'flagship' program. This builds on tourism-oriented initiatives that have been part of the ADB-GMS since its inception in 1992. The objectives are to promote and strengthen subregional cooperation and tourism development in GMS countries and promote increased tourism in the GMS to augment hard currency earnings, reduce poverty, mitigate environmental degradation and develop human resources. The GMS Tourism Working Group (TWG) established in 1993 brings together representatives of GMS National Tourism Organizations (NTOs), ESCAP, the Pacific Asia Travel Association (PATA), UNESCO, World Tourism Organization (WTO) and donors.

Since its inception, the work of the TWG has included initiatives to facilitate the establishment of increased international border checkpoints; establish a single visa system for GMS countries; and expedite customs, immigration and quarantine procedures. As well, the TWG has developed regional village-based tourism policies and an action plan; facilitated agreements on commercial navigation on the Mekong River; promoted the opening of regional air transport networks; and organized friendship caravans between Thailand and Lao PDR.

The Tourism Flagship Program proposed for the next decade has six components. The first, to promote the GMS as a single tourism destination, is an ongoing initiative of ADB-GMS. In collaboration with AMTA, it involves support to NTOs to strengthen the joint tourism promotion and marketing efforts of the GMS countries. The other five components include:

- Developing tourism-related infrastructure;
- improving human resources in the tourism sector;
- promoting pro-poor community-based sustainable tourism;
- encouraging private sector participation in the GMS tourism sector; and,
- facilitating the movement of tourists to and within the GMS.

These components will be implemented through the Mekong Tourism Development Project to promote tourism development in Cambodia, Lao PDR and Viet Nam over the period 2003-2008. The investment project comprises four components: tourism-related infrastructure improvements; pro-poor community-based tourism development; subregional cooperation for sustainable tourism; and institutional strengthening. Subregional cooperation and institutional strengthening will focus on the establishment of NTOs, training and capacity building for NTOs and private sector entrepreneurs, reduction of obstacles to investment in tourism and measures to facilitate tourist movements in the GMS. The total cost of the project is US$47 million, of which US$35 million will be an ADB loan to the countries.

Mekong Tourism Development Project - Cambodia: The ADB has recently announced (September 2002) a US$20.3 million project for tourism development in Cambodia. The project will include improvements to tourism infrastructure, especially in places outside the Angkor Wat complex. Proposed infrastructure includes repairs to the road to Choeung Ek killing fields, renovating airports in Rattanakiri and Stung Treng and improving the sewer system in Siem Reap. Other initiatives include training to improve service, management and hospitality; and installation of computers and improved offices at international border checkpoints with Lao PDR, Thailand and Viet Nam.

The Viet Nam component of the Mekong Tourism Development Project is underway and a loan program is being mobilized in Lao PDR. Further information is required to identify the specific investments planned in these countries.

Tourism is also an explicit component in other ADB-GMS flagship programs:

North-South Economic Corridor: development of tourism infrastructure at Jinghong (Yunnan Province) and assessment of unified travel visa arrangements within and from outside GMS countries.

Chiang Rai Special Economic Zone: tourism and trade development projects.

East-West Economic Corridor: Tourism is one of five key areas of economic development, including tourism infrastructure at Savannakhet.

ESCAP: In collaboration, ESCAP and ADB have taken a leading role in developing tourism in the GMS. This has included the creation of the ADB-GMS Tourism Working Group. In 1997, ESCAP undertook the ADB/ESCAP-financed Mekong/Lancang Tourism Planning Study, the first step in preparing the ADB Mekong Tourism Development Project. The

ongoing focus of ESCAP projects, studies and other initiatives include human resources development, assessment of economic impacts of tourism, improved environmental management of tourism, infrastructure development and investment, facilitation of travel within the region and regional and sub-regional cooperation.

In 1999, ESCAP adopted the Plan of Action for Sustainable Tourism Development in the Asian and Pacific Region (PASTA), with the intent to implement it by 2005. The objective of PASTA is to increase the contribution of tourism to national social and economic development in ways that sustain people's prosperity in the short and long term. The focus of PASTA is a series of actions around six themes to strengthen national capabilities and promote regional cooperation for sustainable tourism: human resources development; economic impacts; environmental management; infrastructure development and investment; facilitation of travel; and regional and subregional cooperation.

APEC: The Asia-Pacific Economic Cooperation Secretariat (APEC) includes Thailand and Viet Nam as members. APEC organized a Tourism Working Group in 1991. The APEC Tourism Charter adopted in 2000 serves as a statement of ministerial intent to achieve four policy goals: remove impediments to tourism business and investment; increase mobility of visitors and tourism demand in APEC region; manage tourism in sustainable ways; and recognize tourism as a vehicle for socio-economic development.

UNESCO: UNESCO has been active in the Mekong region, particularly in the area of protection and promotion of heritage sites of religious, historical and cultural significance. A number of World Heritage sites are located in the region, including Luang Prabang (Lao PDR) and Hue (Viet Nam). In Lao PDR, UNESCO collaborated with multilateral and bilateral donors to develop the Nam Ha ecotourism project. The objective was to use tourism as a tool for integrated approaches to rural development that would conserve the natural heritage as well as validate and preserve traditional cultures.

AMTA: The Agency for Coordinating Mekong Tourism Activities (AMTA) acts as the TWG Secretariat. ADB-GMS, through its TWG, is exploring ways to strengthen and expand the role of AMTA to make it a professional regional marketing agency for the GMS, an organizer of subregional tourism events and a facilitator of subregional tourism projects.

PATA: The Pacific Asia Travel Association (PATA) is an organization with wide membership among tourism industry companies (airlines, hotels, cruise lines, etc.) and national, state and local tourism authorities. PATA, in collaboration with the World Tourism Organization (WTO), has been involved in promoting and developing tourism products in the region and encouraging private sector contributions to marketing and promotion efforts. Since 1996, PATA has organized an annual Mekong Tourism Forum to build cooperation between public and private sectors in the GMS region, for example, easing visa formalities and promoting transportation networks to develop the region as an integrated tourism destination. The PATA Mekong Forum Innovative Product Award was launched to acknowledge exceptional achievement in creating new tourism products within the region. In support of sustainable tourism, PATA has adopted a Code of Environmental Conduct and promotes its application in the tourism industry.

MPDF: The Mekong Project Development Facility (MPDF) was established in 1997 to support the development of private, domestically-owned, small and medium enterprises in Cambodia, Lao PDR and Viet Nam. MPDF is managed by the International Finance Corporation (IFC), the private sector arm of the World Bank, and is financed by a number of bilateral donors. MPDF provides assistance to two principal target groups: private sector managers with plans for business expansion; and organizations providing business support services to private companies.

In the tourism sector in Lao PDR, MPDF has been instrumental in assisting entrepreneurs to upgrade quality in areas such as customer services, architectural style and cultural and environmental impact. Financing packages and technical support offered to local banks strengthens their capacity to offer credit facilities to entrepreneurs in the tourism sector. MPDF is also developing management information systems (MIS) for tourism service providers and offers seminars to its tourism clients.

Bangkok Airways and Siem Reap Airways operate in the region and have initiated the *Mekong World Heritage Network Program* linking UNESCO World Heritage sites in Cambodia (Siem Reap/ Angkor Wat), Lao PDR (Luang Prabang), Viet Nam (Hue) and Thailand (Sukothai).

8 Domestic water supply & sanitation

8.1 Overview

Domestic water supply and sanitation (WSS) is often seen as a national responsibility, with few transboundary implications because domestic water supplies usually represent small volumes relative to total withdrawals. Three aspects of domestic water use make it a regional concern:

- Demand for domestic water use is universal;
- wastewater disposal may contaminate water for downstream users; and,
- social and economic consequences of disruption of supply are very serious.

Domestic water use issues in the Lower Mekong Basin have been reviewed in detail by Seager (2002).

8.1.1 Demand, access and sources

Domestic use typically represents only a small fraction (about 5%) of total water use in terms of volume (Seager 2002), but access to clean water and adequate sanitation are essential for health.

Total domestic water use is determined by both population and lifestyle; including access to water and level of development. Use is generally higher in urban areas than in rural areas and consumption increases significantly with availability of piped water. Table 8.1 lists estimated population for the LMB and estimated population distribution.

Table 8.1: Population of the Lower Mekong Basin

	Population LMB (est.)	Demand per capita (m^3 per year) MRC-WUP (2002)
Cambodia (1998)	9,800,000	12
Lao PDR (2000)	4,905,000	20
Thailand (2000)	23,130,000	24
Viet Nam (2000)	16,920,000	42
Total	54,755,000	

Source: Novak 2002

Reported per capita use of water for domestic purposes varies widely - estimates quoted by Seager (2002) are from 2 m^3 per year in Cambodia to 47 m^3 per year in Viet Nam. Estimates of demand from MRC-WUP (2002) are shown in Table 1. An alternative measure of likely demand is given by the supply targets set by each country. Lao PDR aims to provide 7 m^3 per year per capita (ADB 1998) and Viet Nam 22 m^3 per year per capita (NSWSS 2000). Given a total population in the LMB of approximately 55 million (see Table 1) and assuming a demand of between 20 and 100 m^3 per year, current total demand for domestic water is in the order of 1,100 to 5,500 million m^3 per year, or about 0.2% to 1.2% of Mekong annual flow (estimated as 450,000 million m^3 per year from data in MRC 1998).

Table 8.2 shows coverage in terms of safe water and sanitation for the four countries of the LMB (1999-2000). A very high proportion of the population of Viet Nam, Lao PDR and Cambodia do not have adequate access to safe water and sanitation. Access to water and sanitation is much higher in urban than rural areas, except in Thailand.

Table 8.2: Access to Improved Water Supply and Sanitation, 1999-2000

	Improved Water Supply			Sanitation		
	Total	Urban	Rural	Total	Urban	Rural
Cambodia	30	54	26	17	56	10
Lao PDR	37	61	29	30	67	19
Thailand	84	95	81	96	96	96
Viet Nam	77	95	72	47	82	38

Source: UNICEF, 2002

All major cities and provincial towns in Viet Nam and Thailand have piped water, but the capacity of supply systems is often insufficient for requirements. In Cambodia, only major towns have piped water (ADB; 1998, 2001). Existing urban water supply and sanitation systems are often old and in poor repair and are inadequate to deal with rapid urbanization. Even where piped urban water supplies exist, they may not be accessible to the poor, particularly in the rapidly expanding urban fringes and in squatter and low-income settlements (Seager 2002).

Urban supplies may be drawn from reservoirs, rivers or groundwater. Major cities along the Mekong (e.g. Phnom Penh, Vientiane and Nongkhai) draw their water directly from the river. Many towns in Thailand rely on groundwater. Sixty percent of groundwater abstraction

in Thailand is used for domestic supply (World Resources Institute 2000). In Viet Nam, about two-thirds of town water supplies are drawn from surface water with the remainder from groundwater (ADB 2002).

Typically, rural water supply is from streams or shallow wells that may be distant from dwellings and vulnerable to contamination. In both Cambodia and Viet Nam, over 60% of the rural population use groundwater for domestic supplies (Feldman et al. 2001, ADB 2002). Tube wells are increasingly used - for example, in Viet Nam, 21% of rural water is supplied from drilled wells and pumps. Rainwater collection is an important supplementary source of domestic water in some areas.

With the exception of Thailand, access to sanitation is even lower than for water supply. Contamination of surface and shallow ground waters due to inadequate sanitation is a significant problem in both rural and urban areas and water-borne diseases are a major cause of illness and death. Even where sewerage systems exist in major cities, treatment of urban wastewater is often rudimentary or non-existent. For example Phnom Penh's sewers discharge into holding ponds or the rivers without treatment (ADB 2001). There has been very little progress on development of urban sewerage in Lao PDR and most houses use septic tanks and pit latrines, which may contaminate shallow groundwaters and adjacent streams (ADB 1998). Similarly, in Viet Nam, septic tanks are the main form of domestic wastewater treatment, although wastewater treatment plants are constructed in the newly industrialized zones.

8.1.2 Social and economic issues

Secure water supply is an important aspect of poverty reduction strategies. Access to water and sanitation are basic human needs and their importance in terms of health and quality of life cannot be overstated. Diseases linked to poor hygiene and low availability of water includes intestinal worms, cholera, dysentery, typhoid, viral hepatitis, schistosomiasis and trachoma. For example, in Thailand a sixteen-fold reduction in deaths related to gastro-intestinal illnesses was achieved from 1960 to 1999, in parallel with increased coverage of sanitary latrines from less than one percent to over 98 percent during the same period (UNICEF 2001 in Seager 2002).

Equity of access to water is a significant issue (Seager 2002). In Cambodia for example it is estimated that for the poorest 20% of the rural population, the percentage with access to improved water supply falls to 4%, compared to 30% for the country as a whole (Royal Government of Cambodia 2001). Access to adequate sanitation is likely to be even lower.

All countries in the region are moving to de-centralised models of water delivery, with increasing involvement of the private sector and emphasis on demand-driven user-pay models of supply. The impact of this on equity of supply should be monitored carefully.

Increasing use of groundwater for domestic supplies in the delta region may cause health problems due to the presence of high levels of naturally occurring arsenic. Elevated levels of arsenic in groundwaters have been reported in both Cambodia and Viet Nam. UNICEF has instigated programs to investigate the risks of arsenic in groundwater in Viet Nam and Cambodia (http://www.unicef.org.vn/). (For more information on arsenic in groundwater, see http://www.who.int/inf-fs/en/fact210.html).

8.1.3 Environmental issues

Withdrawals for domestic water supply are unlikely to produce major environmental impacts, except on a very local scale, since they generally represent a small fraction of overall withdrawals.

The major environmental issue associated with domestic water is the threat to water quality resulting from disposal of contaminated wastewater. Potential impacts include:

- Reduced recreational amenity;
- threats to human health due to microbial contamination;
- impacts on irrigation and other uses due to decreased water quality;
- eutrophication and toxicity causing algal blooms, fish/invertebrate kills and/or disruption of fish migration; and,
- changes in ecosystem function due to increased turbidity and nutrient loadings.

Hart (2001) reviewed the potential effects of municipal and industrial wastewater from Phnom Penh and Vientiane on downstream uses, including environment and fish migration. Hart concluded that the risks of transboundary impacts from effluent releases were often uncertain, but were likely to be low due to the very large dilution factors operating in the Mekong. Local impacts, however, may be more pronounced, particularly in the dry season when flows are reduced.

8.1.4 National and regional initiatives and investment

The UN Millenium Development Goals (www.un.org/millenniumgoals/) include the goal (by the year 2015) the goal of reducing by half the proportion of people without sustainable access to safe drinking water. This goal is reflected both in national priorities for development and in the programs of international agencies.

Recently developed national policies on water supply (the Rural Water and Sanitation Strategy in Lao PDR, the Rural Clean Water Supply and Sanitation Strategy in Viet Nam and the Cambodia Rural Water Policy and Strategy) have a number of common themes (BDP 2002):

- An integrated approach to water supply and sanitation within a framework of integrated water resource management, to control water quality as well as quantity;
- decentralized planning, implementation and community-based management of water and sanitation services, including greater participation of women;
- expanded water supply through approaches that are demand-driven and responsive to users' willingness to pay;
- greater participation of the private sector, combined with targeted subsidies to ensure basic levels of service;
- continued data collection and monitoring to contribute to further policy development; and,

- increased services to the poor and to remote, ethnic minority areas.

These strategies are being implemented with the aid of a wide range of international and bilateral donors as well as NGOs. The Asian Development Bank also supports a range of activities relating to both urban and rural water supply. The Water and Sanitation Program, an international partnership of aid agencies administered by the World Bank, oversees a number of programs in the region (www.wsp.org) and acts as a coordination point for bilateral assistance in water and sanitation.

Annual expenditure on domestic water and sanitation varies considerably among countries, but generally relies heavily on international aid and loans. Infrastructure development is heavily supported by bilateral donors and NGOs provide much of the water supply development in rural areas and villages. Appendix 1 lists the major WSS projects and investment in each country.

8.2 Sector analysis

8.2.1 Sector development trends

The main trends affecting development in the domestic water supply and sanitation sector are:

- Increased demand due to changes in lifestyle, particularly in the cities where piped water is available. Figures from Viet Nam indicate that a four-fold increase in demand can be expected with availability of piped water (ABD 2002).

- Increased demand due to population growth – estimates are that population in the LMB will grow from the current figure of 55 million to around 65 million by 2010.

- Intensification of demand due to urbanization (see Tables 1-3, Industrial Water Review), placing increasing pressure on urban water supply and wastewater disposal systems.

- Increased vulnerability of surface and ground waters to pollution, as population density increases and industrial development proceeds, threatening domestic supplies.

Population growth rates are estimated at 2-2.5% for Cambodia and Lao PDR, 1% for Thailand and 1.5-1.7% for Viet Nam (Novak 2002). Thus population in the LMB can be expected to increase from the current level of around 55 million to about 65 million by 2010. Given the increased per capita demand associated with urbanization and increasing development, overall demand for domestic water is expected to grow by at least 50% over the next 10 years (Nielsen 2002). National estimates of increases in demand over the last 10 years indicate even higher growth: domestic demand was projected to increase between 1990 and 2000 by a factor of six in the Mekong Delta; and by a factor of three in Northeastern Thailand (Seager 2002).

Increased demand could be offset to some extent by improvements in efficiency of supply and reduction of losses in urban supply systems, which are estimated to be as high as 40-50% (Seager 2002). Increases in demand will also depend on the economic framework by which the water supply is managed and cost structures imposed. Demand management requires that an appropriate value be placed on water to discourage waste. However, the advantages

of adequate water supply to the community as a whole may be significantly higher than costs recovered by charging for water and this should be taken into account in water pricing. For example, a World Bank study concluded that for each dollar invested in water and sanitation measures in Thailand, almost US$7 is gained in health and other benefits (http://www.worldbank.or.th/env/copw.html).

In Cambodia and Lao PDR, the major cities and towns are close to ample water sources and withdrawals are more likely to be constrained by plant capacity than by the size of the resource (ADB 2001). In Thailand and Viet Nam, where some urban areas rely on groundwater, demand may outstrip available supplies. Security of supply in the dry season is already a problem in Thailand. Official estimates are that 50% of all villages lack sufficient water for domestic consumption (Bangkok Post 1998 in ADB 2000).

In rural areas throughout the basin, the eventual provision of year-round access to safe water in areas away from rivers may depend primarily on groundwater supplies. Information on sustainable yield of groundwater aquifers is often lacking. There is also considerable scope to develop domestic rainwater harvesting to supplement surface and groundwater supplies.

8.2.2 Transboundary issues

Because of the relatively small volumes involved, extraction of domestic water supply from rivers will not usually result in transboundary impacts, unless reservoirs are constructed to augment supply. In the past, reservoirs have been constructed primarily for irrigation and hydropower, rather than domestic supply, though this may change if demand increases dramatically.

Contamination of surface and ground waters by sewage and other wastewaters is currently localized and Hart (2001) found that the risk of transboundary impacts from wastewater disposal is generally low, due to the large dilution factors. However, water quality is an on-going concern for the riparian countries. Coordination of water quality standards for release of wastewaters would be a useful step in protecting water quality.

If dry season flows were to be reduced substantially due to off-take in upstream areas, increased intrusion of marine waters in the delta could threaten domestic supplies in areas relying on shallow ground waters.

8.2.3 Inter-sectoral issues

Security of supply for domestic water is essential as disruption has very serious consequences in terms of health and quality of life. Domestic supply should thus be given first priority in water use. This nominally is the case, but in some instances, failure to regulate other uses can threaten domestic supply.

The industrial sector often uses the urban water supply and drainage infrastructure. This adds significantly to the pressures on urban domestic water supply and wastewater disposal systems. At present, with urban infrastructure not well developed, many industries have established their own water supplies, often from groundwater (www.boi.go.th). In the longer-term, however, provision of industrial water may compete with domestic water in terms of infrastructure.

The quality of domestic supplies may be threatened by water use in other sectors. Industrial pollution, though uncommon in the basin at this stage, is increasingly likely as development proceeds. The Industrial Water Review gives an overview of industrial pollution in the LMB.

Point sources of pollution can usually be identified and monitored – for example, deterioration of water quality in Khon Kaen Province on Nam Phong River was traced to releases from a pulp and paper mill (Inmuong 1998). Non-point sources, for example agricultural pesticides, are more difficult to monitor and control and may pose a threat to domestic water supplies in the long-term.

Contamination of domestic supplies by inappropriate wastewater disposal is a significant problem basin-wide and it is essential that water supply and sanitation programs are integrated. In general, contamination from domestic wastewater will not compromise other human uses, except in the immediate vicinity of the release point, although faecal contamination may pose health risks if wastewater is used in irrigation of vegetables. High nutrient contents and other contaminants (such as detergents) in wastewater can seriously disrupt the ecology of rivers and wetlands at local scales, particularly downstream from urban centres.

8.3 Water supply and sanitation investment and projects

8.3.1 Cambodia

In Cambodia, the government is committed to achieving the long-term goal of providing access to clean drinking water and environmental sanitation for the entire population, but has not set specific targets. Water supply projects are funded almost entirely by international aid and loans. Almost US$35 million in loans from ADB and World Bank was invested in domestic water supply and sanitation in Cambodia in the period 1996-2000. No estimates of total expenditure in the sector were available, but water supply and sanitation are components of a number of major aid programs, including:

Rural Water Supply and Sanitation project to improve access to water supply and sanitation in Kampot, Kampong Thom and Pursat (ADB)

http://www.adb.org/Documents/Profiles/LOAN/34382013.ASP

ADB provincial towns improvement project, including water supply and sanitation projects in six major towns

http://www.adb.org/Documents/Profiles/LOAN/29282013.ASP

ADB-financed rural water and sanitation project in preparation, to apply the new directions set out in the Cambodian rural water and sanitation strategy (MoRD 2001a, MoRD 2001b).

UNDP/WB Water and Sanitation Program has an alliance with the Ministry of Rural Development and an NGO, Partners for Development, to pilot and demonstrate aspects of Cambodia's new rural water and sanitation sector policy framework through an on-going rural development program in Stung Treng and Kratie Provinces

http://www.wsp.org/english/eap/eap.html

European Union supported PRASAC project includes improved domestic water supply through the provision of wells, dug wells, ponds and rainwater catchment systems (jars, tanks); and establishment of Water Point Committees for domestic Water Supply http://www.prasac.org/PRASAC/prasac_cambodia.htm.

The World Bank supports development of urban and rural water supply through its Social Credit and Flood Emergency Rehabilitation projects: www.worldbank.org

WSS projects are also covered by bilateral agreements with France, Australia, Sweden, Japan and United Kingdom; and by the work of a large number of NGOs.

8.3.2 Lao PDR

In Lao PDR, the Sector Investment Plan for water supply set national targets to provide safe water supply for 80% of the population by 2000; access to sanitary toilets for 50% of the rural population; and sewerage reticulation for the Vientiane, Luang Prabang, Pakse and Savanakhet by 2003.

Most funding for public infrastructure comes from bilateral aid agencies or multi-lateral lenders. ADB (1998) estimated that a total of US$100 million was invested in domestic water supply and sanitation in the period 1994-98, of which 95% came from external sources. Major current projects include:

Secondary Towns Urban Development projects (ADB loan of US$24.7 million, with a component for WSS)

Water Supply and Sanitation Sector Project (ADB loan of US$18.3 million)

Vientiane Urban Infrastructure and Services Project (ADB loan of US$25.1 million, partly for WSS) (http://www.adb.org/Documents/Profiles/ctry.asp?ctry=17)

Technical Assistance to expand WSS facilities for Northern and Central regions (ADB Japan Special Fund) US$0.7m

(http://www.adb.org/Documents/TARs/LAO/R159_02.pdf)

World Bank Provincial Infrastructure Project - town and rural water supply (www.worldbank.org) (http://www4.worldbank.org/sprojects/Project.asp?pid=P042237)

UNDP/WB Water and Sanitation Program, in collaboration with the Swedish International Development Cooperation Agency, has assisted the government of Lao PDR in formulating a sector strategy and action plan for rural water supply and sanitation

UNICEF supports projects in both urban and rural water supply

Water supply projects are also covered by bilateral agreements with France, Sweden, Germany and Japan; and by the work of a large number of NGOs.

8.3.3 Thailand

In Thailand, the Provincial Water Authority has responsibility for WSS outside Bangkok. Spending on rural water supply to 2000 was estimated at TB 13,500 million and TB 24,600 million on urban supply in provincial towns (a total of around US$900 million) (www.boi.go.th/). Major current projects within the LMB include:

Nongkhai-Udon Thani Water Supply Project - to construct a new water intake and treatment plant on the Mekong River at Nongkhai and transmission main to Udon Thani and 12 nearby rural communities (ADB loan of US$50 million, total cost US$83.5 million)

(http://www.adb.org/Documents/News/1997/pi1997060.asp)

World Bank Social Investment Project (on-going, US$300 million) includes a small component (5%) for water and sanitation.

Provincial Waterworks Authority in Roi Et Province plans to increase water production to 10.3 million m^3 per year from the current 6.3 million m^3 per year, to meet current shortfalls and projected demands over the next ten years.

(www.investmentthailand.com/en/).

8.3.4 Viet Nam

In Viet Nam, the National Strategy for Rural Water Supply and Sanitation aims to provide 85% of rural inhabitants with access to safe water (at the level of 60 litres per capita per day) and 70% of families with good standard latrines, by the year 2010. Investment in rural safe water supply in the period 1996-2000 was VND 864 billion (US$58 million), of which VND 330 billion (38%) was from external contributions. Major current projects include:

Third Provincial Towns WSS Project for provinces in the Mekong Delta including Kien Giang (US$60 million ADB loan) (www.adb.org)

Hygiene and safe WSS in rural areas (UNICEF)

Community based rural infrastructure (World Bank loan of which 23% is for WSS)

(www.worldbank.org)

Bilateral projects on WSS with Japan, Australia, France, Denmark, Germany and the Netherlands.

8.4 Indicators

For purposes of the BDP it is important to have measures of:

- Demand for total required volume for domestic water supply, spatial distribution of demand and projected changes in demand over the next 5-20 years;
- effect of domestic wastewater on quality of surface and shallow ground waters;
- security of supply (water availability as a function of projected demand);
- equity of access (difference in access due to urban vs rural, or poverty); and,
- quality of domestic water (chemical and bacteriological).

Seager (2002) discusses appropriate indicators to monitor progress in provision of domestic water and sanitation. Seager points out that it is important to monitor equity, effectiveness and sustainability of supply and that simple measures such as proportion of the population with access to safe water and sanitation do not provide this information. In addition, these measures are often poorly defined and may differ between countries. As a starting point,

however, figures on access to safe water and sanitation provide some idea of distribution and are often used as one measure of poverty.

Water quality monitoring upstream and downstream of major urban centres should include tests for faecal coliforms as well as chemical tests. Water quality monitoring programs at MRC are outlined in Campbell et al. (2002).

8.5 Conclusion

The main regional and transboundary issues for domestic water are:

- Securing adequate supplies of suitable quality, in the face of rapidly expanding demand due to population increase; and,
- appropriate treatment and disposal of wastewater to prevent contamination downstream.

Urban demand can usually be adequately met from surface water supplies (rivers or reservoirs), but rural supplies rely more heavily on ground water. Ground water resources in most areas are poorly defined and may not be adequate to cover growing demand. This is particularly likely to be true in Northeastern Thailand and the Mekong Delta, which are the potential hot spots for domestic water supply. These areas are also most vulnerable in terms of water quality, due to higher industrialization and the potential for saline ground waters to contaminate shallow aquifers (marine intrusion in the Delta; naturally saline waters in Northeastern Thailand).

There is potential for regional collaboration in projects that focus on efficiency of supply and use, demand management and water conservation strategies. Although water scarcity is not a pressing issue in much of the LMB, reduction of domestic demand has significant pay-offs in reduced need for wastewater treatment. Other potential areas of cooperation include development of regional water standards for release of wastewater and promotion of domestic rainwater harvesting to enhance security of supply in rural areas.

9 Industrial water use

9.1 Introduction

This chapter explores the trends and issues of industrial water use and wastewater in the Lower Mekong Basin. The Mekong River Commission's sector programmes do not cover the water supply sector, and the Secretariat knowledgebase on this aspect is limited. Therefore, it is foreseen that more research on industrial aspects will be needed.

Industrial development in the Lower Mekong Basin is at an early stage, however, urbanisation is rapid and the growth rate of the industrial sector is high. Northeastern Thailand and the Mekong Delta are the most advanced industrial areas in the region. Industrial development in Cambodia and Lao PDR is almost exclusively taking place in the capital municipalities, Phnom Penh and Vientiane.

Industrial water withdrawal is still limited compared to the agricultural sector. Water is in general considered plentiful, and water demand conflicts between industry and other sectors are only known to have occurred in Northeastern Thailand. Water quantity aspects are therefore not regarded as a general problem for the industrial sector development in the foreseeable future. However, with double-digit growth rates for industrial development in certain areas, water demand issues will be an issue later.

Considering industrial water quality, pollution problems are identified in the LMB, especially in the capital cities of Vientiane and Phnom Penh, and more generally in Northeastern Thailand and the Mekong Delta region. Generally, there is limited treatment of industrial wastewater and insufficient handling and disposal of industrial hazardous waste. So far, industrial water pollution is mainly concentrated around specific industrial establishments and downstream of major urban areas. Overall, the Mekong River and most tributaries are considered relatively healthy. However, the growing industrialisation in the LMB provides a warning that more severe water discharge problems will occur and inter-sectoral conflicts of water quality demands will increase.

9.2 Regional overview

9.2.1 Industry

While economic development in the four countries has been booming, industrial development within the Lower Mekong Basin (LMB) has been quite modest. The country most industrialised is Thailand, although the bulk of the industries are located outside the LMB, mainly in the Bangkok metropolitan region.

In Thailand's part of the Basin, the main industrial products are agricultural inputs and processed food (Ringler, 2001). Ojendal and Torell (1997) also mention the production of precious stones and jewellery, cement, sugar, refined oil, synthetic fibres, textiles, assembled vehicles and parts, paint and steel. Nakhorn Ratchasima is the main industrial centre of the northeast.

In Lao PDR and Cambodia the industrial sectors are small and industrial development is at an early stage. However, the industrial sector is growing quickly. Production of tin concentrates is an important industrial activity in Lao PDR, but there are also some small scale manufacturing industries that produce for example beer, cigarettes, detergents and rubber footwear (Ojendal and Torell, 1997). In Cambodia, the major water using industries

are food processing and textile industries. One fast growing industry in both Lao PDR and Cambodia is the textile industry.

Viet Nam is rapidly undergoing industrialisation. The Mekong Delta comprises mainly agro-industries like rice milling and polishing, breweries and canneries, as well as aqua-food processing industries. The number of industries in the Delta is moderate, partly because of a lack of infrastructure and transport facilities (Ojendal and Torell, 1997).

Whereas in Cambodia and Lao PDR, industries are concentrated in the respective capitals, industrial development can also be found in several areas of the Thai part of the Basin and the Mekong Delta (Ringler, 2001). Table 1 illustrates the number of inhabitants as well as the population growth in the major urban centres of the LMB.

Table 9.1: Number of inhabitants and population growth in major LMB urban centres

Municipality	Country	Population (000)	Annual Growth (%)
Phnom Penh (1995)	Cambodia	1,000	10
Can Tho (1994)	Viet Nam	326	
Nakhon Ratchasima (1992)	Thailand	270	10
Vientiane (1995)	Lao PDR	250	6
Battambang (1995)	Cambodia	128	
Khon Kaen (1990)	Thailand	126	7
Savannaketh (1995)	Lao PDR	109	
Udon Ratchathani (1990)	Thailand	95	2
Pakse (1995)	Lao PDR	55	

Source: (UNEP/MRC, 1997)

According to (UNEP/MRC 1997), economic migration to Nakhon Ratchasima is based on the manufacturing boom and to Khon Kaen on its growth in agro industries. Tables 9.2 and 9.3 illustrate the country-by-country annual urban growth rate in the region, and future urbanisation trends. The tables illustrate trends that will inevitably have an impact on water supplies in the Basin whether domestic or industrial as well as wastewater issues.

Table 9.2: Annual urban growth rate, 1999

Country	Growth rate (%)
Cambodia	4.8
Lao PDR	5.5
Thailand	2.4
Viet Nam	2.1

Source: (UNESCAP/ADB, 2000)

Table 9.3: Urbanisation trend 1999-2030, degree of urbanisation in %

Country	1999	2005	2021	2015	2020	2025	2030
Cambodia	23.0	26.6	29.7	32.9	36.2	39.5	42.8
Lao PDR	23.0	26.4	29.5	32.7	36.0	39.3	42.6
Thailand	21.1	23.7	26.2	29.3	32.5	35.8	39.1
Viet Nam	20.0	20.6	22.1	24.3	27.3	30.4	33.7

Source: (UNESCAP/ADB, 2000)

In recognition of the increasing population pressure in centres within LMB, growth of labour-intensive rural industries is a significant new policy direction for riparian countries. The objectives are to generate higher levels of non-farm employment to meet the demands of the growing labour force, including those displaced from agriculture; to stabilize migration from rural to urban areas; and to increase incomes (BDP, 2002).

The dominant strategy is the development of a wide range of agro-processing industries and other natural resource based industries (forestry and water resources), to increase value-added products for domestic and regional markets. Other rural industries will include construction materials, textiles and chemicals, including the relocation of city-based industries to rural areas as in Viet Nam (BDP, 2002). In general, these industries will rely on the establishment of small and medium-size enterprises. In terms of location, the relatively good transport network in Northeastern Thailand, as well as the proposed regional highways will tend to attract industrial activities. In the Delta, six industrial parks are planned for the 2001-2005 period, in Can Tho, Bac Lieu, An Giang and Ben Tre (BDP, 2002). According to a recent study for MRC, the objectives for Thailand are about moving further up the ladder technologically and in terms of labour skills, adding further to export values, and also increasing rural-urban linkages. Also of direct relevance to BDP and LMB are plans to diversifying industry geographically out of the Bangkok Metropolitan/Central Plains areas (BDP, 2002a).

The UNEP/MRC study from 1997 recognises two main industrial regions that could be discernible in the foreseeable future: a light-manufacturing base in Northeastern Thailand and another in the Mekong Delta for agro-industries. It also outlines certain limitations. Thus, it is stipulated that if development of industrial minerals in Northeastern Thailand is accelerated, it is likely that the raw materials may be exported outside the region instead of contributing to the establishment of an industrial base in the Basin. Furthermore, in Viet Nam industrialisation in the south is expected to be much more concentrated in the quadrangle of Song Be – Dong Nai – Ho Chi Minh City – Vung Tau rather than in the Mekong Delta (UNEP/MRC, 1997). In Table 9.4, some key figures on the industrial sector are presented for the four countries

Table 9.4: Key figures on the industrial sector in the riparian countries

	GDP	Comments
Cambodia	25% of GDP 8% of employment	-overwhelmingly textiles
Lao PDR	22% of GDP	mainly handicrafts some agro processing or assembly
Thailand	40% of GDP	-highly concentrated around Bangkok -North/Northeast largely light manufacturing and agro-industry
Viet Nam	35% of GDP	-early 1990s manufacturing growth has slowed -major oil and gas earnings

Source: (BDP, 2002a)

9.2.2 Water withdrawals

Water is necessary for all industrial activities, including cooling processing or manufacturing operations, power generation, cleanup and other sanitary purposes, and fire protection. The quality and quantity of industrial water demand varies significantly by country, industry and particular uses, ranging from high water quality for the beverage industry to brackish water or treated municipal effluent for cooling purposes. Estimates for municipal and industrial (M&I) water withdrawals in the LMB for both 1990 and 2020 as calculated by Ringler (2001) are shown in Table 9.5.

Table 9.5: Water withdrawals in 1990 and projected 2020

Region	Total demand/cap (m^3/cap/year)	Share agriculture (%) A	Share agriculture (%) B	Share M&I (%) A	M&I withdrawal 1990 (million m^3)	M&I withdrawal 2020 (million m^3)
Northern Thailand	350	90		10	60	120
Northeastern	350	90		10	665	1,347
Lao PDR	280	94	82	6	70	168
Cambodia	150	94	94	6	78	187
Mekong Delta	570	90		10	832	1,845
Central highlands	280	90		10	67	149

Source: (Ringler, 2001)

Note: The calculation for water withdrawals in Lao PDR varies depending on sources (A and B).

Following the information sources related to B mentioned in Table 9.5, Table 9.6 illustrates industrial water withdrawals at the national level in the riparian counties.

Table 9.6: Water withdrawal by industry as share of total national sectors withdrawals

Industry	(%)
Cambodia ((1987)	1
Lao PDR (1987)	10
Thailand (1995)	4
Viet Nam (1990)	10

Source: (http://earthtrends.wri.org/datatables)

To indicate the future trend for water requirements by sector in the Mekong Delta in Viet Nam, Table 9.7 illustrates the expected growing demand, especially in industry.

Table 9.7: Increase of water requirements in the Mekong Delta

Uses	Increase between 1990 and 2000 (%)
Consumption	47
Industry	100
Agriculture	29
Total	31

Source: (UNEP/MRC, 1997)

Note: As predicted in 1993 by Ministry of Water Resources in Viet Nam

It should be noted that most private industries in the LMB are using groundwater, and that water withdrawals are generally not reported to the authorities (Tue Nielsen, interview, 2002). Table 9.8 illustrates this point presenting groundwater withdrawal by sector for Thailand.

Table 9.8: Groundwater withdrawal by sector in Thailand (1980)

Sector	(%)
Domestic	60
Industry	24
Agriculture	14

Source: (http://earthtrends.wri.org/datatables)

However, comparison of figures for groundwater and surface water withdrawals illustrates that the groundwater withdrawal is just a small fraction of the total water withdrawals. See Table 9.9 with examples from Thailand and Viet Nam.

Table 9.9: Comparison of water withdrawals from surface and groundwater in Thailand and Viet Nam

Country	Surface freshwater Annual per capita (m^3)	Groundwater Annual per capita (m^3)	Groundwater withdrawal as percentage of surface withdrawal
Thailand	595.9	15	2.5%
Viet Nam	678.8 (1)	11.9	1.8%

Source: (http://earthtrends.wri.org/datatables)

Notes: Calculated by author based on WRI tables. Figures are based on sources from the late 1990s. Per capita calculations were calculated using 2000 population estimates.

9.2.3 Waste water issues

Rapid urban population growth and inadequate infrastructure may lead to deteriorating environmental quality and public health problems from improper disposal of domestic and industrial wastes. Of concern are not only cities inside the LMB, but also cities in the vicinity, which may cause a spill over of pollution and human settlements (e.g. Ho Chi Minh City in Viet Nam, population 4.3 million).

Even though industrial development in the LMB is low, a major portion of industrial waste receives no treatment before discharge. This has started to cause environmental problems particularly near populated areas and more generally in the Mekong Delta and Northeastern Thailand, where the first negative impacts have been observed (UNEP/MRC, 1997).

In Lao PDR, treated industrial effluent is estimated at 15% of total (ADB, 1998), and wastewater in Viet Nam is being discharged from services, industrial areas and domestic uses without treatment, causing serious pollution. Pollution indicators in wastewater from the aqua-food processing industry in the Mekong Delta include high levels of biochemical oxygen demand (BOD), nitrogen and suspended solids (Triet and Dan, 2002).

Some wastewater is hazardous including that from metal galvanizing factories, battery recycling/disposal, vehicle repair/disposal, pesticides storage/disposal, petroleum exploration, fuel oil storage and shipment, paint manufacturing, mining, leather tanning, hospital/medical facilities, garment manufacturing (certain dyestuff), and factories using organic solvents. Handling and disposal of hazardous materials is uncontrolled and there are no treatment facilities in the region.

Illegal importation and subsequent mishandling or illegal dumping of hazardous wastes may become a problem (UNEP/MRC, 1997).

Conservative estimates presented in Table 9.10 of the production of hazardous waste in Thailand and Viet Nam (national level) may provide some indication for the future pollution problems in the LMB.

Table 9.10: Conservative estimates of annual production of hazardous waste (000 tonnes)

Country	1993	2000	2010
Thailand	882	2,215	4,120
Viet Nam	460	910	1,560

Source: (UNESCAP/ADB, 2000)

Levels of urban solid waste are relatively low, around one kg per capita per day; Phnom Penh generates 1,200 cubic meters of solid waste daily (UNEP/MRC, 1997). Since most solid wastes are not collected and properly handled, it often has an impact on the water quality in adjacent water sources. In Phnom Penh, for instance, it is estimated that around 158 tons/day solid waste is disposed into the water system (Chheng, 2002).

Some overall urban/industrial water related environmental issues for the four countries are presented in Table 9.11.

Table 9.11: Urban/industrial water related environmental issues and causes

Country	Key issue	Key Causes
Cambodia	Threat to natural fisheries.	Unmanaged waste and effluent discharge into Tonle Sap Lake.
Lao PDR	Limited access to potable water, diseases prevalent.	Inadequate water supply and sanitation infrastructure.
Thailand	Shortage of water resources, pollution from solid waste, hazardous materials and waste.	Freshwater resources being polluted by domestic and industrial wastes and sewage runoff.
Viet Nam	Groundwater contamination.	Inadequate water supply and sanitation.

Source: (UNESCAP/ADB, 2000)

Note: Moderated to include only issues and concerns that relate to urban/industrial waste issues.

9.2.4 Mines

All the MRB countries are rich in mineral resources. There are many areas that are not yet investigated and exploitation has not been very active.

In Cambodia mineral investigations began in the 1950s when significant deposits of sapphires, rubies, alluvial gold, allvial cassiterite, silica, bauxite, manganese and coal were found. The only significant exploitation carried out was gemstone production in the region of Pailin in Battambang Province. These mines, still under operation, are only nominally under control of the Cambodian government, and the gems are exploited by artisanal methods (Ojendal and Torell, 1997).

There is currently active mining of construction materials such as sand, gravel, granite and clay as well as certain industrial minerals, for example phosphate and limestone. It is difficult to estimate the extent of this mining as the extraction has been uncontrolled with respect to the government and tax collectors (Ojendal and Torell, 1997).

Lao PDR has significant mineral resources, the exploitation of which may become an important input to economic growth in the future. Commercial mining of tin, gypsum, coal, salt, gemstones and construction materials has so far been carried out on a small scale with exports of tin, gypsum and sapphires. The mining sector constitutes about 1% of the total GDP of Lao PDR (Ojendal and Torell, 1997).

Viet Nam is rich in mineral resources. In the Dak Lak province of the Central Highlands there are abundant reserves of kaolin and bauxite (Ojendal and Torell, 1997). The bauxite reserve is estimated to be 5 billion tons (UNESCAP/ADB, 2000).

In Thailand, the Northeastern region is rich in salt and potash. Several large mining companies are now considering taking an interest in a major potash deposit in the Udon Thani region (Ojendal and Torell, 1997).

However, there are no clear prospects of mineral exploitation in the foreseeable future in the LMB. Lao PDR has requested and obtained technical assistance in EIA capacity strengthening particularly for the mining sector, apparently in preparation of such development. The prospect for bauxite exploitation in the central highlands of Viet Nam is remote due to the weak infrastructure, lack of water and electricity for smelting (UNESCAP/ADB, 2000).

Mining can create adverse environmental impacts. Key concerns are landscape modification, soil erosion, vegetation destruction and sediment transport. Sediment transport and the spread of malaria (due to abandoned mine pits) in Cambodia have been attributed to extensive gem mining. If the mining in Lao PDR is developed without careful planning and conscientious mitigation, adverse environmental impacts could be severe, because of the mountainous landscape. Aluminium refineries elsewhere have been noted for their impacts on water and air quality. Bauxite mining and aluminium refining in the central highlands, which are in the upstream reaches of the Mekong River, would be of significant concern (UNESCAP/ADB, 2000).

There are onshore natural gas deposits on the Korat Plateau. In 1995, the Nam Phong gas field produced about 23 million cubic meters gas per day. Cambodia has some onshore potential as well, but this has so far attracted little attention. Oil has also been discovered in Lao PDR, between Thakhek and Pakse in the Vientiane Valley (Ojendal and Torell, 1997).

9.3 Cambodia

9.3.1 The industrial economic sector

Cambodia witnessed a rapid expansion of urban-based industries (such as textiles, construction, hotels, services etc) in the wake of continuing political stability. In 2000 the industrial value-added grew at double digit rates. Industry, of which three quarters is manufacturing including production of textiles, generates some 25% of GDP but accounts for only 8% of the employed population (BDP, 2002a). The development in percent of GDP of the industrial sector in the late 1990s is shown in Table 9.12 and illustrates the fast growing industrial sector. The high growth of manufacturing in Cambodia is illustrated in Table 9.13, which shows the increase in the number of different types of industries.

Table 9.12: Percent contribution of the industrial sector to the GBP

	1995	1996	1997	1998	1999
Industry	14.0	14.9	17.3	18.4	19.6
Mining	0.2	0.2	0.2	0.2	0.2
Manufacturing	8.4	9.5	12.4	14.1	14.7
Electricity, gas, and water	0.5	0.5	0.5	0.5	0.5
Construction	4.9	4.7	4.3	3.6	4.2

Source: National accounts of Cambodia, Ministry of Planning, National Institute of Statistics.

Note: The figure for industry's contribution to GDP is somehow lower than illustrated by BDP report (2002a)

Table 9.13: Number of various industries, 1993 – 1998

Type of industry	1993	1994	1995	1996	1997	1998
Mining and quarrying	99	101	101	102	102	102
Food, beverages and tobacco	77	146	164	189	198	204
Textiles and wearing apparel	10	26	39	55	111	149
Wood and wood products	19	21	51	62	68	70
Paper and paper products	3	8	8	11	13	13
Chemical, rubber and plastic products	12	22	26	34	39	40
Non-metallic mineral products	55	179	188	191	201	202
Manufacture of basic metals	3	5	5	6	6	6
Fabricated metal products	7	24	27	35	41	42
Other manufacturing industries	0	1	1	2	2	2
Electricity, gas and water	23	25	25	25	25	25
Total	308	558	635	712	806	855

Source: (Chheng, 2002)

Most manufacturing and warehouses in Phnom Penh are located along the embankment of the Tonle Sap River north of the town or at the Bassac River south of the town mixed with commercial and residential areas. Such locations allow direct access to river transport and high consumption of water. Light and medium industries, workshops and artisan establishments are very common in Phnom Penh Municipality. Another area of industrial concentration is along the Veng Sreng Road in Sangkat Stung Mean Chey. Recently, a new pattern of industrial location has emerged which is more random with establishments scattered in many areas of the city and some provinces (MoE, 2002).

The industrial sector accounts for 8 percent of the employment in Cambodia and even though wages are higher in the industrial sector than in agriculture, labour market statistics collected by the Cambodia Development Research Institute (CDRI) show that wages for unskilled workers in Phnom Penh were stagnant or declining in 2002, highlighting the difficulty that the labour market faces in absorbing new entrants (ADB, 2002)

The outlook for 2002-2003 indicates that garments and tourism will continue to be the most dynamic economic areas (ADB, 2002). The recent opening of Siam Reap airport to international flights has boosted the flow of visitors to the country with further implications for the magnitude of water withdrawals and water discharge environmental problems.

To indicate the potential development of types of industries in Cambodia for the near future, the Industrial Development Action Plan 1998-2003 prepared by the Ministry of Industry, Mining and Energy has identified the following main opportunities related to industrial development (BDP, 2002).

- Palm oil refineries;
- Rubber processing factories;
- Cashew nut processing factories;
- Jute factories based on jute growing near the Tonle Sap River;
- Textile factories created for the purpose of dyeing traditional cloth/silk.
- Other factories producing tapioca starch, flour, and fruit products (juice, canned fruit, dried fruit);
- Expansion of small-scale tobacco producers to increase the supply of raw materials to the larger manufacturers; and,
- Sugar factories based on two to three sugar cane harvests annually in Battambang and Kampong Speu; and also use of waste products of sugar milling for power generation, fertiliser production, molasses and alcohol production.

Even though Cambodia has a high economic growth rate and a double-digit development growth rate in manufacturing, there are some risks. An ADB study mentions the following risks regarding Cambodian development (ADB, 2002): Political risks: In the short term, renewed political disturbance could rapidly decelerate economic performance; Economic risks: A stalled reform programme could impact economic development; High world oil prices would slow world economy; Environmental hazards; Demographic: The rate of population growth is 2.5%; HIV/AIDS.

According to a BDP report (2002a) some negative economic trends have already been identified. Cambodia's boom years of Foreign Development Investment (FDI) enthusiasm (largely for textiles) are over, and FDI has fallen for the last few years. Political risks, high costs of doing business, competition from China and the slow economic recovery worldwide and in Asia, all suggest that this trend will not be reversed in the short term. The exception to this trend may be as regards China as a source of investment funds. Some areas of LMB (e.g., northern Lao PDR) are presently seeing notable amounts of Chinese investment in garments, some agroprocessing, hotels and tourism, although not yet any major manufacturing.

There are doubts about the medium- and longer-term viability of much of the garment industry (traditionally a footloose industry), as it presently depends on preferential access to US and European markets, where such access is not indefinitely assured. However, early accession to WTO would improve Cambodia's prospects in this regard but the country will still be competing with countries such as China.

9.3.2 Waste

The central part of Phnom Penh has a combined sewage system (domestic, industrial, storm water), but it is in poor condition. The remainder of the city has no sewerage system, with

the majority of the population in these areas using latrines or septic tanks. A network of street drains conveys water and sewage by gravity to retention ponds where some "treatment" of the wastewater occurs. Wastewater from these ponds is either pumped over embankments directly into the Bassac or Tonle Sap Rivers, or into a system of natural ponds and canals that eventually drain into these rivers. A total of 14 sewers discharge to these two rivers (Hart, 2001).

It is estimated by Hart (2001) that 75 million m^3 of sewage and 470 million m^3 of stormwater is discharged annually to the Tonle Sap and Bassac Rivers (assume approximately equal amounts to each river). The potential local impacts from these discharges are likely to be greatest during the dry season when flows in these rivers are at their lowest, and during no-flow periods in Tonle Sap River (Hart, 2001).

Overall, it is assumed that industrial and urban pollution are not yet serious in Cambodia and the water quality so far is still in good condition. However, due to the high growth of industrial establishments with no urban planning, increasing agro-chemical consumption and urbanisation the water quality will deteriorate in the future unless wastewater management is improved (MoE, 2002). It is important to notice in particular the rapid increase in the number of household-scale enterprises. In the mid 1990s, there were about 1,300 such establishments in Phnom Penh that were improperly built and lacked pollution control facilities (UNEP/MRC, 1997).

Already in some areas wastewater is causing water pollution in terms of both surface and ground water. Wastewater from various pollution sources such as homes, factories, enterprises, hospitals, livestock, floating houses and restaurants are being directly or indirectly discharged into the receiving waters (MoE, 2002).

Some of the waste is hazardous including waste from metal galvanizing factories, battery recycling/disposal, vehicle repair/disposal, pesticides storage/disposal, petroleum exploration, fuel oil storage and shipment, paint manufacturing, mining, leather tanning, hospital/medical facilities, garment manufacturing (certain dyestuff), and factories using organic solvents. Identified industrial pollution sources are dyeing and washing factories, factories consuming chemicals and tanning factories. Some of them have on-site wastewater treatment, and the rest discharge their effluents without treatment. (MoE, 2002).

Solid waste inventories have not widely been implemented in Cambodia, except a few places including the Phnom Penh Municipality. Table 9.14 indicates the fast growing volumes of solid waste.

Table 9.14: Estimates of solid waste per year in Phnom Penh Municipality, 1994-2000

	1994	1995	1996	1997	1998	1999	2000
Waste volume (m^3)	362,518	363,703	381,610	380,098	450,963	511,000	584,000

Source: (MoE, 2002)

Solid waste derives mainly from households (Table 9.15), but it should be noted that the industry sector is expanding rapidly, and that the type of solid wastes from housing and industries have different environmental impacts.

Table 9.15: Solid wastes in Phnom Penh Municipality by classification

Waste classification	Waste quantity (%)
Industrial	6
Commercial	25
Hospital	2
Residential	66
Agricultural	1

Source: (MoE, 2002)

Note: Data are from Office of Solid Waste and Hazardous Substance Management, 1999

With the exception of Phnom Penh, Sihanoukville and Battambang, solid waste collection is extremely patchy in all other urban areas (ADB, 2000A). Even in the cities mentioned, much of the solid waste is disposed into the water system as indicated in Table 9.16.

Table 9.16: Solid waste estimate for Phnom Penh

Solid waste (tons/day)	Collected (tons/day)	Uncollected (tons/day)	Disposed solid waste into water system (tons/day)
650	396	264	158

Source: (Chheng, 2002)

Note: Data from MoE and DEPC, 1999

Provinces and cities including Phnom Penh do not have special incineration plants for special wastes taken from hospitals and industries. All wastes, including hazardous wastes, are being discarded in the same dumping sites (MoE, 2002).

Chheng (2002) notes that many factories were built between 1950 and 1970 with old technology and without environmental considerations. Industrial wastewater management is very poor, few factories have wastewater treatment facilities, and the control of industrial wastewater discharge and enforcement of the law and regulations are not strict.

However, there are few industries and the situation is not urgent, with the exception of how to deal with hazardous wastes. No inventory of pollution discharges is currently available, making it difficult to estimate pollution problems. On the surface, the relatively small number of establishments classified as industrial should make it easy to gain headway through direct regulation. However, if the experience of other countries is to serve as some sort of basis, the combined pollution load of establishments classified as family-owned or handicrafts may be the significant contributor to pollution yet more difficult to manage by direct monitoring and law enforcement (ADB, 2000A).

Another pollution problem relates to the gemstone mining activities in the western part of the country. The field conditions, let alone the environmental impacts of gem mining operations around Pailin/Battambang, have not been assessed technically even if much anecdotal evidence suggests serious environmental impacts caused by sediment transport into the Tonle Sap Great Lake. Other areas where mining has potentially serious environmental implications are several sites in Ratanakiri province (ADB, 2000A). The potential pollution of heavy metals in connection to mining is also mentioned (MoE, 2002).

Another semi-industrial activity related to water resources is the rising demand for fuel wood for artisan production, especially bricks, which contributes to deforestation and changing water regimes.

Finally, considering transboundary issues there is, according to Cambodian Ministry of Environment (MoE, 2002), considerable potential for industrial pollution in transboundary waters from Thailand. Some concern is expressed that Cambodia might become a waste-dumping site for developed countries due to importation of by-products and second hand facilities into Cambodian territory (MoE, 2002).

9.3.3 Management measures

According to (BDP, 2002), a number of urban and industrial waste management measures have been prepared by the Ministry of Environment and enacted by the Royal Government of Cambodia: the Sub-Decree on Water Pollution Control (April 1999), the Sub-Decree on Solid Waste Management (April 1999), and Sub-Decree on Air Pollution Control and Noise Disturbance (July 2000). Corresponding Declarations to spell out implementing guidelines pursuant to the decrees have also been issued by the Ministry of Environment.

9.3.4 Water withdrawal

Urban water usage is estimated at about 100 litres per person per day, for a total average annual supply of 36 million m^3 to Phnom Penh, and of 15 million m^3 for other urban centres in Cambodia. The total water usage represents about 0.01% of the flow in the Mekong River (WUP, 2001).

9.3.5 Transboundary issues

It is assumed that most Phnom Penh wastewater transported to the Delta will travel via the Bassac River. However, with a distance from Phnom Penh to the Viet Nam border (about 110 km) and high water temperature (about 29^{o}C) in the Bassac River, the rate of decomposition of any organic matter discharged from Phnom Penh will be rapidly broken down and organic types of pollution are not likely to reach the border of Viet Nam (Hart, 2001).

9.4 Lao PDR

9.4.1 Industry

The industrial sector in Lao PDR is small. However, in recent years, manufacturing has played an increasingly important role in the economy, growing from 15.4 percent of GDP in 1996 to 16.8% in 2000. Although specific data on the contribution of textiles in this sub-sector are not available, textiles are considered to be one of the driving forces (ADB, 2001).

Also energy production and services (particularly tourism) are increasingly important to the national economy.

The vast majority of large and middle size industry and handicraft establishments are situated in the Vientiane Municipality. As illustrated in Table 9.17, a number of other provinces have large and middle-size establishments.

Table 9.17: Number of industry and handicraft establishments (selected provinces 1998-1999)

Name of province	1998		1999	
	Middle	Large	Middle	Large
Vientiane Municipality	134	60	140	64
Bokeo	8	-	21	-
Xayabury	33	-	34	-
Vientiane	46	1	48	4
Borikhamxay	22	3	31	7
Khammuane	8	18	11	18
Savannakhet	41	10	69	8
Saravane	19	-	18	-
Sekong	15	-	16	-
Champasack	53	6	53	6

Source: (SPC, 2000, Table 69).
Note: Large = number of employees more than 100 persons;
middle = number of employees between 10 and 99 persons

Table 9.18: Production of principal products that doubled production units between 1990 and 2000

Product	Units	1990	2000
Oxygen-Acetylene	Th.tubes	8	22
Soap	Th. pieces	100	400
Skin shoes	Th. pairs	-	520
Drugs	Mill. kips	659	3,800,000
Fan	Th. pieces	-	470
Vaccines	Mill.amp	2	7
Plastic goods	Tons	281	3,800
Wood and wood articles			
Lumber	Th.m3	78	200
Plywood	Th.sheets	1,000	2,100
Rattan Furniture	Mill.kips	94	13,270
Books	Mill.units	1	3
Textiles			
Clothing	Th.pieces	864	21,000
Articles of stone, cement, etc			
Bricks	Mill.pieces	21	67
Blocks	Th. pieces	-	700
Cement	Th.tons	13	80
Chalks	Th.boxes	75	250
Lime	Tons	289	600
Electric poles	Th.poles	5	25
Base metal articles			
Nails	Tons	114	720
Electric wire	Th.meters	254	2800

Source: (SPC, 2000, Table 68)

9.4.2 Waste

Vientiane does not have an effective sewerage system (Hart, 2001). All sewage and storm water is collected either in small open concrete or dirt channels that exist throughout most of the city, or in the newly constructed combined storm water-sewage pipe network that now runs through the city center and along the main roads. This pipe network connects to three main drainage channels that flow into the That Luang-Salakham wetland complex.

Some of the sewage and storm water which gathers in the large and deep channel now running through Nong Chan wetland (behind the Morning Market/Bus station) is pumped to a complex of six oxidation ponds built some years ago by the European Community (Hart, 2001). These each have a treatment capacity of 30,000 equivalent persons. The output from these ponds also flows to That Luang wetland. That Luang is a large wetland system (about 13 km long) located to the east of Vientiane. It now receives the entire wastewater load from the city since all direct outflows from the city to the Mekong River ceased around 1990. Outflow from the wetland drains to the Mekong via a 50 km river.

Since 1990, the size of the wetland has been reduced by drainage and agricultural expansion, seriously affecting its capacity to treat the continually increasing wastewater load from Vientiane (Hart, 2001). Additionally, the quality of the wastewater entering the wetland has deteriorated over the years as the channels that transport the wastewater to the wetland have had in-channel vegetation removed and been concrete-lined. During the dry season, the wastewater is almost pure sewage, but is more diluted in the wet season.

Hart (2001) has estimated that the total volume of storm water and sewage discharged annually to the Mekong from Vientiane is around 120 million m3; the volume of storm water is approximately double that of sewage. This compares with an annual volume of about 140,000 million m3 transported by the Mekong River at Vientiane, giving an annual average dilution of over 1000:1. Even during the dry season when flows in the Mekong River are much lower (e.g. mean flow at Vientiane in March = 1,190 m3/s), the dilution of the sewage is still around 800:1 (assuming most of the wastewater flow is sewage with little storm water).

Present development trends point to increased urbanization, rural to urban migration and expanding industrial and tourism sectors, which are anticipated to lead to exponential increased in waste related environmental problems for the country in the immediate future (ADB, 2000a).

Average urban solid waste production is 0.7 kg per capita per day, consisting of approximately 30% organic material, 30% plastic, 15% paper, and 25% glass, cans and other metals. Hazardous and toxic wastes such as batteries, old paint cans, aerosols, and other refuse are mixed with these wastes. (ADB, 2000a). A recent review of industries found that about 20 industries in Lao PDR caused significant but quite easily controllable pollution problems (UNEP/MRC, 1997).

9.4.3 Water withdrawal

An estimate of water usage is based on water production capacities. Total annual water production capacity of all urban water supply systems sourced from surface water in 1999 was approximately 60 million m^3, of which 60% was in Vientiane. The other significant capacities were in Luang Prabang, Pakse, and Khanthabouly, which were of the order of 4-5 million m^3 annually. The total water production capacity represents about 0.01% of the flow in the Mekong River. Actual water usage would be even less than this (WUP, 2001).

Water withdrawal for specific industries are estimated at 200 m^3/ton of product in the paper and pulp industry (only one in Lao PDR), and 5-10 m^3/ton in the food industry (Pedersen, interview, 2002).

9.4.4 Mines

Tin is mined 30 km north of Thakhek. The largest Laotian mining operation is located at the Dong Hen gypsum mines in the province of Savannakhet. Furthermore, a small-scale coal mine in the province of Vientiane produces about 1000 t of coal per year for domestic consumption. It should also be noted that there are known reserves of oil and gas in an area of more than 20,000 square km in the province of Savannakhet. There are also oil and gas reserves in Saravan and Cham Pasak (Hori, 2000).

9.4.5 Transboundary issues

Since the Mekong River between Vientiane and Khong Chiam is the border between Lao PDR and Thailand, potential transboundary issues could occur both in the immediate

vicinity of the discharge and further downstream. The distance from Vientiane to the Cambodian border is approximately 600 km meaning that organic matters discharged from Vientiane are not likely to reach Cambodia.

9.5 Thailand

9.5.1 Industry

Thailand is one of the world's major primary products and agro-industrial producers and is sometimes referred to as a NAC, a 'newly agroindustrialised country' (BDP, 2002a).

The industrial sector contributes more than 40% percent of GDP, of which manufacturing is more than 80%. Table 9.19 illustrates the economic activities as percent of GDP.

Table 9.19: Economic activity as percent of GDP, 2000

Sector	%
Agriculture	10
Industry	44.3
Service	45.7

Source: ADB, 2001b

On the employment side, three branches account for more than 60% of the total employment in manufacturing. However, the value-added from the same branches is less significant. See Table 9.20-

Table 9.20: Value-added and employment in manufacturing, 1994

Branch	Value-added Share in total (%)	Employment Share in total (%)
Food products	9.3	12.5
Textiles	8.0	16.5
Wearing apparel, except footwear	9.4	28.9

Source: www.UNIDO.org

Note: Based on data supplied by national sources with estimates by the Statistics and Information Networks Branch.

Most industrial establishments are situated in the greater Bangkok metropolitan region, whereas agriculture is still a major sector of the economy in the Thai areas of the LMB, contributing well over 20% of the regional GDP (BDP, 2002a).

Industrial activity in the Thai areas of the LMB is dominated by manufacturing (including agroindustry, but also some textiles, light assembly, rubber processing etc). However, despite its relatively poor industrial status in national terms, the Thai northeast and northern areas

remain by far the most developed areas of LMB in agricultural and agro-industrial terms. Medium and large local and national companies have made major investments in all types of food processing, animal feed production, wood products manufacture, fertilizer and other agrochemical production, and various sorts of agricultural equipment manufacture (BDP, 2002a). Nakhon Ratchasima has become the industrial centre of the Northeast, and may attract further industrial development, and the area around Khon Kaen too (UNEP/MRC, 1997).

9.5.2 Waste

As indicated in Table 9.21, industrial wastes are expected to grow accordingly with expansion of the sector. Over the next 10 years the pollution loading is expected to increase by 87%. Industrial development is also increasing the amounts of hazardous wastes. For example the generation of hazardous wastes in Northeastern Thailand is expected to increase by about 72% over the next five years (but this level represents only 1% of total hazardous waste generated in Thailand), (UNEP/MRC, 1997).

Table 9.21: BOD loadings in Thailand, 1991, (2001 and 2010 forecasted)

Factory type	1991	2001	2010
Sugar	154	321	566
Pulp and paper	103	233	444
Rubber	96	178	276
Beverages	91	171	274
Tapioca	40	87	157
Slaughter	15	19	22
Canned fish	11	20	32
Tannery	10	40	136
Canned Pineapple	4	6	7
Total	525	1,075	1,914

Source: (UNEP/MRC, 1997)

Note: BOD = Biochemical oxygen demand.
High BOD loadings imply oxygen low discharge water sources.

Pollution from factories has occurred in Nam Phong River in Khon Kaen province with a large impact on fisheries. Molasses leaked into the river in 1992 from the Khon Kaen Suger Refinery Factory, and the following year wastewater was released from the Phoenix Pulp and Paper factory. Other factories located along the banks of the Nam Phong River, including a factory affiliated to the Surathip Liquor group have released toxic waste into the river (Bangkok Post, 1998).

9.5.3 Water withdrawal

Water withdrawals are estimated to be 7% for domestic use and 3.5% for industry (ADB, 2000A) Competition and conflicts over water consumption between agriculture, industry, service sectors, and urban and household consumptions are increasing. Water is becoming increasingly scarce and the government faces supply-and-demand side challenges (ADB,

2000A). Domestic urban water supply in the Northeast Region of Thailand was estimated at 130 million m^3/ year during 1990 and estimated to triple by 2000 (WUP, 2001).

9.6 Viet Nam

9.6.1 Industry

Industry performance in the 1990s has seen strong growth followed by deceleration, and most recently, signs of recovery. During the strong growth phase (1993-1997), the industry and construction section grew in constant prices on average by 13.3 percent, and its share of GDP increased to more than 30 percent. However, although industry accounts for more than one third of GDP, it accounts for only 12% of employment (ADB, 2000b). The recent modest rise in industrial growth reflects the strong performance of the mining and quarrying sub-sector led by higher crude oil production. Manufacturing growth decelerated further in 1999 due to sluggish domestic demand (ADB, 2000b). Please refer to Table 9.22 and 9.23.

Table 9.22: Economic activity, percent of GDP

Economic activity	1995	1996	1997	1998	1999
Agriculture, forestry and fishery	26.2	25.1	24.2	23.8	23.9
Industry and construction	29.9	31.3	32.6	33.5	34.5
Service	9.8	8.8	7.1	3.0	2.1

Source: ADB, 2000b

Table 9.23: Economic activity, annual percentage change

Economic activity	1995	1996	1997	1998	1999
Agriculture, forestry and fishery	4.8	4.4	4.3	2.8	5.2
Industry and construction	13.6	14.5	12.6	7.3	7.6
Mining and quarrying	13.5	13.6	13.2	19.8	14.9
Manufacturing	13.5	13.6	12.8	9.2	7.4
Electricity, gas, and water supply	18.5	17.8	14.7	12.3	7.0
Construction	12.7	16.1	11.3	-0.5	2.4
Service	9.8	8.8	7.1	3.0	2.1

Source: ADB, 2000b

The signing in 2000 of the Viet Nam-US trade agreement gave substantial impetus to the production of agro-industrial products as well as increasing Viet Nam's exports. For example, the agreement lowers duties on food products, nuts, fruits and vegetables by three quarters (BDP, 2002a).

Viet Nam now has three major economic zones. The one in the south includes HCMC, Dong Nai, Vung Tau and Ba Ria, which are all located outside the Mekong Delta. Overall, the industry sector can be roughly divided into heavy industrial facilities (mostly located in

the north) and a heterogeneous and medium-scale light industry sector concentrated in the south (ADB, 2000a).

Manufacturing in the central region of the country is generally underdeveloped. With about 30 percent of the country's population, the region accounts for less than 10 percent of national industrial output (BDP, 2002a). However, goals presented in the Vietnamese Socio-Economic Strategy, 2001-2010 provide some prospects for development of processing industries, the energy industry and mining in the Central Highlands (BDP, 2002).

In the Mekong Delta provinces, industrial output is about 9% of the country's total (from 24% of its population) (BDP, 2002a). The Mekong delta has focused on agro-business, such as rice milling and polishing, breweries, beverages, and canneries. The rate of industrial development has been slow due to inconvenient land transportation (with ferries over the Mekong and Bassac rivers, and under-developed international river-ways (UNEP/MRC, 1997). However, the government's intention for the Mekong River delta (as evidenced in the '99 Decree') is to promote its role as the country's largest rice and agro product producer and to increase commodity production and raise quality cash food, vegetables and fruit (BDP, 2002a).

The 5-Year Plan for Socio-Economic Development, 2001-2005 presents the ambition of developing food processing, textiles, and chemical industries and to establish six concentrated industrial parks and set up small/medium industrial parks in Can Tho, Bac Lieu, An Giang and Ben Tre (BDP, 2002). According to researchers at Viet Nam National University in Ho Chi Minh City (Triet and Dan, 2002), aquaculture, fishery and fish processing in LMB are sectors with rapid economic growth. The seafood processing industry is the third most important export earner after raw oil and textiles. More than 400,000 people work directly in capture fisheries, and over two million people in support industries and related services. The general scale of aqua-fish processing industries in LMB are family scale (not surveyed) and medium scale (about 50 factories). The processing factories are located mainly in coastal provinces such as Kien Giang, Tra Vinh, Ben Tre and Bac Lieu.

9.6.2 Waste

Already, water pollution in Viet Nam is serious, especially in rivers and canals near urban centres. Most industrial wastewater is discharged without proper treatment. Hazardous wastes are generated by the fastest-growing sectors such as steel, electronics, and chemicals. Overall, there are no systems in place for the handling, storage, or treatment of hazardous wastes (ADB, 2000a). Also in the Delta, where development of industry has been relatively slow, existing industries have caused quite serious water pollution (e.g. organic contamination from breweries and canneries. Also, the development of heavy industries has been initiated with a steel rolling mill of 120,000 t/y capacity in Can Tho (UNEP/MRC, 1997).

Pollutants in wastewater from the aqua-food processing industry are high levels of biochemical oxygen demand (BOD), nitrogen and suspended solids. Livestock farms in LMB have caused pathogen contamination and BOD pollution (Triet and Dan, 2002).

9.6.3 Water withdrawal

In Viet Nam, water withdrawal to meet municipal and industrial water demands accounts for 10% of total water withdrawal. Growth in industry and the services sector is expected to range from 7 to 10 percent. However, agriculture will remain the main user of water, but by 2030 its share will drop to 75% with industrial and domestic consumption increasing to six

times its current withdrawal of water. Rapid growth in the industry sector requires increased use of natural resources, particularly water, (ADB, 2000a).

In industrial zones, most large firms build their own water supply systems independent of municipal systems, especially if their demand is large and they need a high quality, reliable supply.

Abstractions for urban domestic water supply in the Delta in 1990 were 52 million m^3, of which approximately 30% was from groundwater. All of the 33 million m^3 of rural domestic water supply and the 12 million m^3 of industrial water supply were supplied from groundwater. The total non-agricultural water supply is less than 1% of the estimated agricultural water supply. Groundwater abstractions for urban and rural domestic water supply were projected to double by 2000. Total projected domestic demand for the Delta in 2000 was estimated as 400 million m^3, and total industrial demand for 2000 was estimated at 230 million m^3. These figures are over six times the 1990 supply figures. Projections for 2015 are approximately double those for 2000 (WUP, 2001)

9.7 Sources for more information

Table 9.24 presents potential sources for further investigation and a few ideas for next steps for more in depth understanding of industrial sector water issues. For an overall assessment of LMB statistical bases, please refer to Table 9.25 imported from (BDP, 2002a).

Table 9.24: Ideas of potential sources for information on industrial water withdrawal and water related environmental impacts

Institution	Comments
General	
Authorities concerned with licensing industries	These would provide information about large-scale operations but not about the majority of companies, which are small or medium size.
Local and enforcing authorities	May be able to provide information on the "typical" company and its water use and pollution load
Sector specific industry associations	Some may have useful statistics
Economic sector statistics	Work backward from information on economic/sector data.
Ministry of Environment	
Department of Water Management	
National Statistical Office	
Research Centre for Water Environment Technology at the University of Tokyo	Projects cover all riparian countries. Objective to develop academic collaboration to achieve sustainable water environment in the Mekong region. Activities include prediction of potential pollution by industrialisation and identification of hazardous pollutant in the region.
Statisticians have been trained in National Industrial Statistics in Viet Nam at the General Bureau of Statistics.	For more information; UNIDO web pages
Asian Institute of Technology	
ADB	Water section
UNIDO	

Institution	Comments
	It is recommended to investigate in depth a few relevant industrial plants for water intake and water discharge pollutants and then do extrapolation (Tue Nielsen, interview, 2002).
Cambodia	
Ministry of Industry, Mining and Energy	Provides an industry directory of Cambodia from 1999. It covers up-to-date industrial data of 972 industrial establishments giving the present structure of the Cambodian industry. It further contains details on the Industrial Plan 1998-2003. There is supposedly also a directory of large and medium industries from 1996.
municipal/ provincial environmental departments	Small scale industrial establishments
Ministry of Environment	Urban environmental monitoring
Dept. of Pollution Control is responsible for controlling and monitoring factories, large-scale enterprises, hotels and hospitals.	JICA is involved in data collection at provincial level in cooperation with DEPC. Report on the current situation of solid waste management in Cambodia prepared in collaboration with JICA, July 26, 2001
Ministry of Public Works and Transport (waste management division) in each province including the municipalities of Phnom Penh and Sihanouk Ville.	Solid waste issues
Royal University of Phnom Penh, Department of Environmental Science	
MOWRAM	
Cambodia Development Research Institute (CDRI)	
Lao PDR	
	ADB, UNDP and the World Bank are working in the water resource sector in Lao PDR
Ministry of Industry and Handicrafts, Department of Industrial Management	Deals with industrial waste water treatment
Thailand	
Department of Pollution Control	
Thailand Development Research Institute (TDRI)	
Committee of water resources	
Viet Nam	
Viet Nam National University HCM City CEFINEA, Institute for Environment and Resources	
National Water Resources Council	
Ministry of Agriculture and Rural Development (MARD)	

Table 9.25: Major features of LMB countries' statistical base

	Major characteristics of statistical / data collection, storage, publication and access
Cambodia	Very small statistical base, almost nothing at provincial levels apart from agriculture and demographic data. No industry data at all (survey 10 years old). One-off publication of National Yearbook with ADB support. Good macro and trade/investment data from MEF. No web site functioning yet; publications available in Phnom Penh in limited quantities
Lao PDR	Basic statistical collection (by line ministries) and compilation (by National Statistical Centre) from village to district to province. Only agriculture and demographic data (plus some social stock) at provincial level. Problems with industry and enterprise statistics, and estimation of national GDP. Some provinces publish annual summaries across sectors and topics; most do not. Good range of one-off surveys (e.g., LECS, Business Tendency etc), about to be incorporated into poverty-focused rolling programme, including usual 10-year census No web site functioning yet; publications easily available in Vientiane.
Thailand	Comprehensive range of provincial-level data, especially annual provincial summaries (available via NSO computer in different format). Regional summaries now discontinued, so Changwat compilation may be unavoidable. Rolling programme of surveys and censuses LMB and nation-wide. Good website, with a lot of data available in Excel – some only in PDF – and publications can be ordered.
Viet Nam	Comprehensive national and provincial data set, although classifications of economic origin and ownership are outdated. Doubts about methodology used in compilation of any provincial level figures – thus utility of District-level analysis is questionable. Major differences in published data between national GSO and Provincial sources. BDP best to use provincial estimates of sector-level activity from annual yearbook. Reasonable publications range and access; limited materials available on CD. Effective non-functioning of website.

9.8 Conclusion

9.8.1 Information gaps

For this review, information was more easily available on Cambodia than on the three other countries. For the next step, more coverage on specific industries with wastewater pollution potentials may be collated, and an improved understanding of the pollution scale and the social and environmental impacts obtained. A discussion on the value-added of water uses between sectors may also be included in further studies.

9.8.2 Driving forces related to industrial development

The driving forces for industrial development in Lao PDR, Cambodia and Viet Nam are considered to be further economic reforms, anti-corruption measures and political stability. The economies of Cambodia and Lao PDR are most vulnerable to trends in the regional and world economy and to interest from foreign investors via Foreign Direct Investments (FDI). Economic development in China as a world market export competitor but also as a potential source of regional investments will influence the type and extent of industrial development in the LMB.

9.8.3 Major water related issues

For the industrial sector, water quality rather than water quantity is the key issue. Overall, the water quality of the Mekong River and its tributaries is still considered healthy. However, as industrial wastewater treatment facilities are inadequate, spot pollution is common and with more industrialisation, large-scale water quality deterioration may be expected in the foreseeable future. Furthermore, accidental pollution from events such as oil spills flowing into the Tonle Sap in the wet season may be detrimental to the ecology of the lake.

Industrial water withdrawal is considered low. However, if and when conflicts over water withdrawal occur, the presumption is that water for the industrial sector provides more value-added than within the agricultural sector. Hence, water withdrawal for industries may be given higher priority.

9.8.4 Hot spot issues

Based on this review, it is considered important to follow the trend in the textile industry in the LMB considering the disposal of dyeing stuffs in particular. With regard to specific hot spot locations, downstream areas adjacent to Vientiane and Phnom Penh are considered critical as well as downstream areas of Northern Thailand (industrial towns such as Khon Kaen and Nakhon Ratchasima). Mining activities around Battambang in Cambodia may have negative repercussions on the Great Tonle Sap Lake.

9.8.5 Transboundary aspects

The Mekong River represents the border between Thailand and Lao PDR. Downstream of Vientiane, industrial development and polluted wastewater discharge is likely to have transboundary repercussions. Furthermore, if major incidences of polluted wastewater discharge occur from industries in Northeastern Thailand there may be negative impacts on the Mekong downstream of Pakse in Southern Lao PDR. Polluted wastewater discharge from industries is likely to have negative water quality impacts on domestic water, irrigation water for agriculture and for fisheries.

9.8.6 Monitoring indicators

To monitor the trend of industrial water withdrawal and wastewater discharge it will be necessary to monitor the development of specific critical industries (i.e. there number, scale and location) and to collect samples of water quality at specific locations.

10 Flood management and mitigation

Floods are a recurring event in the Lower Mekong Basin (LMB). Each year, flooding results in loss of life and property, damage to agriculture and rural infrastructure and disrupts the social and economic activities of people living throughout the LMB. At the same time, flooding of the mainstream and tributaries of the Mekong River is an important reason for the wealth in biodiversity, abundance of fish and soil fertility.

Flood management and mitigation (FMM) has become a priority issue at the national and regional levels within the LMB, particularly in the aftermath of the disastrous floods of 2000 and 2001. This regional overview summarizes the characteristics, issues and trends affecting flooding and the roles and orientations of the different national and regional "players" promoting more effective and integrated approaches to FMM.

10.1 Nature and extent of flooding in the LMB

Throughout the LMB, climate - particularly the southwest monsoon – is the immediate cause of the annual floods. The level of the Mekong starts to rise at the beginning of the southwest monsoon 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. However, the flood patterns of Cambodia, Lao PDR, Thailand and Viet Nam are very different with respect to sources of flooding and effects, rising speed, time and duration of flooding, frequency and extension of the inundated area.

In Cambodia, the Mekong enters into the lower part of the delta and becomes a slow flowing river. The area is very flat and flooding is generally related to the main river system. The dynamic river junction at Phnom Penh, where the Mekong bifurcates into the Bassac and the Lower Mekong and where the Tonle Sap River begins, is an indication of the complexity of the river system.

The Tonle Sap River and the Great Lake (Tonle Sap) have a significant effect on flood flows and flood level in Cambodia and downstream in Viet Nam. 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 some 150 billion m^3. During the flood season, the water surface of the lake expands from 250,000-300,000 ha (dry season area) to 1-1.4 million ha.

Flooding in Cambodia covers large areas. There is extensive lateral flow of flood waters as the Mekong annually overflows its banks from Kratie to the border with Viet Nam. Bank overflows also occur along the entire length of the Tonle Sap. Following heavy rainfalls, surface runoff often flows parallel to the river, filling land depressions lateral to and between the two rivers. Moreover, because of the low elevation of the whole delta, the tidal motion of the sea is transferred up the river with a tidal effect felt up to Phnom Penh.

The wet season in this portion of the LMB occurs from June to November with flood flows in the Mekong-Bassac system peaking in September and October. Each year up to 4 million ha of lowland areas are inundated (including the Great Lake), or 37% of the territory of the country.

In Lao PDR, floods generally result from heavy monsoon rainfall, combined with the occurrence of typhoons. 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 lowland areas. A feature of floods in Lao PDR is that they are very much influenced by tributary flows. According to MRC estimates, 80% of the rural flooding and 20% of the urban flooding is caused by tributaries.

The four major flood prone areas in Lao PDR are situated along the mainstream near large tributaries: Vientiane Plain, Khammoune Province (Thakhek town), Savannakhet Province and) Champasak Province (Pakse town). The peak flood period in Lao PDR begins in July and lasts until late August. In 2000, serious flooding in Lao PDR affected approximately 500,000 ha.

In the portion of the Mekong Basin in Thailand, flooding results from tropical disturbances, typhoons, or a combination of the two. The heavy rainfall on the Lao PDR side swells the Mekong River, which bursts its banks or creates severe flooding conditions along the tributaries in Thailand from 'backwater' effects. Flooding in the tributary basins in Thailand is often severe. Urban areas along the mainstream are regularly flooded. Dykes have been constructed along the Thai side of the Mekong around urban areas to provide flood protection.

The principal flood prone areas of the LMB within Thailand include low-lying areas along the Mekong and tributaries, particularly in Nong Khai, Mukdahan, Nakhon Phanom and Ubon Ratchasima Provinces. Flooding affects over 500,000 ha in the basin in Thailand. The peak flood period lasts from early August to early September.

In Viet Nam, the Mekong River forms a highly fertile and productive delta. In the later stages of the monsoon season, tropical typhoons produce long-lasting heavy rainfall by interacting with the monsoon. Flooding in the delta is highly influenced by tidal effects from the South China Sea, combined with high discharge from the Mekong River coming from upstream Cambodia and heavy rain in the delta itself. Flooding in the delta often results in an almost complete inundation of the flood plain. Regulating structures hold back the flood waters in some areas during the early floods, but high floods cause extensive damage.

Flooding in the delta frequently inundates up to 1.8 million ha, or 47% of the land area in the delta. Flood levels generally occur from July through the end of November, with the peak period in September.

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.

10.2 Causes and contributing factors of 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. Flooding can occur due to river overflow or surface runoff. Heavy local rains throughout the region and typhoon-induced surges of water in the Mekong Delta contribute to the overflow of riverbanks. In addition, a range of natural and man-made factors presently affect flooding.

Climate change: Climate change, particularly global warming effects, is believed to be a contributing factor to increased frequency and intensity of severe flooding. Increased rainfall amounts and sea-level rises will result in greater risk of flooding in low-lying coastal and estuary areas. Warming of the water temperature in the South China Sea would result in an increase in the number and intensity of typhoons causing sea surges that would also

contribute to inundation of low-lying areas. Some estimates indicate that 15,000-20,000 km^2 of land in the Mekong Delta are threatened[189].

Deforestation: Deforestation, particularly in the upland and remote areas of the LMB can have significant consequences for flooding. The causes of deforestation include widespread harvesting of fuelwood for household energy, mismanaged and illegal logging and extensive conversion of forest land to agricultural and other uses. The direct results of deforestation include increased volume and speed of surface run-off, which in turn cause increases in peak discharges and peak water levels. Deforestation and land clearance as a cause of floods is more pronounced for small and medium sized floods and along tributaries (rather than the mainstream) of the Mekong.

Land degradation: In areas where forest have been cut to create more agricultural land there is often a process of land degradation that can cause (or exacerbate the risks of) flooding. In these areas, intensive shifting cultivation, shortened fallow periods and agricultural systems that are not adapted to topographic and soil conditions lead to increased erosion and sediment deposit in rivers. Sedimentation of the mainstream channels of the Mekong can dramatically reduce drainage capacity contributing to increased flood hazards at a regional scale.

Changes in flood storage capacity: The construction of flood embankments and other man-made structures designed to protect areas along the Mekong result in a loss of natural flood plain 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 flood plain storage that causes increased discharges and flood levels both upstream and downstream.

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

Rapid expansion of urban settlements and infrastructure: Increased urbanization replaces natural vegetation with sealed surfaces like roads, 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 – 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.

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. Similarly, dredging and other modifications to river channels can change the characteristics of water flow, erosion and sedimentation, affecting peak discharges during flood season.

Reservoir operation: During the First Annual Flood Forum in 2002, representatives from Cambodia and Viet Nam identified the presence and the operation of reservoirs as a contributing factor to Mekong floods.

[189] IPCC, n.d.

10.3 Economic and social costs of flooding

The 2000 floods were the worst in the region in 40-50 years. These high levels in 2000 were followed by serious floods in 2001 and, some early reports suggest, in 2002. This section summarizes data on the economic and social costs of flooding in these years. Also, the extensive documentation of the costs of the 2000 floods provides a vivid portrait of the direct and indirect economic and social consequences of flooding.

10.3.1 Summary of flooding costs 2000-2002

Year 2000

Cambodia: Severe flooding affected 22 of the 24 provinces in Cambodia. The official figures of the Royal Government of Cambodia (RGC) put the death toll at 347 people, of whom 80% were children. A total of 760,000 families (over 3.4 million people) were affected, with 85,000 families (387,000 individuals) temporarily evacuated from their homes and villages. The RCG estimated the total physical damage at US$161 million.

Lao PDR: Flood levels reached unprecedented levels on the mainstream and tributaries in the central and southern provinces and remained at high levels for long periods. Preliminary estimates (WFP, October 2000) 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). Fifteen people died directly related to flooding. At the time of publication of this report there was no information about disease outbreaks.

A total of 80,000 ha of rice fields were flooded and an estimated 10% of the wet season production completely lost. Irrigation systems and rural road infrastructure were widely damaged, as well as large parts of provincial towns that remained under water for more then one week. Production losses of approximately US$20 million were reported in Lao PDR (MRC, 2001).

Thailand: Production losses of about US$21 million were reported for the portions of Thailand situated (MRC, 2001).

Viet Nam: In the Mekong Delta, more than 500 people died. As in Cambodia, most were children. A total of 5 million people were affected by flooding. About 825,000 homes damaged or destroyed and 60,000 households had to evacuate their homes. Agricultural production in the delta was seriously affected – 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 in the Vietnamese delta amounted to US$285 million.

Year 2001

Cambodia: Sixty-two people drowned or were killed of which 70% were children. Flood damages were estimated at US$36 million.

Thailand: A total of 192 people were reported killed. Ubon Thani was particularly hard hit, with 2.8 million people affected (727,600 households); 47,350 km² of farmland inundated; and 5,300 km of roads damaged. The total value of damages was estimated at US$48 million.

Viet Nam: Two hundred thirty people drowned in the delta including 180 children.

Year 2002

Viet Nam: As of late September 2002, floods covered half of the 12-province delta region, affecting about 270,000 people. A total of 71 people had died due to floods including 65 children. Although 112,000 people were in urgent need of food relief, most of the rice crop has not been affected thanks to an early harvest. About 54,000 houses had been flooded and nearly 700 km of roads submerged.

Impacts of floods on socio-economic development, Cambodia 2000

Detailed analysis of the 2000 floods in Cambodia demonstrates more fully the extent of immediate and longer-term impacts on different aspects of socio-economic development, including costs that were not included in government estimates of total damage[190]. Cambodia provides a good example of the kinds of social and personal costs that are not taken into account in straightforward economic measures of flood damage. It would be useful if national overviews for Lao PDR, Thailand and Viet Nam could provide a similar analysis to the one presented here.

Production and food security: The production of rice, other food crops and livestock were severely affected in 2000, with consequences for food security as well as cash income generation among rural households. The significance of the impacts is both immediate and longer-term.

- More than 600,000 ha of paddy were flooded, of which 350,000 ha were completely destroyed. Approximately 20% of the area in rice production in 1999 was destroyed during the 2000 floods in Cambodia. Another 20% was flooded for prolonged periods. Wet season rice accounts for about 85% of total rice production. At the end of the 2000 flood season, there were predictions of significant food shortages (44,000 tons) in 2001.

- Non-rice and cash crops represent 20% of agricultural production in Cambodia. In 2000, flooded and destroyed crops accounted for about 4% of agricultural output. However, the reported losses do not include unreported home consumption from fruit trees and non-rice crops. In addition, damaged fruit and other trees take six months to several years to regrow (depending on the species).

- Large livestock (cows, oxen and buffaloes) are valuable not only for consumption, but also as a form of savings and as animal labor. In 2000, the loss of livestock during the floods was relatively small. However, loss of grazing land and the lack of feed mean that in the months following the flood season, many large animals die of starvation or are sold very cheaply as farmers can not feed them.

Infrastructure and services: The RCG estimated that the costs of repairs to roads, bridges, river banks and irrigation systems damaged in 2000 would exceed US$70 million. The damage to the economy, however, is much greater than just the cost of restoration and repairs. 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.

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[190] Most of the information in this section comes from: Chan Sophal, 2001. "The Impact of Cambodia's Recent Floods", Cambodia Development Review, Vol. 5, Issue 1, January-March 2001.

Housing and community infrastructure were also lost in the floods. More than 300,000 houses were flooded and 7,000 were severely damaged or collapsed. Official government figures for flood damages do not include the costs to households of repairing or replacing housing. Damaged hospitals and clinics seriously limit availability of health services during floods, at a time when the risk of flood-related diseases is high.

Other economic and socio-economic consequences: Major floods have significant effects on overall levels of national economic growth. In Cambodia, it is generally agreed that the 2000 floods reduced GDP growth by 1.0%, from predicted levels of 5.5% to about 4.5% for the year.

The impacts of flooding on the poor are very significant. More than 90% of people living below the poverty line reside in rural areas. In Cambodia, rural households have, on average, one hectare of rice land. Therefore, the loss of 350,000 ha of paddy during the 2000 floods means that a very large number of households lost their primary asset for assuring their own food security as well as 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.

Children frequently lose many weeks of education as schools are flooded or damaged. In the Vietnamese delta (data are not available for Cambodia), 834,000 children were forced out of their schools during the 2000 floods. Earlier during the 2002 season in the Viet Nam delta, more than 100,000 children were unable to attend school for more than a week.

10.4 Environmental and social issues

10.4.1 Environmental benefits of floods

Flooding of the Mekong River and its tributaries is an important source of the wealth of biodiversity, abundance of fish and soil fertility in the Basin.

Soil fertility: Flooding of agricultural land causes periodic silt deposits that add nutrients to the soils. Throughout the LMB, flood recession agriculture is practiced to grow vegetables and other crops that are a source of food and cash income for rural households.

Ecological health of the river system: Flooding also serves to filter or dilute pollutants that enter the mainstream and tributaries, flushing nutrients in the river system, preserving wetlands and recharging groundwater.

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.

10.4.2 Negative impacts

Adverse environmental impacts result from flooding as well as the social and socio-economic costs.

Environmental impacts:

- Flooding in low-lying delta areas can increase salinization of groundwater and soils, leading to freshwater shortages and deterioration as well as reduced agricultural productivity.

- Erosion and increased salinity due to floods can damage tidal wetlands and coastal mangrove forests that are critical breeding grounds for fish and prawns.

- Flooding causes erosion of topsoils that can lead to long-term loss of agricultural productivity of lands and their eventual abandonment.

- Flooding can have negative effects on water quality and aquatic habitats elsewhere.

Direct social and socio-economic impacts:

- Major economic flood-related losses affect the agricultural sector resulting from the flooding of crops, loss of livestock and damage to perennial fruit trees, industrial crops and plantations.

- Loss or damage to industrial, commercial, communications facilities related to economic activities.

- Loss or damage to housing, water supplies, schools, health facilities, other community structures.

- Loss of life and loss or damage to public and private property.

- Damage to roads, bridges, irrigation infrastructure.

- Loss or submersion of crop storage facilities.

Indirect social/socio-economic impacts:

- Lost educational opportunities for children.

- Increased health risks associated with the lack of adequate water supply and sanitation, as well as adequate, accessible health facilities during and immediately following floods.

- Increased exposure to disease and possible death from water borne and vector borne diseases, venomous snakebites, etc.

- Increased risk of poverty due to lost income; forced sale of land, livestock or other assets, etc.

- Increased rural-urban migration of flood-affected people associated with search for work, loss or sale of agricultural land, etc.

- Loss of household income due to direct flood losses (crops, livestock, etc.); lost income from non-farm employment; costs of repairing houses and equipment; unforeseen food, health, transport and other costs.

- Disruption to social structures and systems and increased stress-related problems related temporary displacement of people and communities, concerns about individual and family well-being, etc.

- Lower overall economic performance at the local and national levels associated with decline in the production of businesses and industrial enterprises, inflation, unemployment; disruption and loss of revenues in non-agricultural sectors such as tourism and navigation; and higher government outlays for flood relief, repair and rehabilitation (direct expenditures, debt financing, reallocation of funds, etc).

10.4.3 Trends

A number of aspects of flood management and mitigation are likely to change in the coming years. These include increased frequency of occurrence and intensity of Mekong River floods; increased risks and impacts of exposure to flooding; and increased linkages between flooding and other water and water-related sectors. The factors affecting these changes include population growth and urbanization in the flood plains, climate change and the continued effects of changes in land use and other human activities. Some of these trends and associated issues include:

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. 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.

Increased flooding in low-lying coastal and estuary areas: Increased flooding related to climate change will affect low-lying estuary areas in the Mekong Delta. Changes that may occur include altered flow of estuaries, coastal rivers and wetlands and increased erosion and salinization of tidal wetlands and coastal mangrove forests.

Population growth and increased urbanization: Many major and secondary urban centers are located on the Mekong flood plains. Population growth through natural increase and in-migration to these centers will result in an expansion of the area of residential development, other buildings and roads in the urban centre and the surrounding areas. The loss of flood plain storage capacity will increase the severity of the direct effects of flood events as well as the economic and social consequences.

Rural development issues: National policies to diversify agriculture in the Mekong flood plains include higher value commercial agriculture. This includes expansion of irrigation systems in some areas, which increases the economic risks associated with exposure to floods. If countermeasures are not successful, increased population pressure in upland areas will contribute to the intensity of flooding.

Reduced capacity to cope with floods: If (or as) the frequency of severe flooding increases, there are risks of a reduced capacity to cope with floods at the national, community and household levels due to the cumulative social and economic effects of flooding. For example, recovery 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) was not fully re-established.

10.4.4 'Hot spots' and transboundary issues

With respect to flood management and mitigation, hot spots and transboundary issues tend to be inter-related. The areas that are most severely affected by flooding are Cambodia and Viet Nam, the downstream countries. In general, what happens in an upstream country may affect flooding conditions in its downstream neighbor. 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 of the Basin. In terms of flooding, Northeastern Thailand is also "downstream" of flood season discharges from the tributaries in Lao PDR.

Another hot spot, this time with respect to the environmental benefits of flooding, may be the relation between flooding and fish breeding in Tonle Sap Lake. The concern is that if the management of upstream dams (or other water regulating structures) results in a reduction in flood season flows in the Mekong, there will be significant negative consequences for the ecological role of the lake.

Other hot spots may emerge due to human interventions that increase the risk of more severe flooding through loss of flood plain storage capacity particularly in areas of the Mekong flood plains being developed for higher value uses. Whether these hot spots constitute a transboundary flood management issue will depend on their location and the degree of cumulative impact.

10.5 National strategies and investment

Each of the riparian countries has national institutional structures and strategies for flood management and mitigation. Available information is also summarized about specific country-oriented ongoing and proposed projects and investments for flood management, particularly in Cambodia and Viet Nam. [N.B. There appear to be no multilateral or bilateral initiatives in Lao PDR and no multilateral initiatives in the Thai portion of the LMB. National sector overviews for these countries should attempt to obtain any available information about national projects or programs.]

Cambodia

In 1995, the Royal Government of Cambodia (RGC) established the National Committee for Disaster Management (NCDM) to oversee management of natural and human-made disasters. The mandate of the NCDM reflects the priorities of the RGC for emergency management; that is, to coordinate plans and implementation frameworks at national and sub-national levels; to promote the development of national policies, legislation, plans and procedures for emergency management; to strengthen institutional resources; to develop public awareness programs and promote community participation in disaster management; and to collect, analyze and disseminate relevant data.

The NCDM carries out its work in close collaboration with international and other organizations concerned with flood management in Cambodia, such as the International Federation of the Red Cross (IDRC), the Cambodia Red Cross (CRC), UNDP, the World Food Program (WFP) and various national NGOs. An initial National Policy on Emergency Management was developed in 1997 with technical assistance from UNDP. The scope of this policy includes hazard analysis, emergency preparedness, emergency response and disaster mitigation.

The role of NCDM in short-term measures for flood preparedness and emergency management prior to the 2002 floods were identified at the First Annual Flood Forum and included: public and community awareness on flood dangers (Stung Treng, Kratie, Kampong Cham, Prey Veng, Kandal, Phnom Penh and Takeo); identification of "safe havens"; mobilization of speedboats and stockpiling of essential supplies; strengthening flood protection dykes; preparation of a disaster intervention plan; and mobilization of international and private sector assistance. Longer-term initiatives for land use planning, structural measures, flood preparedness and emergency management will be coordinated with different donor agencies and the MRC.

Cambodia is widely recognized to be among the most flood-prone countries in Asia. Donor agencies and international organizations have focused their assistance on providing support to strengthen the capacity of the RGC and NCDM to carry out flood management and mitigation and to rehabilitate infrastructure damaged in the 2000 floods. The following include ongoing and proposed initiatives.

UNDP Capacity Building (ongoing): Since 1997, UNDP has been providing assistance to NCDM to develop the National Policy for Disaster Management and to carry out institutional strengthening at NCDM.

Emergency Flood Rehabilitation Program (ADB; ongoing): In late 2000, the ADB approved a program to assist Cambodia to repair and rehabilitate road, flood control and irrigation and other infrastructure damaged in 16 provinces during the 2000 floods. Of 200 flood control and irrigation systems damaged in the floods, the repair of over 100 will be included in the ADB program (the remainder are being financed by the World Bank, see below). The project will also rehabilitate the major dyke control systems protecting Phnom Penh. The program costs of US$83 million will include a new loan of US$55 million and reallocation of funds from existing loan programs.

Cambodia Flood Emergency Rehabilitation Project (World Bank; ongoing): In 2001, the World Bank approved a US$35 million loan to Cambodia. The three-year project encompasses rehabilitation of national rural roads, school facilities, flood control and irrigation systems. The flood control and irrigation component of the project includes 90 schemes that were damaged in the 2000 floods, covering about 57,000 ha in 14 provinces (Takeo, Kampong Cham, Svay Rieng, Prey Veng, Battambang, Kampong Thom, Kratie, Kampong Chhnang, Kandal, Pursat, Kampot, Siem Reap, Koh Kong, Krong Kep).

Social Fund II Supplemental (World Bank; ongoing): The Cambodia Social Fund finances small-scale projects. In 2001, the World Bank allocated US$10 million as supplemental funding under an existing Social Fund II to finance repair and rehabilitation of small-scale infrastructure damaged by the 2000 floods.

Natural Disaster Management Study (World Bank; proposed): As part of the Flood Emergency Rehabilitation Project, the World Bank is currently developing terms of reference for a study to support development of a long-term strategy to reduce vulnerability to flooding in Cambodia. The objectives of the study are to increase awareness of the social and economic costs of natural disasters and the need for effective disaster management programs and to develop a pipeline of lending projects in natural disaster management programs.

Study on Floodplain Management in the Mekong River Basin, Cambodia (JICA, proposed): A 24-month study is proposed to begin in 2004 to meet objectives to investigate and clarify flood conditions such as inundation depth, duration and damage and to formulate a master plan for flood management. The master plan will cover the flood plain of the Mekong River Basin downstream from Kampong Cham to the Viet Nam border, the Tonle Sap River Basin

downstream from the outlet of Great Lake and the Bassac River Basin (48,000 km^2). The master plan (Phase 1) will be prepared in parallel with and ensuring consistency with the MRC Flood Management Program (FMP). It will identify priority structural and non-structural measures based on assessments of flood conditions in the study area. Phase 2 will carry out feasibility studies for priority projects.

Lao PDR

In early 1999, the Government of Lao PDR enacted the Environmental Protection Law that provides the legal basis for natural disaster prevention and protection (Articles 17-19). In the same year, the Government also established the National Disaster Management Office (Decree No. 158/PM, August 1999). The National Disaster Management Office is mandated to coordinate disaster prevention and protection within the country in collaboration with line ministries and departments at the national and provincial levels.

The proposed strategy of the Government of Lao PDR regarding disaster management includes the following actions: expand disaster units to all levels of government; establish a legal framework (regulating rights and duties in the case of emergency); improve communication systems and upgrade equipment; establish a social welfare fund for victims of disasters; and provide sufficient funds for research and early warning systems. An integral part of the strategy for FMM relates to Government policies and initiatives to reduce shifting cultivation in upland areas and providing training on permanent cultivation and other sustainable land use and management practices.

In Lao PDR, short-term government measures identified by representatives to the First Annual Flood Forum are similar to those in Cambodia. Longer-term measures include improved land use regulations in flood prone and catchment areas (Vientiane, Luang Prabang, Khammuane, Savannakhet, Pakse); a range of structural measures along the Mekong and major tributaries; and continued development of capacity in the areas of flood preparedness and emergency management.

In preparing this regional overview, no investment projects specifically targeting flood management and mitigation in Lao PDR were identified.

Thailand

The Civil Defense Act 1979 is the most important legislation in Thailand related to disaster management including flooding. The Act clearly prescribes jurisdiction for different types of disaster situations and the responsibilities of concerned organizations and sets out a systematic process for disaster management.

A master plan for disaster management, or National Civil Defense Plan, is prepared by the Office of Civil Defense Secretariat (OCDS). The Plan identifies three stages of disaster management: the pre-disaster stage to deal with structural and non-structural mitigation and preparedness measures; the disaster response stage to provide emergency assistance; and the post-disaster stage to deal with rehabilitation and reconstruction activities. The National Civil Defense Plan is submitted to the National Civil Defense Committee (NCDC) for approval. The Plan is updated every three years. All functional agencies have a duty to prepare their own disaster management plans in conformity with guidelines set out in the Plan.

According to the National Civil Defense Plan, the NCDC has the responsibility to formulate measures and policies related to natural and man-made disasters. The OCDS is responsible for implementing the disaster management policies and measures of the NCDC. It also has a

mandate to provide equipment and tools, technical assistance and training courses to local agencies; and to coordinate with other agencies concerned with disaster relief and rescue operations.

Operational agencies for disaster management are classified as three types: Emergency units provide immediate response to disasters; municipal civil defense centers, sanitary districts and Tambon Administrative Organizations (TAO) work as emergency units in provinces. Main units respond to emergencies beyond the ability of emergency units; district civil defense centers work as main units in provinces. Supportive units provide manpower, rescue equipment and tools and technical assistance to emergency or main units; provincial civil defense centers, NGOs, regional civil defense centers and the armed forces work as supportive units in the provinces.

In Thailand, short-term government measures identified by representatives to the First Annual Flood Forum are similar to those in Cambodia and other countries. Longer-term measures include improved land use regulations in flood prone and catchment areas; a range of structural measures; and continued development of capacity in the areas of flood preparedness and emergency management.

In preparing this regional overview, no investment projects specifically targeting flood management and mitigation in Thailand were identified.

Viet Nam

The Viet Nam Central Committee for Flood and Storm Control (CCFSC) is the chief coordinating body responsible for disaster management in Viet Nam. The CCFSC has ministerial status and is headed by the Minister of Agriculture and Rural Development. It is responsible for monitoring and releasing information and data related to floods and other adverse climate events. It also prepares a flood and typhoon prevention plan each year as a basis for the allocation of budgetary resources. The Hydro-Meteorological Service is responsible for forecasting.

The CCFSC works in close collaboration with the UNDP and other international organizations. In 1994, CCFSC and UNDP jointly established a Disaster Management Unit (DMU) with the CCFSC. The DMU has provided disaster management, communications and assessment training programs for provincial and district officials throughout the country; set up a reference centre and central database on disaster management with the use of Internet and GIS technologies; and provided funding and expertise for the establishment of a nation-wide disaster communications network.

The CCFSC pursues FMM through a combination of structural and non-structural measures. It is responsible for an ongoing program of maintenance and upgrading of the dyke system in Viet Nam. The CCFSC-DMU undertakes a range of non-structural emergency preparedness measures, often in collaboration with other organizations such as the IFRC and the Viet Nam Red Cross Society (VNRC). These are part of a policy of "Living with the Floods". One of the most successful initiatives has been a community-based grassroots disaster preparedness-training program for school children. Others include educating villagers in the delta to adopt a new cropping calendar (to avoid losses during the flood season); construction of 2-storey schools in flood prone villages, developing "hospital ships" to sail the canals; and redesign of villages with dyke-defended housing in the provinces most exposed to flood risks.

Disaster management is a priority of the Government's development agenda. In 1994, the Government prepared its first *Strategy and Action Plan for Mitigating Water Disasters in Viet Nam*. It was based on the themes of forecasting and warning, prevention, preparedness and emergency relief. In 2002, the CCFSC prepared the *Second Strategy and Action Plan for Mitigating Water Disasters in Viet Nam, 2001-2010*. It gives renewed attention to improved forecasting and early warning systems, to identifying better targeted prevention and reconstruction activities at all levels of government and to developing more effective systems of emergency social relief to help vulnerable communities.

Short-term government measures identified by representatives to the First Annual Flood Forum are similar to those in Cambodia and other countries. Longer-term measures include improved land use regulations in flood prone and catchment areas; a range of structural measures; and continued development of capacity in the areas of flood preparedness and emergency management. Other initiatives funded by the World Bank are ongoing or proposed.

Mekong Delta Water Resources Project (World Bank; ongoing): This project aims to improve water resources infrastructures in five subproject areas over the period 1999-2004. A priority issue in the Omon-Xano subproject, located in the mid-delta, is to improve flood control and drainage.

Natural Disasters Mitigation Project (World Bank; proposed): The World Bank proposes financing of projects in three priority areas affected by natural disasters (flooding, drought, earthquakes), namely the Red River-Thai Binh River Delta, Central Viet Nam and the Mekong Delta. The 6-year project scheduled to begin in 2004 will consist of four components: structural and non-structural measures, pilot projects for community based disaster management; contingency funding for reconstruction; and institutional coordination, capacity building and strategic studies. Structural measures may include stabilization of riverbanks, strengthening of river and sea-dyke systems, river flow capacity improvements and construction of diversion channels. Non-structural measures would include flood plain and hazard mapping, flood forecasting and modeling systems, review of building codes and design standards and weather forecasting and early warning systems. Strategic and policy studies will support reduction of long-term vulnerability to natural disasters.

Other multilateral and bilateral funding for flood management and mitigation in Viet Nam include: European Union, disaster preparedness; Germany, flood damage rehabilitation; Italy, flood forecasting and warning; Netherlands, flood protection; United States, flood and coastal storm early warning systems and flood-resistant houses and clinics. [N.B. Information is not available about initiatives specifically located in the LMB, or about the scope of funding.]

10.6 Regional FMM initiatives

Flood management and mitigation has traditionally been a national responsibility, with little or no coordination of the initiatives by riparian countries. More recently, the Mekong River Commission has established a leadership role with respect to regional cooperation and coordination of initiatives to facilitate flood management and mitigation. The other major regional flood management programs are ADB-GMS and UNDP.

10.6.1 Mekong River Commission

Following the 2000 floods, the MRC Council charged the MRC Secretariat with preparing a Flood Management and Mitigation (FMM) Strategy that would target specifically how the MRC as a regional organization should respond to flood hazards and contribute effectively to national and basin-wide strategies in the four riparian countries. An FMM Strategy was endorsed by the MRC Council in November 2001.

The FMM Strategy confirms the strategic roles for the MRC in four principal areas:

- **Land-use planning measures**: "keeping people away from the flood waters."
- **Structural measures**: "keeping flood waters away from people."
- **Flood preparedness measures**: "getting people ready for floods before they come."
- **Flood emergency measures**: "helping affected people cope with floods."

Prior to the FMM Strategy the MRC had been involved for many years in flood forecasting. In 2001 this capacity was significantly improved into a Flood Forecasting and Early Warning System (FFEWS). In 2002 an implementation program was designed for the FMM Strategy. The MRC also collaborated with the U.S. Office of Foreign Disaster Assistance (OFDA) to identify a new project to develop flood early warning systems for flood prone communities. These initiatives are briefly described below.

Flood Forecasting and Early Warning System (FFEWS): Since the early 1970s, the MRC (and its predecessor, the Mekong Committee) has operated a flood forecasting program. This program has been progressively improved to provide daily 5-day forecasts of water levels during the flood season (June-October) that are disseminated to national governments and through the MRC website. Data are collected from 27 rainfall stations and 37 hydrological stations in the Lower Mekong Basin, plus two stations in Yunnan Province (Jinghong and Manan) that were added following a 2002 agreement between MRC and PRC China. After the 2001 floods, 15 key hydrological stations on the mainstream were upgraded to permit the collection of real-time data (2 in Lao PDR, 5 in Thailand, 6 in Cambodia and 2 in Viet Nam). The MRC anticipates Japanese funding to further improve the FFEWS through the addition of hydrological stations on major tributaries. The dissemination of flood warnings will be strengthened through a new project funded by U.S. OFDA.

Flood Early Warning to Flood-Vulnerable Communities in the Lower Mekong River Basin: The U.S. Office for Foreign Disaster Assistance (OFDA) has recently (September 2002) approved funding for improvements to early warning systems in Cambodia and Lao PDR. MRC is the executing agency. The first project component will assist MRC to improve the FFEWS by developing more understandable and timely flood warning information (including flash flooding) for flood prone communities. The second component will be carried out by community-based MRC partners to develop tools and methods and to prepare community leaders to be "emergency managers" for their own communities. The activities of the 5-year project will be launched in time for the 2003 flood season, with the initial focus on Cambodia before launching the program in Lao PDR in 2005.

Flood Management Program (FMP)[191]: The proposed program will be submitted to the MRC Council for approval in November 2002. It consists of projects to be implemented

191 Later re-named to the Flood Management and Mitigation Programme (FMMP)

over the period 2003-2008. These projects address the key priorities identified in the FMM Strategy and include:

- Regional Flood Management and Mitigation Center (RFFMC): It is proposed to establish the RFFMC operating as a Center of Excellence under the auspices of the MRC and capable of generating and disseminating data and information related to integrated flood management and river monitoring in the Mekong Basin. The RFFMC would, among other functions, be responsible to the FFEWS to provide real time flood forecasting along the mainstream and major tributaries of the Mekong.

- Flood forecasting, warning and dissemination services: to develop and operationalise modern regional flood forecasting, warning and dissemination systems for the entire LMB.

- Flood risk and flood impact analysis: to support improved knowledge about and understanding of the causes and processes that determine floods and flood plain management and flood risk assessment in particular. This work will be carried out within the RFFMC.

- Structural measures: to reduce the vulnerability of floods to society and to reduce the risk of flood disasters due to the failure or inappropriateness of structural measures along the mainstream of the Mekong.

- Flood proofing measures: to reduce vulnerability to flooding and reduce flood damages at family, community and sub-regional levels.

- Land use management: to contribute with institutional, human resources and technical support to sustainable land management and improved land use planning integrated into flood plain management and mitigation. Close links are assumed between this component and the BDP.

- Flood emergency management strengthening: to strengthen the capacity of communities, local authorities and emergency professionals in flood preparedness and emergency response.

- Transboundary flood management and mediation: to enhance the capacity of the MRC Joint Committee to address issues of transboundary flood management and to provide facilitation, mediation and training services on transboundary FMM issues.

10.6.2 ADB Greater Mekong Sub-Region

Flood Control and Water Resource Management is one of the Flagship Programs identified in the ADB-GMS 10-Year Strategic Framework for the period 2001-2010. The overall goal for ADB-GMS sub-regional cooperation in FMM is to prevent, mitigate or minimize social and economic losses due to floods through a combination of sustainable resource management actions and flood plain management measures. Specific objectives include:

Land Use Planning

- To strengthen land use planning in GMS countries to minimize risks to people living in vulnerable flood plain areas.

Structural Measures

- To develop and implement a strategy to minimize hazards to people living in flood plains, such as building platforms for dwellings and making roads flood proof to minimize the need for repairs after each flood.

- To strengthen development and building controls to reduce flood damage to urban settlements.

- To finance the construction of structures such as flood mitigation dams, embankments, flood retention basins and floodways, drainage and pumping stations, to minimize damage of regional flood events on people and settlements.

Flood preparedness

- To strengthen institutional capacities for flood preparedness.

Flood emergency

- To build capacity for responding to flood emergencies.

Under the ADB-GMS program, the "additionality" of ADB investments will be flood plain management measures that complement MRC's FMM Strategy. Proposed ADB technical assistance and loan funding within the LMB focuses on initiatives in Cambodia, Viet Nam and, to a lesser extent, Lao PDR. MRC-linked ADB-GMS initiatives include:

MRC FMP: Five technical assistance grants (amounts to be determined) to support the development and implementation of the MRC FMP.

FMM Loan Project: US$15 million each to Cambodia and Viet Nam for development control measures and flood mitigation structures, plus US$1 million for technical assistance to prepare the loan program. ADB will depend on MRC for technical inputs in development of the FMM Loan Project as well as collaboration with national disaster agencies for its implementation. Training for emergency managers on technical services developed in the Emergency Response and Recovery component of the FMP (costs to be determined).

Other proposed ADB investments include technical assistance for flood erosion measures and flood control infrastructure in conjunction with the Flood Emergency Rehabilitation Project in Cambodia; and technical assistance involving improvements in flood forecasting and warning systems. [N.B. Other components of the ADB-GMS program are integrated water resource loan projects including flood management, for areas of Viet Nam outside the LMB.]

10.6.3 UNDP

Beginning in 1989, UNDP offices in disaster and emergency prone countries established UN Disaster Management Teams (UNDMTs). The Teams are composed of UN agencies concerned with response to humanitarian emergencies and work in close collaboration with the host government, diplomatic missions, donors and regional organizations. The core membership of the UNDMTs, for example, includes FAO, UNDP, UNHCR, UNICEF WFP and WHO.

Other agencies such as government bodies, donors, NGOs, IOM, ICRC, IFRC and National Red Cross and Red Crescent Societies are frequently invited to work with the UNDMT. In 2002, UNDP-Cambodia proposed financial support to the MRC to strengthen FMM capacities. The scope and details of such funding are not yet confirmed.

11 Watershed management

Chapter 11 has been compiled from reports produced by the GTZ Appraisal Mission on Watershed Management in the Lower Mekong Basin, in February 2002.

11.1 Introduction

The watershed management concept

Integrated watershed management is the co-ordinated multi-stakeholder management of land, water and other resources within a region (e.g. river basin or sub-catchment), with the objectives of: conserving or rehabilitating resources and environment; ensuring bio-diversity; minimising land degradation; achieving specified and agreed land and water management targets and promoting social and economic development.

Regional overview

The sub-watersheds of the Mekong River in the four LMB countries have experienced rapid deforestation and watershed degradation, particularly in the upland regions. As a result, a number of serious environmental and socio-economic problems have developed, including increased run-off, erosion, siltation, and the loss of rural livelihoods. LMB governments have attempted to respond to these problems through new policy and legislation, reforestation programs and other forms of watershed management. However, the WSM process faces numerous challenges.

Firstly, national-level planning procedures and guidelines tend not to reflect a watershed perspective. Although significant amounts of regulation have been generated over the last decade, much of it is not relevant and stems from government efforts focused on other issue areas such as agriculture or forestry. As a result, there are many contradictory, unclear, and insufficiently supported regulations and policies. All four countries have many government organizations and agencies involved with WSM, but none has a clear national locus of authority. This situation creates a need for high levels of coordination, which is made more difficult by the sectoral thinking of most government agencies. Many of the relevant agencies are understaffed and lack experience in WSM.

There have also been difficulties incorporating local participation into the watershed management process, although all four countries are gradually moving towards decentralization of natural resources management. Along with government WSM efforts, there are also numerous bi- and multi-lateral projects, often pilot projects and capacity building initiatives, as well NGO activities, which generally involve local endeavours to increase community participation in natural resources planning.

WSM in Cambodia

WSM is a fairly new concept in Cambodia and policies and strategies for its implementation are only emerging. A Royal Decree on watershed management was issued in December 1998 outlining the importance of protecting natural resources in watershed areas and instructing the Government to prepare further sub-decrees and instructions on watershed management. However, the further development of a comprehensive national policy or strategy on WSM is complicated by the overlapping mandates of various institutions.

Important parts of the legal framework for watershed and natural resources management in Cambodia have been established in the recent past. Others are currently under preparation,

but even after these have been endorsed there will remain the massive task of translating the general framework into effective regulations and practical guidelines.

The Government of Cambodia has started to implement its policy of decentralisation with the establishment of village and commune development councils. There are a number of projects and programmes in Cambodia promoting participatory planning approaches. These attempt to integrate natural resources management (NRM) issues into local planning processes. As many of these projects are supported by international and local NGOs, most are on a small scale and work with 5 to 20 villages.

WSM in Lao PDR

The watershed perspective is a common feature in policy and planning documents in Lao PDR. The Government is committed to a programme of integrated area-based development centred on watersheds and river basins. Several essential laws with relevance to WSM have been promulgated in recent years. Nevertheless, the legal and regulatory framework for effective WSM is still in a transitory phase and lacks adequate guidelines on the operational level.

Emphasis is put on the stabilisation of shifting cultivation including participatory land use planning, land allocation and land use occupancy entitlement as well as community management of natural resources. The institutional framework for decentralised planning has been established in most provinces. Bottom-up planning is, however, not yet really operational.

There is as yet no focal policy agency for WSM in the Lao Government. Responsibility for WSM related issues are shared among several government institutions of which the Ministry of Agriculture and Forestry is most strongly involved in the development of a national WSM concept.

Since 1995 a number of bilateral WSM projects have been implemented in Lao PDR. Most have included local situation appraisal and data collection, local level development planning, land use planning and land allocation, development of sustainable upland agricultural practices, village forestry and water resources management through local user groups in their fields of activities. The government, with partial donor support, has been running a National Land Use Planning and Allocation Programme since 1996. At present, the major outcome of the land-use planning (LUP) process is land zoning according to general land use categories and forest classification.

WSM in Thailand

Watershed management in Thailand has a long history. However, no explicit government policy or national strategy on watershed management in Thailand has yet been formulated. The overall framework for natural resources management is set by the National Economic and Social Development Plans. In the latest NESDP the main focus is on local planning, human development, strengthening of community organisations and public participation. At the same time a target is set of conserving and rehabilitating protected forests on 30% of the national territory.

In total, 38 Government departments are active in watershed related activities. The Royal Forestry Department (RFD) and the Land Development Department (LDD) are playing particularly important roles, but none have sole responsibility for WSM. Similar to its neighbouring countries, Thailand has embarked on a major decentralisation process with

increased planning responsibilities as well as funds channelled to Tambon, District and Province levels.

There are four main Government Programmes with relevance to WSM: the National Rural Development Programme, the Programmes of the Ministry of Agriculture and Co-operatives line agencies, the Highland Community Development and Narcotics Control Programme, and the Bottom-up Planning Programme. The RFD, NGOs and several ODA projects have been particularly successful in establishing watershed network organisations in upland areas as a result of participatory land-use planning exercises.

WSM in Viet Nam

The Government of Viet Nam has not yet formulated a comprehensive policy or strategy on watershed management or catchment protection. Nevertheless, a series of policies with regard to land use planning, land allocation, forest protection and sustainable management as well as water resources protection have been promulgated. The national programmes of land use planning and forest-land allocation are of particular relevance. Since 1993, large areas of land and forest resources across the country have been allocated to households, local organisations and communities for long term protection and management.

Viet Nam has a number of government institutions that deal with WSM, each with its own and often overlapping mandate. The principal agency is the Ministry of Agriculture and Rural Development. Other important institutions are the General Department of Land Administration and the Land Cadastral Department. A large number of NGOs are also involved in NRM. Many of these run small projects in comparatively restricted areas focusing on participatory planning and development.

A system of national programmes and projects has had widespread impacts in terms of reforested areas, clearly identified management responsibilities for forest protection, improved security of tenure and some contributions to poverty alleviation.

Expected impacts of watershed management

Successful watershed management is expected to provide environmental benefits, micro- and macro-economic benefits, and socio-cultural benefits. Environmental benefits should result from improvements to forestry and agriculture practices, and the strengthening of consultative mechanisms for infrastructure development. Economic changes at the micro and macro levels should result primarily from improvements to the agriculture sector in terms of better technologies, crop diversification and irrigation, as well as improved natural resources quality.

Furthermore, considerable macro-economic costs can also be saved by avoiding environmental damage with effective watershed management. Expected socio-cultural impacts include the strengthening of the self-help capacity of local communities (i.e. increasing their capacity to plan, implement and evaluate their own development activities, to make use of support offers and to access external resources).

Information gaps and areas for further study

Areas that require further investigation for a comprehensive review of the watershed management sector include: the spatial extent of watershed management efforts across the LMB; characteristic and possible impacts of WSM on water availability and use; the current

effectiveness of WSM; and the downstream economic and environmental effects of deforestation, especially non-market environmental benefits. There is a need for the ongoing monitoring of 'hot spot' watersheds, and major forthcoming policies and pipeline projects. Finally, it should be pointed out that there is much less information available on WSM for Thailand and Viet Nam than for Lao PDR and Cambodia. If possible this imbalance should be remedied by the gathering of further data on the former two countries.

11.2 The watershed management concept

A watershed is a topographically delineated area from which rainwater drains as surface run-off via a specific river or stream to a common outlet point (e.g. a large river, lake or the sea). Depending on their location and size, various types of watersheds can be distinguished, ranging from micro-catchments and sub-catchments to larger watersheds and river basins. Watersheds are used as planning and implementation entities in connection with natural resources conservation, sustainable water supply for hydropower and irrigation schemes, development and protection of upland areas and for the mitigation of upstream cause and downstream effect relations.

Definition of watershed management:

Co-ordinated multi-stakeholder management of land, water and other resources within a region (e.g. river basin or sub-catchment), with the objectives of:

- ensuring bio-diversity
- minimising land degradation
- promoting social and economic development
- conserving or rehabilitating the resource and environment
- achieving specified and agreed land and water management on various levels

Effective watershed/river basin management needs to be holistic in its coverage and interdisciplinary in its scope. WSM has to consider the natural resources (land, water, forest) as well as the human resources (households, communities, government institutions, private sector) and co-ordinate their management needs and development potentials. Thus, watershed interventions should consider the different stakeholders' interests and aspirations and include mechanisms of conflict resolution.

The cross-cutting issue is to establish procedures for integrated watershed/river basin management through development and implementation of watershed/river basin management plans, beginning at the village-level plans, which are harmonised into sub-catchment management and development plans. Strong community participation throughout the process is essential. Participatory land use planning and land allocation (for agricultural and forest land) is the foundation of an integrated watershed management approach.

Integrated watershed management planning is the attempt to involve all stakeholders in a process of defining present constraints and potentials and developing priorities, strategies and objectives in a given watershed situation.

Co-ordinated implementation of such a plan will lead to improved management of watershed resources, which can be expected to produce a range of both on-site and downstream

economic, social and environmental benefits through the promotion of suitable land uses and appropriate land management practices. In summary, WSM aims at:

- Creation of a holistic and integrated view on natural resources management;
- Widespread protection of the natural resources in upper catchment areas by forest management, reforestation and soil conservation;
- Mitigation of negative impacts in downstream areas;
- Establishment of fruitful co-operation among existing projects/programmes (IO/NGO) in an area-based planning and implementation approach;
- Increased security of land tenure through a land allocation process with wide area coverage in the watershed;
- Contributions to poverty alleviation through sustainable land use and community based management of natural resources.

11.3 Watershed management in the LMB

11.3.1 Regional overview

The sub-watersheds of the Mekong River in the four LMB countries are experiencing deforestation and forest degradation at an increasing rate. Particularly in upland watersheds deforestation and forest degradation has become a serious problem during the last two decades. The average deforestation rate for these countries between 1990 and 1995 was 1.6% per annum, higher than any other region in the world. In addition to this rapid loss of forest cover, extensive areas of forests have been severely degraded in terms of their structure and composition, through various forms of exploitation and exposure to fires and other destructive factors.

Extensive deforestation and widespread loss in forest quality have resulted in a number of serious environmental and socio-economic problems for most countries in the Lower Mekong Basin. Such problems include loss of ecosystem function, increasing erosion and reduced water regulation capacity, reduction in supply of timber and non-timber forest products and decline in spiritual, cultural and recreational values. The predominant inhabitants of those watersheds are ethnic groups of various origin, which practiced and still practice shifting cultivation, while facing diminishing resources due to population increase, degradation of natural resources, and reduced possibilities for mobility.

Several programs have responded to these problems by implementing massive plantation and forest restoration programs, and by various other methods of implementing WSM. However, many of these programs have failed to address the problems at hand. Key constraints on the successful implementation of WSM are listed below.

WSM requires the involvement of many line agencies and stakeholders, which implies high co-ordination needs, integration and joint responsibilities. This is not easy to achieve in view of the sectoral set-up and thinking in most Government institutions.

The present national planning procedures and guidelines do not reflect the WSM approach. Institutions at all levels plan and act within the framework of administrative boundaries and not in terms of physiographic boundaries.

Many of the relevant institutions in the riparian countries are understaffed and lack expertise in WSM. Moreover, the dominant working attitude of the majority of Government staff still is rather prescriptive than participatory.

There is a general lack of recognition of the fact the decisions concerning the actual use of natural resources in watersheds will ultimately be made by the local people regardless of policy choices. Even when properly resourced authorities do attempt to win the support of the local people, they often lack the required extension capabilities.[192]

Other constraints on local-level participation include: a lack of village-level social cohesion in areas affected by war; widespread mistrust of local authorities; a short-term planning orientation on the part of many of the poorest villagers; traditions of top-down land allocation and land adjudication; insufficient numbers of government officials trained in participatory planning techniques.[193]

Even where critical resource use decisions are made at the local level, problems can arise from limited local management capabilities. For example, weak local judiciaries can leave local level resource management open to political abuse[194]. While relevant resource management legislation often exists, the profusion of new regulatory documents that has been generated over the last decade can cause confusion and is not sufficiently supported by education of government officials and the general population. The result is that regulations are often not enforced. There are also problems with conflicting regulations created by agencies with overlapping jurisdictions.[195]

There are problems with land tenure and allocation systems, including: inaccurate or inappropriate land classifications; conflicts between government zoning and land-use allocation processes and the traditional land-use rights of local groups; and weak land tenure systems that do not give smallholders sufficient ownership security to justify investments in conservation.[196]

Logging industry management practices also impinge upon the successful management of natural resources in watersheds. Overexploitation by legal and illegal loggers in the face of weak enforcement is common, as are opaque concession allocation process, and unnecessarily destructive logging and log transportation practices. As a result, the implementation of new management and conservation regeime becomes more difficult..

On the other hand, it has become evident that decentralized and well planned and implemented restoration and other WSM programs, particularly in upland watersheds, can provide a wide range of environmental and socio-economic benefits including bio-diversity conservation, improved ecosystem functioning, income, forest goods and services and recreational opportunities. In the recent past, forest rehabilitation in upland watersheds, along with other forms of watershed management, has become increasingly important for

192 MRC (2000) p26-27

193 MRC (2000) p31

194 MRC (2000) p32-33

195 MRC (2000) p28, p30-31

196 MRC (2000) p31-32

the national and provincial governments of the LMB. General trends characterising WSM efforts have included:

Increasing empathises placed by governments on WSM, in response to increasing evidence of degradation of watershed natural resources, as well as donor priorities and interests.

Generation of significant amounts of relevant regulation over the last decade, but much of it is tangential, the result of policy development for related sectors such as agriculture, forestry, and water resources management. Such policies and regulations are often overlapping and not sufficiently coordinated. There are generally numerous government organizations and agencies involved with WSM, but there is often no clear national level locus of authority for the coordination of the sector.

The four countries are all engaging in decentralization of watershed resources management to various degrees, subject to the constraints discussed above. Along with government WSM efforts, there are also numerous bi- and multi-lateral projects, often pilot projects and capacity building initiatives, as well NGO activities, which generally involve localized endeavours to increase community participation in natural resources planning.

11.3.2 WSM in Cambodia

Status of watershed natural resources

Cambodia has lost forest cover and forest quality during the last 20 years faster than any other country in the Lower Mekong Basin. This can be partly attributed to the long lasting periods of unrest and political instability, and partly to expanding population and construction of new roads into forested areas for forest harvesting by private concessionaires, which suddenly allowed access to previously inaccessible resources.

Only very recently has the government been able to gain control of illegal logging to a significant extent. Forests today still play a significant role in the lives of the majority of rural population. Particularly in the watersheds of the northeastern parts of Cambodia, forests are the basis for people's livelihoods and provide a variety of products and functions for local communities.

Policy and legal framework

WSM is a fairly new concept in Cambodia and policies and strategies for its implementation are only emerging. A Royal Decree on watershed management has been issued in December 1998, outlining the importance of protecting natural resources in watershed areas and instructing the Government to prepare further sub-decrees and instructions on watershed management. However, the further development of a comprehensive national policy or strategy on WSM is complicated by overlapping mandates of various institutions:

The Department of Water Resource Management and Conservation in the Ministry of Water Resources and Meteorology has elaborated a draft sub-decree on watershed management focussing on the water supply function of watersheds. The Department of Forestry and Wildlife in the Ministry of Agriculture and Forestry intends to prepare another draft sub-decree on WSM. Moreover, the national policies on rural development, decentralisation, natural resources management and poverty reduction contain important implications for watershed management.

Important parts of the legal framework for watershed and natural resources management in Cambodia have been established in the recent past. Others are currently under preparation e.g. the Forestry Law, the Sub-decree on Community Forestry and the Water Resources Management Law. But even after these have been endorsed there will remain the massive task of translating the general framework into effective regulations and practical guidelines

Major legal and policy documents pertaining to WSM in Cambodia:
Law on environmental protection and natural resource management, endorsed in November 1996
Draft Policy for Ethnic Minority Peoples' Development, also called "Highland Policy" (Sept. 1997) [not yet ratified by the Council of Ministers]
Law on Commune Administration Management, endorsed in August 2000
Land Law, endorsed in August 2001
Forestry law, submitted to Council of Ministers in July 2001, not yet passed
Sub-decree on Community Forest Management, final draft elaborated February 2002.
Sub-decree on forest concession management, signed by the Prime Minister in February 2002
Law on water resources management – exists in draft form
Decentralisation and Devolution Policy of the Ministry of Interior
Five-year Socio-Economic Development Plan (2001-2005); particularly relevant on poverty alleviation
Interim Poverty Reduction Strategy Paper
Agricultural Development Plan (2001-2005)
Action Programme for the Development of Agriculture in Cambodia 2001-2010
Government Action Plan 2001, which includes a section specifically dealing with natural resources management
Forest Policy – currently being drafted by a national working group

The Government of Cambodia has started to implement its policy of decentralisation with the establishment of village and commune development councils. A major task of these councils will be the establishment and implementation of participatory development plans that are supposed to be aggregated with district and provincial plans. This planning process and the institutions involved will be of critical importance in watershed management and planning.

Institutions

There is a multitude of government institutions in Cambodia that are relevant to WSM. The most important ones are the Ministry of Agriculture, Forestry and Fishery and the Ministry of Land Management, Urban Planning and Construction.

Government institutions in Cambodia involved in WSM:
Ministry of Agriculture, Forestry and Fishery
Department of Forestry and Wildlife
Planning and International Co-operation Division
Department of Agronomy and Agricultural Land Improvement
Ministry of Land Management, Urban Planning and Construction (MLMUPC)
General Department of Cadastre and Geography

Government institutions in Cambodia involved in WSM:
General Department of Land Management and Urban Planning
Ministry of Water Resources Management and Meteorology (MoWRM)
Department of Water Resources Management and Conservation
Ministry of Environment (MoE)
Department of Nature Conservation and Protection
Ministry of Rural Development (MRD)
Cambodian National Mekong Committee (CNMC)
SEILA Programme
Council for the Development of Cambodia (CDC)
takes decisions regarding rehabilitation, development and investment projects in the country
Inter-ministerial council to oversee ethnic minority development (see further details in the report of national consultants in Volume 2)

Programmes and projects

There are a number of projects or programmes in Cambodia promoting participatory planning approaches, which attempt to integrate natural resources management (NRM) issues in a local planning process. There are numerous examples of community-based NRM, such as community forests and fishery schemes managed by local committees, while participatory land use planning and land allocation according to the new land law has just started. As many of these projects are supported by international and local NGOs, most of them are on a small scale, covering from 5 to 20 villages. More widespread and more holistic approaches to NRM can only be found in Siem Reap (FAO-supported), in Ratanakiri (SIDA-supported) and in Kampong Thom (GTZ-supported). Yet, none of these projects has a watershed perspective.

In November 2001, the national SEILA Task Force prepared a project proposal to DANIDA for a watershed management project in the Stung Pursat and Mongkol Borey areas (Pursat, Battambang and Banthey Meanchey Provinces). The idea behind this proposal is to combine watershed management activities with the existing decentralised planning and implementation mechanisms created by the SEILA system in line with the NRM Mainstreaming Strategy of SEILA (Nov. 2001). The expected outputs and activities of this project have numerous similarities to the output 3 (WSM planning and implementation on the local level) of the AIFP WSM component, but within the framework of a bilateral project. Due to present budget restrictions it is doubtful whether DANIDA will be in a position to start funding the bilateral WSM project within the coming two years.

11.3.3 WSM in Lao PDR

Status of watershed natural resources

The general problems of degradation and deforestation of watersheds are most significant in the northern parts of the country, where shifting cultivation has resulted to the loss of almost all large forested areas, even though the country in the north is populated with only 10 to 15 persons per sq km. Ambiguities over tenure, particularly regarding access and use rights, have created difficulties in dealing with ethnic groups living in watershed areas. The government is attempting to ban or at least curtail shifting cultivation, but to date few feasible livelihood alternatives have been found for shifting cultivators. Legal and illegal logging and the

collection of fuel wood and non-timber forest products, are also sources of pressure on watershed natural resources.

Policy and legal framework

The watershed perspective is a common feature in policy and planning documents in Lao PDR. The Government is committed to a programme of integrated area based development centred on watersheds and river basins. Several essential laws with relevance to WSM have been promulgated in recent years. Nevertheless, the legal and regulatory framework for effective WSM is still in a transitory phase. A consistent concept of integrated watershed management in Lao PDR is expected to be developed by the Lao-DANIDA Natural Resources and Environment Programme, which runs until October 2002, but the present situation is characterised by the absence of adequate guidelines on the operational level.

Major legal and policy documents pertaining to WSM in Lao PDR:
Water and Water Resources Law (1996)
Forest Law (1996)
Land Law (1997)
Electricity Law (1997)
National Water Supply and Environmental Health Programme (1997)
Environmental Protection Law (1999)
Strategic Vision for the Agricultural Sector (Dec.1999)
National Environment Action Plan (STEA 2000)
Decree on the Implementation of the Water and Water Resources Law (2001)
National Socio-Economic Development Plan (NSEDP) (1996-2000)
National Rural Development Programme (1996-2000) (by the National Leading Committee for Rural Development (NLCRD) and the State Planning Committee
Human Resource Development Programme (1997-2000)
Lao PDR National Environmental Strategy until year 2010
National Poverty Alleviation Strategy

The "Strategic Vision for the Agricultural Sector" lists participatory planning and upland development among its key thematic approaches. The envisaged strategy for the uplands provides for decentralised development with an area-based approach focussing on watersheds and entire river basins. Emphasis is put on the stabilisation of shifting cultivation including participatory land use planning, land allocation and land use occupancy entitlement as well as community management of natural resources. The institutional framework for decentralised planning has been established in most provinces. Bottom-up planning is, however, not yet really operational. The recent move towards decentralisation will eventually give local authorities greater authority in issues relating to natural resources management. At present, decision-making is, however, still predominantly reserved for the central and provincial level.

Institutions

There is as yet no focal policy agency for WSM in the Lao Government. Responsibility for WSM related issues are shared among several government institutions of which the Ministry

of Agriculture and Forestry is most strongly involved in the development of a national WSM concept.

Government institutions in Lao PDR involved in WSM:
Agency (STEA)
Ethnic Minority Department
State Planning Committee (SPC)
Lao National Mekong Committee (LNMC)
Water Resources Co-ordination Committee
Science Technology and Environment
Committee for Planning and Co-operation (CPC)
Department of Land Use Planning and Land Allocation
National Agriculture and Forestry Research Institute (NAFRI)
National Leading Committee for Rural Development (NLCRD)
Planning Division - Ministry of Agriculture and Forestry (MAF)

The role of international NGOs in Lao PDR has seen gradual growth and development. However, the extent to which they contribute towards environmental management is still limited. NGO activities are typically focussing on small-scale "on-the-ground" projects in remote rural communities. The only NGO with a programme at national level is IUCN, which is involved in policy development for bio-diversity ecosystems and conservation.

Programmes and projects

Since 1995 a number of bilateral WSM projects have been implemented in Lao PDR. The most prominent among these are the ADB-funded Nam Ngum Watershed Study, the JICA-funded Watershed Management for Forest Conservation in the Vangvieng area, the UNDP-funded Nam Niam Watershed Management Project and the Nam Ngum Watershed Management and Conservation Project supported by GTZ. Most of these projects have included local situation appraisal and data collection, local level development planning, land use planning and land allocation, development of sustainable upland agricultural practices, village forestry and water resources management through local user groups in their fields of activities.

The development of consistent national WSM concepts and practices for Lao PDR is promoted by the Lao-DANIDA Natural Resources and Environment Programme with a National Capacity Building Project (Phase I until Oct. 2002) in particular. National concepts are developed in close relation to and field-tested by the Integrated Watershed Management Project in Huaphan and Xieng Khouang, which is funded under the same Programme structure by DANIDA.

The National Capacity Building Project has been successful in establishing good collaboration in this methodological development process with several of the above-mentioned area-based projects as well as with relevant national institutions. It was planned to continue the National Capacity Building Project after October 2002 in a second phase, which now seems doubtful due to budget cuts by the Danish Government. A continuation of the started conceptual developments and the testing of WSM concepts, such as the integrated watershed planning, on the local level could be important activities of the AIFP WSM component in Lao PDR.

Two potentially very important WSM projects are in the planning stage: a WWF funded Nam Ou Watershed Management Project focussing on natural forest restoration and an ADB-funded RETA 5771 (Phase III) 'WSM Project in Nam Ou' (based on the final report elaborated at the end of an ADB funded 18-month study-phase).

Since 1996 a National Land Use Planning and Allocation Programme has been formulated, distinguishing a process of eight main steps. Partly with donor support, partly with Government funds this programme is implemented in all provinces. Although the original programme documents describe a robust approach, varying standards and instructions from one province to the other, insufficient funding and low staff capacities have led to a simplified approach to reduce costs. In particular the tools to encourage community participation and decision-making have been modified or discarded altogether.

At present, the major outcome of the land-use planning (LUP) process is land zonation according to general land use categories (agricultural land - forest land) and forest classification (protection, conservation, production, regeneration and degraded forest). In theory, the zoning and land use planning should prepare the ground for land allocation (LA) to individual households, but again due to staff and budget restrictions this is often delayed. In recent surveys there are some indications that the LUP/LA Programme as it is carried out at present can contribute to increased poverty among swidden agriculturists and ethnic minorities. (see: Participatory Poverty Assessment Lao PDR, 2001).

11.3.4 WSM in Thailand

Status of watershed natural resources

Thailand has undergone a tremendous loss of forest coverage in the last 40 years. Whereas in 1961 the forest cover was 53%, it had decreased to only 26% by 1995. In many areas of the country, particularly in the upland watersheds in the north and northeast, the trend is still continuing. The reasons for deforestation are manifold: conversion of forest land to agricultural land as a result of increasing population density is common, as is conversion of areas of shifting cultivation to permanent cropping, mostly commercial crops with high inputs of chemicals. Parallel to changing land uses, wide spread forest fire caused loss of forests and subsequent loss of ground cover and soil erosion. Other main causes of deforestation were over-grazing, mining, logging for commercial purposes and road construction, as well as widespread illegal logging, which eventually forced the government to impose a logging ban in 1989.

Policy and legal framework

Watershed management in Thailand has a long history. It was initiated in 1953 under the Royal Forestry Department. The principles of WSM in Thailand were developed and a standardised watershed classification system for the entire country was developed in 1979 on the basis of five parameters (slope, elevation, landform, geology and soil). Nevertheless, no explicit government policy or national strategy on watershed management in Thailand has been formulated until today. The overall framework is set by the National Economic and Social Development Plans (NESDP) No.8 and 9 (2002-2006).

These plans introduce the concept of sustainable development and natural resources management. In order to achieve effective administration and management of natural resources and the environment, the specified national programmes should include management of water resources according to watershed areas, land use zonation and

planning according to land capability, and watershed classification. An integrated approach is emphasised which requires co-operation in design, implementation and evaluation of the programmes by all relevant agencies.

In the latest NESDP (No.9) the main focus is on local planning, human development, strengthening of community organisations and public participation. At the same time a target is set of conserving and rehabilitating protected forests on 30% of the national territory.

Major legal and policy documents pertaining to WSM in Thailand:
National Park Act (1961)
National Forest Reserve Act (1964)
Agricultural Land Consolidation Act (1974)
Agricultural Land Reform Act (1975)
Tambon Administration Act (1992)
Enhancement and Conservation of National Environmental Quality Act (1992)
Forest Policy 1995
Thai Constitution (1997)
Cabinet Resolution on Settlements and Farming in Protected Areas (1998)
Policy and Prospective Plan for Enhancement and Conservation of National Environmental Quality 1997-2016
Cabinet Resolution on Watershed Classification

Similar to the neighbouring countries, Thailand has embarked on a major decentralisation process with increased planning responsibilities as well as funds channelled to Tambon, District and Province level. Based on the Tambon Administration Act (1992) newly elected Tambon Councils and Tambon Administration Offices with representatives from each village have been created in the past three years.

Institutions

In total, 38 Government departments are active in watershed related activities. The Royal Forestry Department (RFD) and the Land Development Department (LDD) are playing particularly important roles, but none of them has the sole responsibility for WSM. Furthermore, there are a number of co-ordinating bodies with relevance to WSM. As a consequence, activities tend to be somewhat uncoordinated and disconnected. In the very near future, a new Ministry of Environment and NRM will be created, which will absorb parts of RFD, possibly LDD and other departments under the Ministry of Agriculture and Co-operatives.

Government institutions in Thailand involved in WSM:
Royal Forestry Department (RFD)
• 1 WSM Division on the national level
• WSM Sub-Divisions in the regions
• 19 Watershed Management Centres in the provinces
• 189 Watershed Management Units
Land Development Department (LDD)
• 12 Regional Offices of Land Development
• 65 Land Development Stations
Thai National Mekong Committee (TNMC)
Office for Environmental Planning and Policy (OEPP)
Department of Public Welfare
• Hill-tribe Welfare Division
National Economic and Social Development Board (NESDB)
Narcotics Plants
National Environment Board (NEB)
National Forestry Policy Board (NFPB)
National Water Resources Council (NWRC)
Committee for Solving National Security Problems Concerning Hill-tribe Population and
Local and Regional Prosperity Distribution Committee

Programmes and projects

There are four main Government Programmes with relevance to WSM:

- The Bottom-up Planning Programme
- The National Rural Development Programme
- The Highland Community Development and Narcotics Control Programme
- The Programmes of the Ministry of Agriculture and Co-operatives line agencies

The RFD, NGOs and several ODA projects have been particularly successful in establishing watershed network organisations in upland areas as a result of participatory land-use planning exercises. Each village in a particular micro-watershed thereby sends representatives to the local watershed network committee or peoples' forum[197]. By 2001, a total of 1,284 villages, most of them participating in watershed networks, received technical support by the watershed management units of RFD. One of the most relevant projects in terms of conceptual development and exemplary field implementation is the Upper Nan Watershed Management Project (supported by DANCED) in Nan Province of North Thailand.

197 The role of these committees is further described in the report of the Thai national consultants in GTZ 2002b.

11.3.5 WSM in Viet Nam

Status of watershed natural resources

Most of Viet Nam's forested land is in the upland and mountainous areas located in the west and north of the country. About 24 million people live in or around forests and derive a substantial part of their food and income from the forest and forestland. The country has suffered significant deforestation and forest degradation during the past 40 years and annual forest loss has been of the order of 100-140,000 hectares (ha). Rapidly expanding populations and migration into forest areas are among the major reasons why pressures remain to clear forests to provide additional agricultural land. Poverty is widespread in rural areas and people are essentially forced to use forest resources for subsistence and market purposes. State forest enterprises have also contributed to forest degradation by engaging in unsustainable harvesting to meet production quotas set by central government.

Policy and legal framework

The Government of Viet Nam has not yet formulated a comprehensive policy or strategy on watershed management or catchment protection. Nevertheless, a series of policies with regard to land use planning, land allocation, forest protection and sustainable management as well as water resources protection have been promulgated.

Major legal and policy documents pertaining to WSM in Viet Nam:
Law on Forest Land Protection and Development (1991)
Land Law (1993/ revised 1998)
Law on Water Resource Use and Management (2000)
Draft Forestry Development Strategy 2001-2010 (Sept. 2001)
Law on Agricultural Co-operatives
Decree No.525 on Mountain Area Development
Decision No. 264 CP on Credit for Forest Planting
Decision No. 08 CP on the Management of 3 Forest Categories
Decision No. 02 CP and Decision No. 163 on (Forest) Land Allocation

The national programmes of land use planning and forest land allocation are of particular relevance for watershed management in Viet Nam. Since 1993, large areas of land and forest resources across the country have been allocated to households, local organisations and communities for protection and management for time periods between 20 and 50 years. This term will be automatically extended if the user doesn't violate the regulations. Maximal area to be allocated for each household is limited in accordance to land resource availability in each province. Not more than 30 ha of forest land can be allocated to each household. The five fundamental rights to land use include: transfer, exchange, inheritance, lease and use as collateral. Households and communities receive official land use certificates for the allocated forest areas.

Institutions

Viet Nam has a number of government institutions that deal with WSM; each with their own and often overlapping mandate. The principal agency is the Ministry of Agriculture and Rural Development. Other important institutions are the General Department of Land Administration and the Land Cadastral Department.

Government institutions in Viet Nam involved in WSM:
Ministry of Agriculture and Rural Development (MARD) • Forest Protection Department • Forest Development Department • million ha of Reforestation Project • Forest Science Institute of Viet Nam (FSIV) • Forest Inventory and Planning Institute (FIPI) • Institute of Water Planning and Projection (IWPP) • Department of Water and Irrigation Constructions • National Institute of Agriculture Planning and Projection (NIAPP)
Committee for Ethnic Minority and Mountain Areas (CEMMA)
Ministry of Science, Technology and Environment (MOSTE)
General Department for Meteorology and Hydrology
Viet Nam National Mekong Committee (VNMC)
General Department for Land Administration
Ministry of Planning and Investment (MPI)
Institute for Water Resources Planning
National Water Resources Council
Land Cadastral Department

A large number of NGOs are involved in NRM. Many of these run small projects in comparatively restricted areas focussing on participatory planning and development. International NGOs with larger programmes are IUCN and WWF.

Programmes and projects

A system of national programmes has had widespread impacts in terms of reforested areas, clearly identified management responsibilities for forest protection, improved security of tenure and some contributions to poverty alleviation. Major national programmes are:

- million ha reforestation (1998-2010):
  Reforestation of 5 million ha (2 million ha protection and special use forest, 3 million ha production forest) in view of increasing forest cover to 40%, protection of existing forests

- Programme 133 (started 1998)
  Hunger eradication and poverty alleviation– employment generation, rural credit

with no or low interest rates (Bank for the Poor), subsidies for crops, livestock and aquaculture, partly subsidies for health care, education etc.

- Programme 135 (started 1998)
  Socio-economic Development Programme for particularly needy communes in remote areas. In 2001, each commune (totaling 2,200) received the equivalent of US$2,700 for infrastructure development.

- Resettlement Projects
  500 projects have been conducted, resettling 1.9 million people in 26 provinces

- Water Sector Support Programme

Important projects on WSM and NRM supported by bi- and multilateral donors include:

- Reforestation through local credit schemes in the provinces of Ha Tinh, Quang Binh and Quang Tri
  German Financial Co-operation through KfW

- Forestation in Quang Ninh, Bac Giang and Lang Son
  German Financial Co-operation through KfW

- Community-based Watershed Rehabilitation and Management in four provinces
  ADB-funded

- Song Da Social Forestry Development Project
  German Technical Co-operation through GTZ

- Forestry Sector Project
  ADB

- Lai Chau – Son La Rural Development Project
  EU

- Northern Mountain Poverty Reduction Project
  WB/DFID

11.4 Expected impacts of watershed management

The GTZ WSM Appraisal Project Report suggests that the following environmental, economic, and social changes should result from the strengthening of WSM in the LMB. The capacity to manage critical watersheds sustainably is expected to materialise predominantly at the level of national line agencies and their sub-national units. Direct impacts will have effect at the target group level (i.e. the population of pilot watersheds) and will therefore affect only a small proportion of the basin's inhabitants. Indirect impacts will materialise only in the long run as a result of improved national policies and strategies and through the replication of improved WSM approaches by national programmes and donor-funded projects.

11.4.1 Environmental impacts

Improving WSM aims directly at sustainable use of natural resources. Major levers in this respect are forestry, agriculture and consultative mechanisms for infrastructure development. Reforestation and sustainable management of existing forests particularly in the steep headwater areas will contribute to reduced soil erosion and water run-off, to improved water quality and water availability, to conserving bio-diversity and to carbon-dioxide fixation. Sustainable agriculture aims at improving livelihoods while preserving and improving soil-fertility and reducing unwanted side effects ranging from erosion to misuse of agro-chemicals. Mutually acknowledged procedures and standards in the environmental impact assessment of dams and irrigation schemes will help to reduce negative impacts on down-stream areas.

11.4.2 Micro-economic impacts

As agriculture is the basis of the livelihoods of the majority of the rural population in the LMB, major micro-economic impacts at target group level will derive from changes in this sector. This pertains to improved agricultural technologies, crop diversification and irrigation. An important factor for the latter is better availability of water through the reduction of water run-off. Fisheries, an important source of food and income along rivers and lakes will benefit from improved water quality and – particularly in the greater Tonle Sap area - from reduced siltation. Reforestation and sustainable forest management through local communities contribute to stabilising and improving wood supplies for fuel and construction, can provide income from timber sales and improve availability of and access to non-timber forest products.

An important aspect is the development of sustainable financing mechanisms for WSM in the headwaters of the river systems. The transfer of resources into remote and poor areas will not only contribute to the provision of "public goods" (water quality and quantity, prevention of flash floods, clean air, bio-diversity, etc.) down-stream but also to socio-economic development in the up-stream areas.

11.4.3 Macro-economic impacts

The sum of the micro-economic impacts described under the previous section will result in a contribution to macro-economic development and growth. The conservation of the natural resource base for the livelihood of the rural poor will contribute to poverty alleviation and to employment in rural areas. Sustainable primary production will also secure jobs in the processing industry and support its long-term viability and its effects on growth and foreign exchange balance.

Considerable macro-economic costs can also be saved by avoiding environmental damage. Erosion and siltation are major threats to large-scale investment into hydropower. The expected life-span of the Hoa Binh Dam, Viet Nam's biggest source of hydropower, will be drastically reduced if current sedimentation levels cannot be curbed. Large and medium-scale irrigation systems are affected by salinisation due to insufficient water availability. Water pollution – if unchecked - will result in increasing costs for water purification and in serious health problems of the population.

11.4.3 Socio-cultural Impacts

Integrated WSM is defined as a multi-stakeholder process with intensive participation by these stakeholders in both planning and implementation. This includes participatory land-use

planning and land allocation, participatory village and commune development planning including resource allocation and a fair and transparent harmonisation of the lower level plans with national and provincial framework planning.

An important impact of these approaches is the strengthening of the self-help capacity of local communities i.e. the capacity to plan, implement and evaluate their own development activities, to make use of support offers and to access external resources. This will not only result in a general increase of self-confidence and self-determination of the communities, particularly if they belong to ethnic minorities, but – to some extent – also to improved interactions between communities and the local administrations.

Traditional roles of men and women, legal rights, religion and other socio-cultural parameters are, however, likely to constrain equal benefits for men and women. Against this background it would not appear realistic to expect major changes in the social and economic status of women from one single project even in a few locations. What can be done, however, is to continuously pursue gender issues at all levels in WSM strengthening projects.

11.5 Information gaps and areas for further study

It is necessary to create a systematic repository of information about the spatial extent of watershed management efforts across the LMB. It could be useful to append such information to the MRC's Watershed Classification Project Dataset by specifying for each watershed the type of management it is under and the responsible agency or agencies.

More information is required on the characteristic and possible impacts on water availability and use, as is broad and systematic assessment of effectiveness of WSM and the constraints it faces. To gather such information it may be necessary to conduct specialized studies.

"Hotspot" watersheds, those in a critical environmental situation or those with important trans-boundary linkages should be actively monitored.

There is a need for further information on major forthcoming policies and pipeline projects. Further studies of the downstream economic and environmental effects of deforestation, especially non-market environmental benefits such as soil and water conservation, would be useful.

In analysing the source documents used by GTZ to compile the original country reports and regional summary it became clear that much less information on Thailand and Viet Nam was available than for the other two countries. Further light could thus be shed on the status of WSM in Thailand and Viet Nam if more research material became available.

12 Issues and priorities

Inter-sector issues and priorities will be addressed in connection with the scenario analyses and in the *'Strategic Directions for IWRM in the Lower Mekong Basin'* (in preparation, mid 2005).

Current sector issues and priorities may be summarised as follows.

Agriculture and irrigation

Agriculture is the most important sector in terms of occupation, and an important sector in terms of national economy, particularly in Thailand and Viet Nam.

In many parts of the Lower Mekong Basin, the dry season cultivation is limited by water availability.

There is scope for expanding the agricultural production in the region, as well as a scope for increasing the water efficiency and the value generated within the sector. Such development can significantly enhance rural incomes and national macroeconomic performance. Increasing commercialization 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.

Fisheries

The Mekong River stands third in the world as having the highest number of freshwater fish species and fourth in terms of tonnage caught. To date, there are 1,200 recorded species of fish found in the Mekong River. Many of these species are endemic to the river.

It is estimated that most of the 12 million rural households (approximately 40 million people) earn their living by rice farming and fishing. Approximately 71% of rural households (2.7 million people) in Lao PDR rely on fishing to a varying degree as a livelihood strategy, and about 1,200,000 people living in fishing communes around Tonle Sap depend nearly entirely on fishing as their main occupation, with 10.7 million people in Cambodia dependent to some extent on capture fisheries.

The sector is under pressure from habitat degradation and blocking of migration routes; over-exploitation; and water pollution. Development opportunities comprise a range of conservation measures; and improved production efficiencies (of the entire product cycle). There is also a scope for sustainable development of aquaculture and reservoir fisheries.

Hydropower

The total potential for feasible hydropower projects in the Lower Mekong Basin is approximately 30,000 MW, distributed with 13,000 MW on the Mainstream, 13,000 MW on Lao tributaries, 2,200 MW on Cambodian tributaries, and 2,000 MW on Vietnamese tributaries.

Only 5 percent (some 1,600 MW) of the potential has been developed. Considering the escalating demand of electricity in the region, and the ever-increasing energy price, there is a huge scope for development of this resource.

Navigation

The importance of the Mekong River and its tributaries as a transport artery for member countries may be assessed in terms of the access it provides for poor communities, which would otherwise have no year-round transport to markets, or health and education services which are usually located in district or provincial centres. It may also be assessed in terms of volume and value of the foreign trade flows made possible by river transportation.

There is an attractive development potential within regional navigation, both in terms of management and regulatory framework, as well as in terms of physical infrastructure and facilities.

Tourism development

Southeast Asia – and the Mekong Basin in particular – is one of the fastest growing tourism destinations in the world. To date, tourism activities are largely restricted within the geographical boundaries of each LMB country, although national tourism products are complementary to one another. Ecotourism and sustainable development of tourism are regional priorities.

Sustainable development of tourism will assess economic opportunities in the context of the carrying capacity of natural and cultural resources to support tourism, as well as greater emphasis on equitable distribution of economic benefits.

There is an open-ended scope for further tourism development in the Lower Mekong Basin. In the context of water resources management, support to such development involves awareness of a variety of water-related assets; and preservation and development of such assets.

Domestic water supply and sanitation

Domestic water supply is insignificant in terms of volume, but the most important waqter allocation in terms of value.

Domestic water supply and sanitation is often seen as a national responsibility, with few transboundary implications because domestic water supplies usually represent small volumes relative to total withdrawals. Three aspects of domestic water use make it a regional concern:

- Demand for domestic water use is universal;
- Wastewater disposal may contaminate water for downstream users; and,
- Social and economic consequences of disruption of supply are very serious.

Related development opportunities at the basin scale comprise for example priority given to the sector in connection with over-all water allocation for other purposes; and regional knowledge-sharing.

Industrial water use

In the Lower Mekong Basin, industrial water use is small in terms of volume but high in terms of value. Many water-consuming industries use groundwater.

Industrial development in the Lower Mekong Basin is at an early stage, however, urbanization is rapid and the growth rate of the industrial sector is high. Northeastern Thailand and the Mekong Delta are the most advanced industrial areas in the region. Industrial development in Cambodia and Lao PDR is almost exclusively taking place in the capital municipalities, Phnom Penh and Vientiane.

Regional development opportunities comprise for example priority given to the sector in connection with over-all water allocation for other purposes; and regional knowledge-sharing within industrial water efficiencies and industrial waste management.

Flood management and mitigation

Floods are a recurring event in the Lower Mekong Basin (LMB). Each year, flooding results in loss of life and property, damage to agriculture and rural infrastructure and disrupts the social and economic activities of people living throughout the LMB. At the same time, flooding of the mainstream and tributaries of the Mekong River is an important reason for the wealth in biodiversity, abundance of fish and soil fertility.

The MRC Flood Management and Mitigation Programme (FMMP) started on a full scale in 2005 in support of the many development opportunities within regional flood management, such as flood forecasting and preparedness, structural intervention, land management, and related capacity-building.

Watershed management

The sub-watersheds of the Mekong River in the four LMB countries have experienced rapid deforestation and watershed degradation, particularly in the upland regions. As a result, a number of serious environmental and socio-economic problems have developed, including increased run-off, erosion, siltation, and the loss of rural livelihoods. LMB governments have attempted to respond to these problems through new policy and legislation, reforestation programs and other forms of watershed management. However, the WSM process faces numerous challenges.

Regional development opportunities comprise for example awareness- and capacity-building joint research, and knowledge-sharing.

13 Solutions

No solutions are offered in the present document. Recommendations on appropriate responses to the various sector issues and priorities will be addressed by the *'Strategic Directions for IWRM in the Lower Mekong Basin'* (in preparation, mid 2005).

14 Findings and recommendations/ lessons learnt

Important lessons were learnt during preparation of the regional sector reviews, as well as during the subsequent application of the results, and, later on, during preparation of the BDP Planning Atlas[198].

- There is a scope for identification and implementation of a set of practical and useful development indicators for basinwide monitoring within water-related sectors, for the sake of water resources management support and for appropriate and timely response to new challenges

- Knowledge gaps about basic cause-effect relationships need to be filled in many places

- There is a scope for consolidation of the inter-sector dialogue and knowledge-sharing, at all planning levels

- There is a scope for further consolidation of the regional dialogue and knowledge-sharing , within the BDP framework and among the MRC sector programmes

- The applied sector structure may be re-considered in the context of water-related sectors (and themes) that was used throughout BDP Phase 1. There would be clear practical advantages of a gradual convergence between the *'BDP sectors'* and the MRC programmes; and there are some visible gaps in the present sector and theme structure, such as drought management; morphological management; and operational flow management.

15 Relevance

15.1 Relevance for NMCs and/or line agencies

While each NMC and each line agency have full insight into their own national sector issues and development agendas, the regional sector overviews provide a basin-scale context that can expand the scope of the national development efforts, and (via the subsequent planning activities) add value to these efforts.

198 In preparation (mid 2005)

15.2 Relevance for MRCS and/or BDP Phase 2

Just like sub-basin and national planning, basinwide planning must build on 'the best knowledge available', notably including knowledge about the concerns, opportunities, dependencies and constraints that exist within and among the sectors covered by the planning.

16 Concluding general outlook

The regional sector overviews were prepared before the closely related national sector overviews and the sub-area studies. Since their publication in 2002, the knowledge base has been applied in connection with various subsequent activities (scenario analysis and strategy formulation), and the sector overviews have been re-visited during preparation of the BDP Planning Atlas.

During BDP Phase 2, the sector overviews should be carried up to date, in a more condensed form, as introduced in the BDP Planning Atlas, and possibly in connection with preparation of a new State of the Basin report.

The work should be carried out by the various MRC programmes that have the particular expertise within each sector.

References

ADB (1998): National Water Sector Profile - Lao PDR (Draft). Asian Development Bank.

ADB (2000): Environments in transition: Cambodia, Lao PDR, Thailand, Viet Nam. www.adb.org

ADB (2000b): Country economic review, Socialist Republic of Viet Nam, www.ADB.org

ADB (2001): Building on Success: A Strategic Framework for the Next 10 Years of the GMS Program. 29 November 2001.

ADB (2001): Lao PDR – Country Strategy and Program 2002-2005. www.adb.org

ADB (2001): National Water Sector Profile, Kingdom of Cambodia. MOWRAM and ADB Project Report No. 7, July 2001.

ADB (2001): Viet Nam – Country Strategy and Program 2002-2004. www.adb.org

ADB (2001a): Country strategy and program 2002-2004, Lao PDR, www.ADB.org

ADB (2001b): Country economic review. Thailand, www.ADB.org

ADB (Nov 2001): Indicative master plan on power interconnection in GMS countries, Volume II main report, draft final report

ADB (2002): Asian Development Outlook 2002, Cambodia, www.ADB.org

ADB (2002): Building on Success, GMS Flagship Programs and Development Matrix. 19 September 2002.

ADB (2002): Cambodia – Country Strategy and Program 2003-2005. www.adb.org

ADB (2002): Mekong River Countries Stepping Up Cooperation in 10-Year Plan. ADB News Release No. 162/02, 19 September 2002. www.adb.org/Documents/News/2002/nr2002162.asp

Asean Focus Group, 2000. Disastrous Floods on the Mekong http://www.aseanfocus.com/asiananalysis/Article.cfm?Article ID=350

Bangkok Post, 1998; July 12

BDP (2002): National Development Policy Review. In Draft Working Paper – Planning Process. BDP-004.

BDP (2002): Basin Development Plan, planning process, BDP, No. 004

BDP (2002a): Economic in the BDP: Macroeconomic overview of the Lower Mekong Basin and the BDP project cycle, BDP, No. 10

Cambodia Country Paper 1999

Cambodia Ministry of Agriculture 1993. Agricultural Statistics: Quarter 1 1993. Cambodia Ministry of Agriculture, Phnom Penh.

Cambodia Ministry of Agriculture, Forestry and Fisheries 2000. Agricultural Statistics 1999-2000. Cambodia Ministry of Agriculture, Phnom Penh.

Cambodia Ministry of Planning 1996. Summary: First Socio-economic Development Plan, 1996-2000. Cambodia Ministry of Planning, Phnom Penh.

Cambodia National Institute of Statistics 1998. 1998 Population Census of Cambodia. Cambodia National Institute of Statistics, Phnom Penh.

Campbell, I, Tin Nguyen Thanh and Sein Mya (2002) The Mekong River Commission and Water Quality Monitoring in the Lower Mekong Basin. Mekong River Commission Environment Program.

Chheng, Ear Kim 2002; Industrial wastewater management in Phnom Penh city, Cambodia, report at AIT.

CNN, 2002. Floods kill 49 in Viet Nam (Monday, 23 September 2002). http://asia.cnn.com/2002/WORLD/asiapcf/southeast/09/23/vietnam.floods.reut/index.html

Desbarats, J., Sik, B. 2000. People and Land in Rural Cambodia. Cambodia Development Review, Vol 4, Issue 3, Sept. 2000, p 6-10.

Disaster Related Laws – Thailand. http://www.adrc.or.jp/management/THA/Thailand_Legal_System.html

Draft Regional Report on Protected Areas and Development. A discussion paper for the review of protected areas and their roles in the socio-economic development of the four countries in the Mekong region. IUCN/ WWF/MRC, October 2002.

Falvey, L. 2000. Thai Agriculture: Golden Cradle of Millennia. Kasetsart University Press, Bangkok

FAO 1997. FAO-AQUASTAT: Thailand Country Profile. Accessed at http://www.fao.org/ag/agl/aglw/aquasat/countries/thailand/index.stm on 20 October 2000.

FAO 1999a. FAO-AQUASTAT: Cambodia Country Profile. Accessed at http://www.fao.org/ag/agl/aglw/aquasat/countries/cambodia/index.stm on 20 October 2000.

FAO 1999b. FAO-AQUASTAT: Lao PDR Country Profile. Accessed at http://www.fao.org/ag/agl/aglw/aquasat/countries/laos/index.stm on 20 October 2000.

FAO 1999c. FAO-AQUASTAT: Vietnam Country Profile. Accessed at http://www.fao.org/ag/agl/aglw/aquasat/countries/viet_nam/index.stm on 20 October 2000.

FAO 2001. Selected Indicators of Food and Agriculture in the Asia-Pacific Region 1990-2000 Food and Agriculture Organization of the United Nations, Regional Office for Asia and the Pacific, Bangkok.

FAO 2002. FAOSTAT- Agriculture Database. Accessed at http://apps.fao.org/page/collections?subset=agriculture on 13 August 2002.

FAO/UNDP 1994. Cambodia: Agricultural Development Options Review (Phase I), Volume 1: Sector Review. FAO/UNDP, Phnom Penh.

FCMP 1999. Forest Cover Monitoring Project Final Report. MRC/GTZ, Vientiane.

Gregory, R. and H. Guttman, 2002. The ricefield catch and rural food security, p1-13. In: P. Edwards, D.C. Little and H. Demaine (Editors), Rural Aquaculture, CABI Publishing, Wallingford, UK.

GTZ 2002a. 'Report on the Appraisal Mission of Watershed Management in the Lower Mekong Basin. Volume 1: Main Report.' GTZ, Phnom Penh.

GTZ 2002b. 'Report on the Appraisal Mission of Watershed Management in the Lower Mekong Basin. Volume 2: Country Reports.' GTZ, Phnom Penh.

Halcrow Water 2002. 'Review of Historic Water Resources Development and Water Use: Water Utilisation Programme Component.' Mekong River Commission / Halcrow Water, Phnom Penh.

Hart B (2001) Transboundary water quality issues in the Mekong River basin. Water Studies Centre, Monash University / Mekong River Commission. Melbourne, Australia.

Hart, Berry T, 2001; Transboundary water quality issues in the Mekong River Basin, MRC

Hori, H. 2000. The Mekong: Environment and Development. United Nations University Press, Tokyo.

Hori, Hiroshi 2000; The Mekong. Environment and development

http://earthtrends.wri.org/datatables

http://www.adrc.or.jp/management/KHM/KHMeng99/Cambodia99.htm

Huguet, J. W., Aphichat Chamratrithriong, Nott Rama Rao and San Sy Than 2000. Results of the 1998 Population Census in Cambodia. Asia-Pacific Population Journal, September 2000.

IFRC, 2000. Millions affected by massive Mekong Floods. Insight, July 2001.

IMF 2002a. Cambodia: Statistical Appendix. International Monetary Fund, Washington D.C.

IMF 2002b. Lao PDR: Selected Issues and Statistical Appendix. International Monetary Fund, Washington D.C.

IMF 2002c. Thailand: Statistical Appendix. International Monetary Fund, Washington D.C.

IMF 2002d. Viet Nam: Selected Issues and Statistical Appendix. International Monetary Fund, Washington D.C.

Inmuong, Y (1998) Thailand Water Pollution Crisis : A Case on Massive Fish Deaths in Nam Phong River. FACT SHEET - Environmental Health : Vol. 1 No. 9 June 1998. http://www.anamai.moph.go.th/factsheet/health1-9_en.htm

IPCC, n.d. IPCC Special Report on the Regional Impacts of Climate Change, An Assessment of Vulnerability. www.grida.no/climate/ipcc/regional/index.htm

IRRI 1997. Rice Production in Cambodia: A Cambodia-IRRI-Australia Project. International Rice Research Institute, Manila.

IRRI 2002. International Rice Research Institute Country Statistics. Accessed at www.Riceweb.org on 13 August 2002.

JICA 1993. The Study on the Regional Development Plan for the Lower Northeast and the Upper East Regions in the Kingdom of Thailand: Final Report. Volume I: Agriculture. Japan International Cooperation Agency and Government of the Kingdom of Thailand National Economic and Social Development Board, Bangkok

JICA 2001. Master Plan Study on Integrated Agricultural Development in Lao Peoples Democratic Republic. Volume III: Appendices. Japan International Cooperation Agency and Lao PDR Ministry of Agriculture and Forestry, Vientiane.

JICA, n.d. Application for the Technical Cooperation (Development Study) by the Government of Japan – The Study on Flood Plain Management in the Mekong River Basin in the Kingdom of Cambodia.

KOICA 2000. Flood Control Planning for Development of the Mekong Basin Delta (Basinwide) Final Report. Volume 1: Main Report. Korea International Cooperation Agency, Phnom Penh.

Lao PDR Country Report 1999. http://www.adrc.or.jp/countryreport/LAO/LAOeng99/Lao%20PDR%2099.htm

Lao PDR Ministry of Agriculture and Forestry 1999. The Government's Strategic Vision for the Agricultural Sector. Lao PDR Ministry of Agriculture and Forestry, Vientiane.

Lao PDR National Statistical Centre 2000. Basic Statistics of the Lao PDR: 1975-2000. Lao PDR National Statistical Centre, Vientiane.

Miller, F., Nguyen Viet Thinh & Do Thi Minh Duc 1999. Resource Management in the Vietnamese Mekong Delta. Australian Mekong Resource Centre University of Sydney, Sydney.

Ministry of Water Resources and Meteorology (Cambodia), 2002. Managing the Effects of Sedimentation and Channel Migration, Mekong River at Kampong Cham Province.

MoE, 2002; Waste management program, Ministry of Environment, Department of environmental Pollution Control

Monirith, I., Haruhiko Nakata, Shinsuke Tanabe and Touch Seang Tana 1999. Persistent Organochlorine Residues in Marine and Freshwater Fish in Cambodia. Marine Pollution Bulletin Vol. 38, No. 7 pp. 604-612, UK

MRC (1993): Mekong Water Quality Monitoring and Assessment Expert Meeting: Residue Pesticide Monitoring in the Mekong Basin. Mekong River Commission Secretariat, Bangkok.

MRC (1997): Mekong River Basin Diagnostic Study Final Report. Mekong River Commission Secretariat, Bangkok.

MRC (1997): Mekong River Basin Diagnostic Study, Final Report.

MRC (1997b): Mekong Basin Development Plan Phase I - A Country Report: Thailand. Mekong River Commission Secretariat, Bangkok.

MRC (1998) Hydrological Year Book. Mekong River Commission.

MRC (1998a): Agriculture and Irrigation Programme for Co-operations Towards Sustainable Development of the Lower Mekong Basin. Mekong River Commission Secretariat, Bangkok.

MRC (1998b): Guidelines on Mainstreaming Gender in Water Resources Development in the Lower Mekong Basin. Mekong River Commission Secretariat, Bangkok.

MRC (1999): Basin Development Plan Draft Working Paper 2: Baseline Conditions. Mekong River Commission Secretariat, Phnom Penh.

MRC (2000): 'Strategy Study on the Development of the Watershed Management/Forestry Sector in the Lower Mekong Basin.' Mekong River Commission, Phnom Penh.

MRC (2000): Strategy Study on the Development of the Watershed Management/Forestry Sector in the Lower Mekong Basin: Strategy and Action Plan. Mekong River Commission Secretariat, Phnom Penh.

MRC (2001): Metadata for MRC SECRETARIAT GIS Core Datasets. Mekong River Commission Secretariat, Phnom Penh.

MRC (2001): MRC Strategy on Flood Management and Mitigation. November 2001.

MRC (2001): Working Paper No. 12 – Interim Report on Development of Models. Halcrow Water. Phnom Penh.

MRC (2002): First Annual Mekong Flood Forum: Proceedings.

MRC (2002): FMM Strategy Implementation Program (FMMSIP), Draft. September 2002.

MRC (2002): Provision of Flood Early Warning to Flood-Vulnerable Communities in the Lower Mekong River Basin: A Flood-Referencing Proposal to the Office of US Foreign Disaster Assistance.

MRC (2002, July): Assessment of trends in the transport sector of the Lower Mekong Basin with special emphasis on waterborne transport

MRC (2002a): Cambodia National Policies. Unpublished Paper by Solieng Mak, MRCS-BDP.

MRC (2002b): MRC-EP Water Quality Data

MRC (2002c): Technical Paper 6

MRC (2002d): Land Resources Inventory for Agricultural Development Project: Technical Report – Part III. Mekong River Commission Secretariat, Phnom Penh.

MRC (2002e): MRC Irrigation Database

MRC (2003): State of the Basin Report

MRC Technical Paper No. 4: Deep pools as dry season fish habitats in the Mekong Basin

MRC Technical Paper No. 6: Fisheries in the Lower Mekong Basin: Status and Perspectives 2002

Nielsen T.K. (2002) Water utilisation in the Lower Mekong Basin. DHI Water & Environment. Web page http://kellnielsen.dk/tkn/mekong/w-uses.htm

Nielsen, Tue, 2002; DHI, Interview, September

NSWSS (2000) National Strategy for Water Supply and Sanitation. Government of Viet Nam.

Ojendal and Torell, 1997; The mighty Mekong mystery. A study on the problems and possibilities of natural resources utilization in the Mekong River Basin, AFI

Pedersen, Ole, 2002; Danida consultant, Interview, November

Plan – Cambodia http://www.adrc.or.jp/management/KHM/Cambodia_Plan.htm?Lang=en&Key=&Fram...

Plan – Lao PDR. http://www.adrc.or.jp/management/LAO/LaoPDR_plan.html

Plate, E.J. and Thanongdeth Insisiengmay, 2002. Warning Systems for the Mekong River. Paper presented at an international seminar in Beijing, September 2002.

Ringler, C. 2001. Optimal Water Allocation in the Mekong River Basin ZEF Discussion Report 38 on Development Policy .

Ringler, Claudia 2001; Optimal allocation and use of water resources in the Mekong River Basin: Multi-country and intersectoral analyses

Royal Government of Cambodia (2000) Second five year socio economic development plan 2001-2005: National economic growth and poverty reduction strategy. Draft. Royal Government of Cambodia. Ministry of Planning. Phnom Penh, Cambodia. 55p

Seager, M (2002) Water for domestic use and sanitation. Chapter 2, State of the Basin Report, Mekong River Commission (DRAFT)

Sophal Chan, 2001. The Impact of Cambodia's Recent Floods. Cambodia Development Review, Vol. 5, Issue 1. January-March 2001, pp. 1-4.

SPC, 2000; Basic Statistics of Lao PDR, 1975 – 2000, State Planning Committee, National Statistical Centre

Thailand Country Report 1999. http://adrc.or.jp/countryreport/THA/THAeng99/Thailand99.htm

Thailand Ministry of Agriculture and Cooperatives 2001. Agricultural Statistics of Thailand, Crop Year 2000/2001. Thailand Ministry of Agriculture and Cooperatives, Bangkok.

Thailand National Statistics Office 2000. Statistical Reports of Region: Northeastern Region 2000. Thailand National Statistics Office, Bangkok.

Triet and Dan, 2002; Prof Triet and Dr. Dan at CEFINEA, Institute for Environment and Resources, Viet Nam National University, Ho Chi Minh City, communication by e-mail.

UNDMT-Structure. http://www.disaster.info.desastres.net/saludca/desastresCR/udmt.html

UNDP, 2002. UNDP Support to Mekong River Commission in Flood Management and Mitigation and Environmental Governance, Report of Programme Formulation Mission (Draft). Phnom Penh: UNDP-Cambodia, July 2002.

UNEP/MRC, 1997; Mekong River Basin diagnostic study. Final report

UNESCAP/ADB, 2000; State of the environment in Asia and the Pacific, www. unescac.org

UNICEF (2001) Shaping the future for children in east Asia and the pacific. Fifth East Asia and Pacific Ministerial Consultation, 14-16 May 2001, Beijing. New York. 89p

UNICEF (2002) End Decade Data Bases. Web site http://www.childinfo.org/eddb/water/trends.html

Valdimarsson, Omar, 2002. Mekong River Basin threatened by major floods. Red Cross Red Crescent – News, 23 August 2002. http://www.ifrc.org/docs/news/01/082301/

Viet Nam Country Report 1999. http://www.adrc.or.jp/countryreport/VNM/VNMeng99/Vietnam99.htm

Viet Nam General Statistics Office 1999. Statistical Yearbook: 1999. Statistical Publishing House, Hanoi.

Vikrom Mathur, Mak Sitirith, Joakim Öjendal (2001): Assessing environmental governance in the lower Mekong river basin: A study of the hydropower site selection process in the Se San and Sre Pok. Papers from the Mekong Regional Environmental Governance Research and Dialogue Group (Resource Policy Support Initiative)

WFP (2000): Immediate Response Emergency Operation Laos, Project Document.

World Bank (1999): Vietnam Mekong Delta Water Resources Project, Project Appraisal Document

World Bank (2000): Water Utilisation Project, Project Appraisal Report

World Bank (2001): Cambodia Emergency Flood Recovery Project: Project Information Document

World Bank (2001): Cambodia – Flood Emergency Rehabilitation Project: Program Identification Document.

World Bank (2001): Cambodia – Social Fund II Supplemental Financing for Flood Rehabilitation of Small Scale Infrastructure: Program Identification Document.

World Bank (2002): Mekong Delta Water Resource Project: Project Details. http://www4.worldbank.org/sprojects/Project.asp?pid=P004845

World Bank (2002): The Kingdom of Cambodia – Vulnerability and Natural Disaster Management Study, Terms of Reference

World Bank (2002): Viet Nam – Natural Disasters Mitigation Program: Program Identification Document. http://www.worldbank.org/pics/pid/p073361.txt

WUP (2001): Review of historic water resources development and water use, Working Paper No 2

www.UNIDO.org