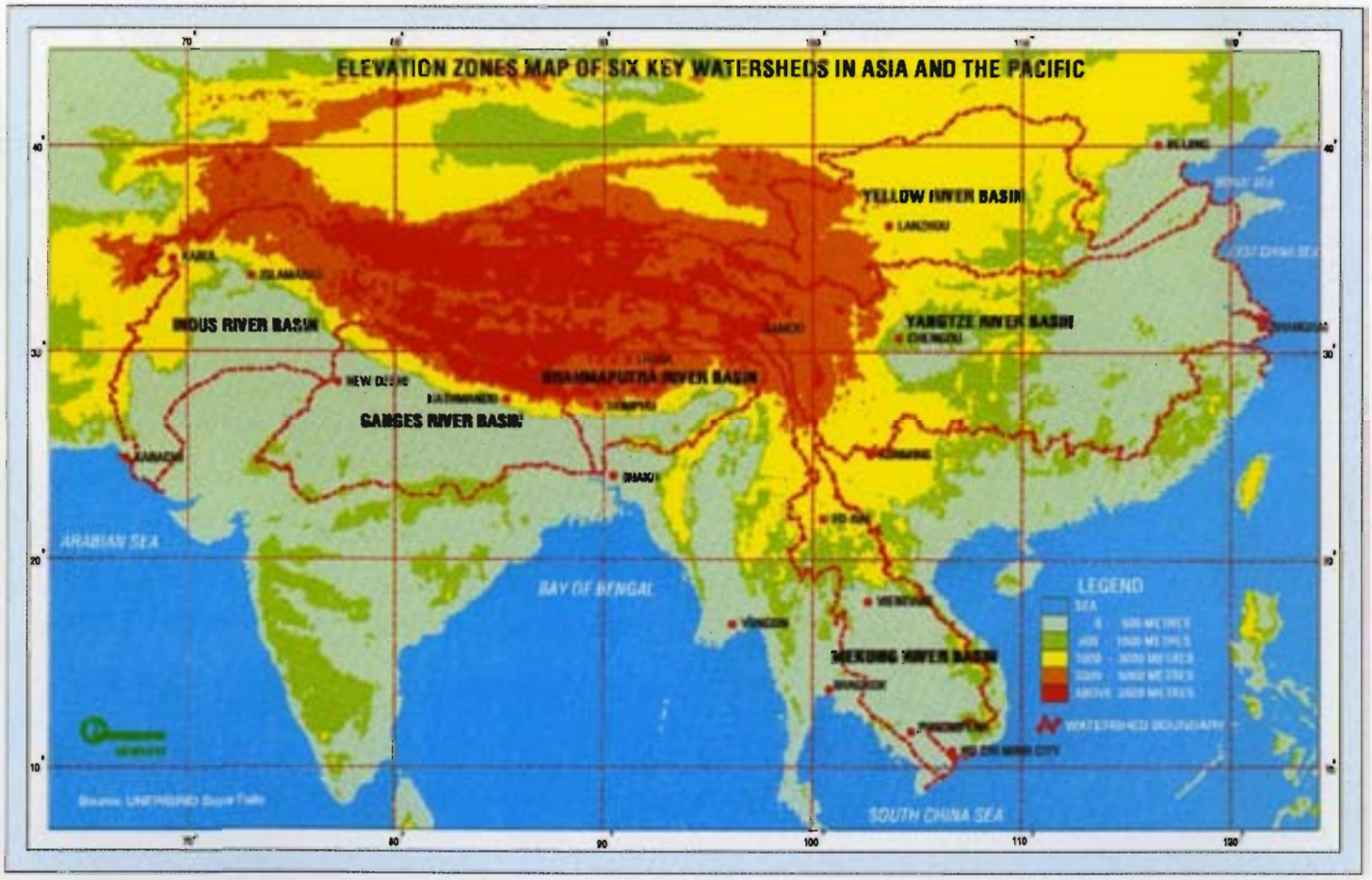
Forestry and Key Asian Watersheds



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Cover Page: Map of Elevation Zones of Six Key Watersheds in Asia and the Pacific

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Forestry and Key Asian Watersheds

A Paper Prepared as Background Document for the Asia-Pacific Forestry Outlook Study of the Food and Agriculture Organization with Financial Support from the Canadian International Development Agency (CIDA)

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With Inputs from Four Background Documents

'Yangtze River Basin Forestry'
by
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'Yellow River Basin Forestry'
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'Indus River Basin Forestry'
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'Brahmaputra River Basin Forestry'
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Foreword

Six of the largest river basins in the world originate from the Tibetan Plateau, far above the tree line, and cover downstream areas with the highest population density in the world, no longer allowing for any substantive areas of forest. In between, these rivers flow through mountains and hilly areas, where millions of people over the ages have been highly dependent on forests for their daily needs for fuel, fodder, timber, and numerous other non-timber forest products and services. Forest also play an important role in protecting soils and regulating water flows.

While over the last 40-50 years, many studies have been carried out on the role of forests in watersheds of small and medium sizes, in Asia no comparative studies had been undertaken at the time the Asia Pacific Forestry Commission decided to prepare the Asia Pacific Forestry Sector Outlook study in 1996. As part of this study, ICIMOD was asked to prepared a background document analysing the role of forestry in key Asian watersheds. It was a new challenge for ICIMOD to go beyond the centre's usual focus on the Hindu Kush-Himalayan Region, and in particular to areas below 300 metres, areas inhabited by hundreds of millions of people who are largely dependent on irrigated agriculture fed by the rivers that had collected their waters in rugged terrains and high forests upstream.

The present document is a first attempt to synthesise the information that could be collected in a relatively short period. This has only been possible by combining the information available from satellite imagery with the considerable knowledge and experience of five consultants who prepared background documents on four of the watersheds. An earlier draft had benefitted from comments by the Forestry Outlook Study Steering Committee, which met at ICIMOD in Kathmandu in November 1997.

We are grateful to FAO for giving us this opportunity to look at the broader picture of forestry and large watersheds and to the Canadian International Development Agency which provided financial support for the study, as well as for the meeting of the steering committee. The authors of the background documents deserve a special mention for their timely submission of highly useful information. Prof. A. K. Myint, Dr. T. Hofer and ICIMOD's editorial and desktop publishing staff have been particularly helpful in processing the document in time for the next session of the APFC in Yogiatarta, Indonesia.

The present study provides some of the answers to the questions raised two years ago. It also points out that more detailed analysis and collection of data, focussing on specific areas in these watersheds, would be particularly helpful in determining the types of interventions and support mechanisms needed in the forestry sector and beyond. The people and environment of these lifelines of development deserve this much attention.

Egbert Pelinck
Director General

Acknowledgements

This case study was made possible by the support and collaboration of the Canadian International Development Agency (CIDA) and FAO. The authors thankfully acknowledge the constant support of these organizations.

The authors would like to acknowledge with sincere appreciation the contributions of Professor Li Wenhua, Chinese Academy of Sciences, Professor Shen Guofang of the Beijing Forestry University, and Professor Chen Guagwei of the Chinese Academy of Sciences to work on the Yangtze and Yellow River basins. For contributions on the Indus River Basin, we would like to acknowledge the valuable contributions of Dr. Ghazi Marjan of the Forest Management Centre, Pakistan. Without the contributions of Professor D.C. Goswami of Gauhati University, India, the sections on the Brahmaputra River Basin would have been incomplete. We also benefitted from the wealth of knowledge of Dr. V. N. Pandey of the Forest Survey of India with respect to information on the Ganges' Basin.

We here would like to acknowledge the continual encouragement and support provided by the Director General of ICIMOD, Mr. Egbert Pelinck. His valuable suggestions and guidance have been persistent throughout.

The document was prepared for publication in a very short period of time. We here acknowledge the contributions of the Senior Editor, Greta Rana; Cartographer, Asha Kaji Thaku; and Desktop Publisher Sushil Man Joshi. The original maps were prepared by Govinda Joshi of MENRIS, ICIMOD.

Prof. A. K. Myint
Dr. T. Hofer

Abstract

Six major rivers of Asia are studied for the forestry situations in their watersheds: the Indus, Ganges, Brahmaputra, and Mekong are international rivers, whereas the two other rivers studied are the Yangtze and Yellow rivers of the People's Republic of China. Basic information on the geography, climate, hydrogical conditions, sediment and water quality, land cover, and socioeconomic conditions of these river watersheds are described. The importance of hydropower potential in the areas is mentioned, while the amounts of erosion and sediment loads are pointed out. Forest resources in each individual watershed are discussed. The main driving forces affecting the forest cover, which include national policies, population growth and poverty, economic development and industrialisation, infrastructure and hydropower production, climate change, and highland lowland interactions are classified and deliberated upon. Prospects for forestry towards the year 2010 assuming the various scenarios are predicted. The implications for future action are assessed concerning the elevation zones between 300 to 3,000 m; forestry management for and by local communities; integrated approaches in planning; economies based on forestry and environmental conservation; development of other sectors; international conventions; measures for mangrove forest improvement; the reimbursement of highland societies for benefits received in the lowlands; and the assistance of the global community in conserving biodiversity are emphasised . Recommendations for assessment of forest cover and analysis of the role of forestry in selected meso-watersheds are made.

Table of Contents

Chapter 1
Introduction

The United Nations Conference on Environment and Development (UNCED) held in Rio de Janeiro in June 1992 provided impetus and commitment to international activity focussed on the world's forests by defining Chapter 11 of Agenda 21 as *'Combating Deforestation'*. In Chapter 13, *'Managing Fragile Ecosystems: Sustainable Mountain Development'*, the forests receive considerable attention, too.

The annual loss of tropical forests in South Asia and Continental South East Asia was reported as 0.6 million ha and 1.3 million ha respectively during the periods from 1980-90 (FAO 1995a and 1995b) and 0.14 and 1.16 million ha respectively for the period 1991-95 (FAO 1997b and 1997c). FAO (1995c) carried out a comprehensive study on tropical forest plantation resources and reported that nineteen tropical Asian countries had annual plantation rates averaging 2.112 million ha during the period from 1980-90.

In view of these figures there is no doubt that the Asia-Pacific region is undergoing changes brought about by rapid economic growth and the continuing increase in its population. In order to assess these various changes, the FAO has proposed an outlook study for the forestry sector with the time horizon of 2010. This proposal was agreed to by the Asia-Pacific Forestry Commission at its sixteenth session in Yangon. The Asia-Pacific Forestry Outlook Study has the overall function of assessing the status, trends, and outlook for the forestry sector up to 2010. Implementation will involve the collection of specific studies which will then be jointly analysed and blended into the overview report.

As one component of the Asia-Pacific Forestry Sector Outlook Study, ICIMOD was asked to provide an in-depth analysis of forestry development and key Asian watersheds. The purpose of the study, entitled 'Forestry and Key Asian Watersheds', was to present a summary assessment of the current situation, trends, and prospects up to the year 2010 of mountain watersheds/ ecosystems, the significance and roles of forests and trees in them, pressures and potentials on these forest resources, and the main uses by local and external beneficiaries of the productive environmental and social roles of forests in these areas. The specific topics to be covered by the study include the following.

- The key mountain/watershed systems of Asia-Pacific and their significance in the region. Economic and social significance singly and in the context of downstream benefits.

- The situation; main situation of forests and trees in mountain/watershed regions, with a focus on observed patterns of degradation and/or rehabilitation and the institutional and policy environment for conservation, sustainable management, and use of forest resources in these zones.

- The main driving forces influencing the state and continued survival of the forests in key mountain/watershed areas.

- Implications of future scenarios for policy and action - including necessary investments.

The present study covers the watersheds of the Yellow River, the Yangtze River, the Mekong River, the Ganges River, the Brahmaputra River, and the Indus River. The six basins selected for this study represent the major, largest and most important river systems in Asia and the Pacific region. In order to procure background information for the study, national professionals were consulted, and their reports were brought together into this report. Various other studies were available and used: studies on the Ganges and Brahmaputra River basins and the upper reaches of the Yangtze River Basin were carried out by Bruijnzeel and Bremmer (1989) and Jizheng (1993). The Mekong River Commission reported on the analytical situations of the riparian countries of the Mekong River (MRC 1997) and published the proceedings of the Mekong watershed classification and forest cover seminar (MRC 1995). Hofer and Messerli (1997) have discussed the flood characteristics of Bangladesh in the framework of Himalayan highland-lowland interactions.

For this study some very important general comments have to be made. Generalisations have to be made in order to achieve the goals of the study.

- The watersheds discussed in this report are huge. There is a lot of variation within and between the six watersheds which can not be given sufficient attention in this report. Many, in part risky, generalisations have to be made in order to achieve the goals of the study.

- The aim of this study is not to provide complete, detailed information, this would be impossible to do. The approach we have taken is to highlight a number of striking key issues, typical of the six watersheds, on a highly aggregated level.

- The data situation is very difficult. Comprehensive data sets are either not available or not comparable. Only the 1992-93 NOAA satellite data provide a basis for comparison in a broader sense. Therefore, many statements in the report are generalisations.

- The first part of the report provides an overview of the physical conditions in the six key watersheds. In the second part the forests are at the centre of the discussion.

Chapter II
Basic Information

The Geographical Context

The Indus, Ganges, and Brahmaputra are of a comparable length and have their source in a common area, which is near the Mount Kailash Range (Map 1, Table 1). The flow direction in the mountainous catchments, however, is different for each river: the Indus to the west, Ganges to the south, and Brahmaputra to the east. The Ganges and Brahmaputra discharge as joint rivers into the Bay of Bengal, the Indus flows into the Arabian sea.

Table 1: **The Six Key Asian Watersheds - Statistical Figures**

River	Length (Km)	Watershed Size (Sq.Km	Countries Sharing the Watershed
Indus	3200	945,000	China, India, Afghanistan, Pakistan
Ganges	2950	1,050,000	China, Nepal, India, Bangladesh
Brahmaputra	2880	580,000	China, India, Bhutan, Bangladesh
Mekong	4800	795,000	China, Myanmar, Laos, Thailand, Cambodia, Vietnam
Yangtze	6290	1,808,500	China
Yellow	5464	752,443	China

Source: UNEP 1995

The Mekong, Yangtze, and Yellow rivers are considerably longer. The Yangtze and Yellow rivers form the two longest rivers in Asia and are the third longest and the seventh longest rivers in the world respectively.

Only 30 per cent of the total drainage area of the six river systems is located in the lowlands below 300m (1,000 feet). Twenty-seven per cent are located above 2,300m (7,000 feet). The area of the big watersheds located in hilly and high altitude zones is rather significant (Map 1, Table 2).

This general statement has to be differentiated for the six watersheds which can be seen also from the individual maps for each of the watersheds : Indus (Map 3), Ganges (Map 5), Brahmaputra (Map 7), Mekong (Map 9),Yangtze (Map 11), and Yellow River (Map 13). The catchments of the

Table 2: **Elevation Zones for Six Key Watersheds in Asia and the Pacific**

No	Elevation Zone (Feet)	River Basin (Area in thousand sq. km.)													
		Yangtze		Yellow		Indus		Ganges		Brahmaputra		Mekong		Total	
		Area	%	Area	%	Area	%	Area	%	Area	%	Area	%	Area	%
1	0 - 1,000	603.86	33.39	56.06	7.06	330.32	34.97	510.09	48.58	108.92	18.78	250.19	31.47	1,859.44	31.14
2	1,000 - 3,000	418.13	23.12	61.54	7.75	95.97	10.16	113.51	10.81	34.22	5.90	290.81	36.58	1,014.17	16.98
3	3,000 - 7,000	290.26	16.05	467.09	58.82	135.55	14.35	70.88	6.75	43.15	7.44	136.42	17.16	1,143.35	19.14
4	7,000 - 11,000	119.72	6.62	77.11	9.71	85.30	9.03	33.81	3.22	30.86	5.32	20.43	2.57	367.22	6.15
5	Above 11,000	338.91	18.74	132.22	16.65	263.35	27.88	82.74	7.88	315.23	54.35	93.65	11.78	1,226.10	20.53
6	No data	37.44	2.07	0.00		34.10	3.61	238.98	22.76	47.68	8.22	0.32	0.04	358.51	6.00
	Total	**1,809**	**100**	**794**	**100**	**945**	**100**	**1,050**	**100**	**580**	**100**	**795**	**100**	**5,972**	100

Source : USGS-IGBP Land Cover Classification Project June '97, 1992-93 NOAA (Loveland et al. 1997)

Ganges, the Yangtze, and the Mekong are dominated by elevations below 1,000m (3,000 feet). In contrast, more than 50 per cent of the Brahmaputra watershed is located above 3,600m (11,000 feet). The Indus catchment has considerable portions in the lowlands below 300m (1,000 feet) and in the highlands above 2,300m (7,000 feet). The Yellow River, finally, is dominated by altitudes between 1,000 and 2,300m (3,000-7,000 feet). This differentiation results in other patterns of natural resources in the watersheds, e.g., forests, and therefore has different implications for future strategies.

Climatic and Hydrological Conditions

General Climatological Conditions

The six key Asian watersheds are characterised by a variety of climatic conditions ranging from tropical/subtropical to alpine climates, e.g., the Ganges, Brahmaputra, and Mekong catchments, from rather humid to dry conditions, e.g., the Yangtze and Yellow rivers, from dry conditions to alpine climates, e.g., the Indus catchment. The rainfall diagrams in Figure 1 document a wide range of rainfall characteristics from west to east and from higher areas to lower areas. The diagrams are grouped according to the six key watersheds and within each watershed according to the position within the respective river system (higher to lower areas).

In general there is a dominance of monsoon rainfall patterns with maximum precipitation in the summer months. An exception is the Indus catchment where the winter precipitation, caused by the westerlies, is generally higher than the monsoon rains.

- The annual rainfall increases from the Indus to the Brahmaputra catchment and then decreases again further to the east.

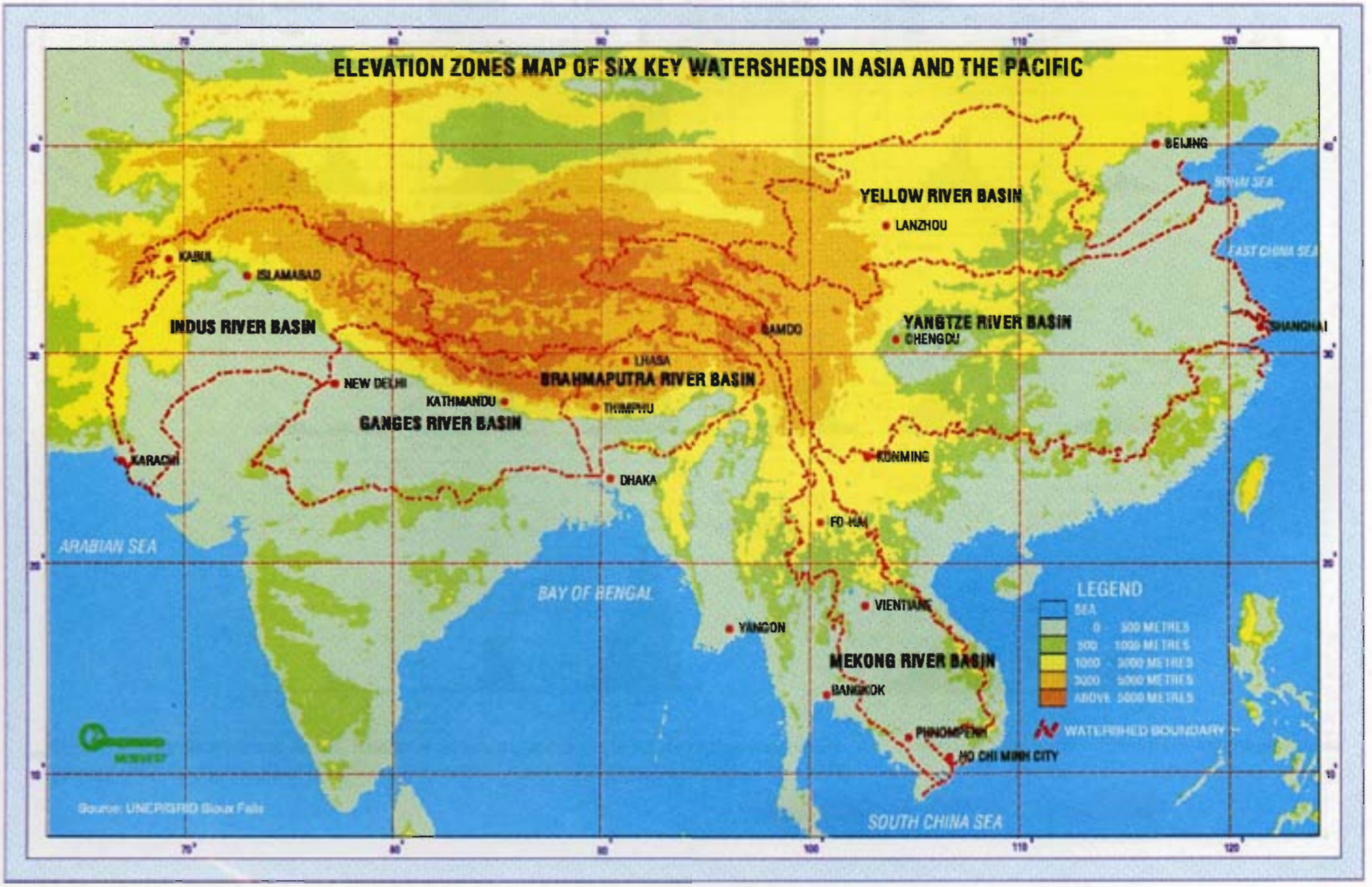
- The duration of the rainy season increases towards the east.

- In the Indus, Ganges, and Brahmaputra, the rainfall in the hills is higher than on the plains. For the other three watersheds, the situation is vice versa.

- In the Indus catchment, dry conditions prevail in the lowlands. In the Yellow River catchment, however, dry conditions are found on the highland plateaus.

The rainfall intensities during the monsoon season are very high, especially in the first ranges of the Himalayas where the humid winds have to rise. These rains exert a great deal of pressure in the context of erosion. This indicates that forests or good ground coverage are very critical, especially on the first Himalayan ridges, for protection against surface erosion and runoff.

MAP 1


ELEVATION ZONES MAP OF SIX KEY WATERSHEDS IN ASIA AND THE PACIFIC
BEIJING
YELLOW RIVER BASIN
LANZHOU
KABUL
ISLAMABAD
INDUS RIVER BASIN
YANGTZE RIVER BASIN
CHENGDU
SHANGHAI
LHASA
NEW DELHI
BRAHMAPUTRA RIVER BASIN
KATHMANDU
GANGES RIVER BASIN
KARACHI
DHAKA
KUNMING
ARABIAN SEA
BAY OF BENGAL
VIENTIANE
YANGON
MEKONG RIVER BASIN
BANGKOK
PHNOM PENH
HO CHI MINH CITY
SOUTH CHINA SEA
LEGEND
SEA
0 - 500 METRES
500 - 1000 METRES
1000 - 3000 METRES
3000 - 5000 METRES
ABOVE 5000 METRES
WATERSHED BOUNDARY

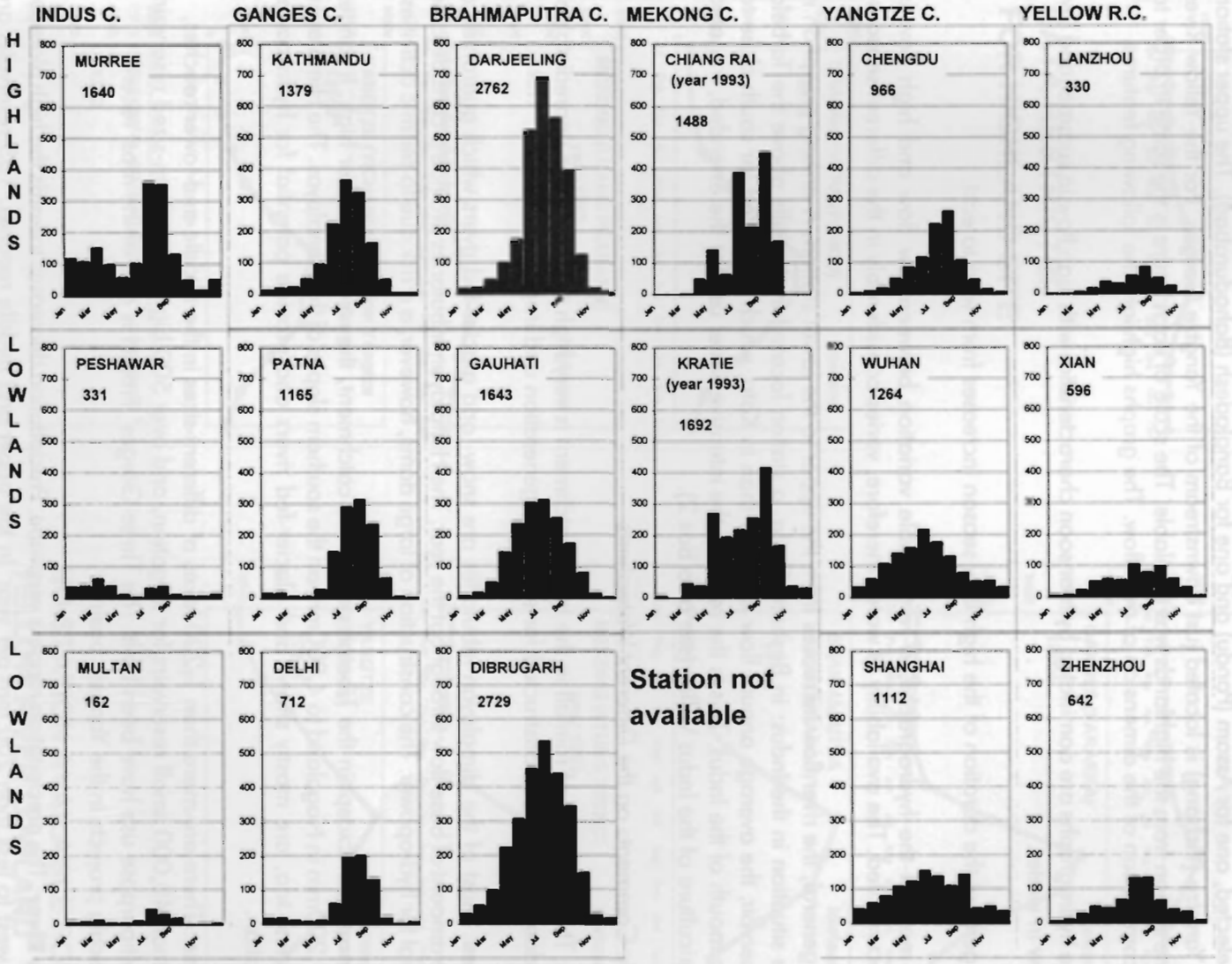


Figure 1: **Average Monthly and Annual Rainfall of Selected Stations in the Six Key Asian Watersheds** X-axis: months; Y-axis: rainfall in m; numbers in the graphs: annual rainfall
(Sources: CRU unpublished; Khan 1995; Mekong River Commission 1993, China Climatological Atlas 1978)

General Hydrological Conditions

In Figure 2, one or two typical hydrographs for each of the six rivers are shown. Except for the Mekong, the data represent average figures over a number of years. Where available (Indus, Mekong), one station in the highlands and one in the lowlands was selected. For the Ganges, only data of one station was available for the lowlands. For the Brahmaputra, two lowland stations were selected, one for Assam (Pandu) and one for Bangladesh (Bahadurabad). The upper station of the Yangtze (Yichang) is located just downstream of the Yangtze Gorges. For the Yellow River only one station from the highlands was available. The scale of each figure is the same in order to get a comparison of the dimension of river flow. The graphs highlight the following features.

- The hydrographs are dominated by monsoon characteristics with high flow in summer and low flow in winter.
- In general the duration of the high flow season increases from west to east.
- In most of the hydrographs, a remarkable variation between low flow and high flow is documented. The availability of water, therefore, varies considerably in the different seasons.
- In general, the river flow increases from the upper to the lower station. A striking exception is the situation in the Indus: in Besham Quila, a station located in the hills above the Tarbela reservoir, the average annual flow is higher than in Kotri, which is located far south close to the mouth of the Indus. This is the result of the intensive water use for the extended, irrigated agriculture of the Indus Valley (see also Box 2).

Specific Comments on the Different Watersheds

Indus: The variability of rainfall in the Indus catchment is very high and rainfall is unpredictable. Large dams have been constructed for electricity generation and irrigation.

Ganges: Most of the Himalayan tributaries are snow- and glacier-fed rivers which guarantee a certain amount of base flow throughout the year. The Himalayan tributaries provide a considerable potential for hydropower. The construction of large dams, however, is a risk due to seismic activities.

Brahmaputra: Except in the Tibetan part of the catchment, the rainfall is rather high. It ranges from 1,200mm in Nagaland to 4,000mm on the southern slopes of the Himalayas. The Himalayan tributaries, too, are mostly snow- and glacier-fed rivers and provide potential for hydropower generation.

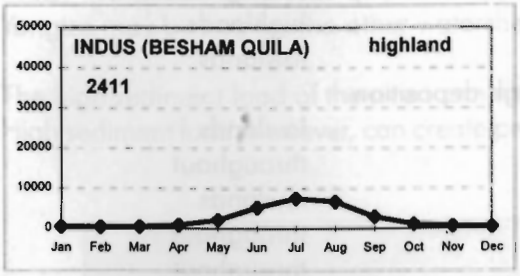
Yangtze: There are more than 1,200 lakes of different sizes in the middle and lower reaches, more than 40,000 small reservoirs for irrigation, and over 500 big and medium-sized reservoirs for multipurpose use have been built. The Three Gorges' Project is one of the most recent, large-scale projects in the Yangtze basin.

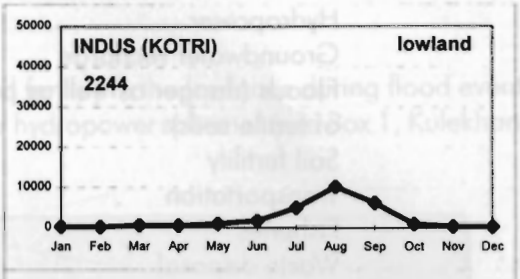
Yellow River: The precipitation range is very wide. Precipitation decreases towards the high plateaus in the west to less than 200 mm per year. In the upper and middle reaches, 155 reservoirs are operating. Thousands of checkdams and pumps are used for water harvesting.

Relevance of the Rivers within the Six Key Asian Watersheds

The rivers have a tremendous relevance for the watersheds. The relevance includes physical, economical, and cultural aspects. This relevance changes from the highlands to the lowlands.

X-axis: months; Y-axis: discharge in cubic metres per sec; numbers in the graphs: annual discharge in cubic metres per sec





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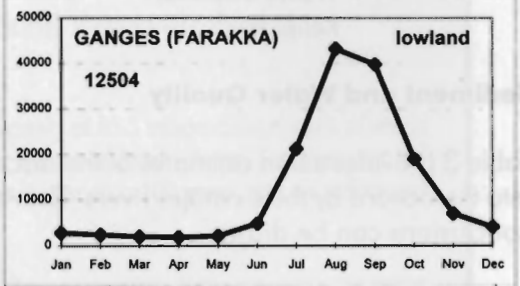
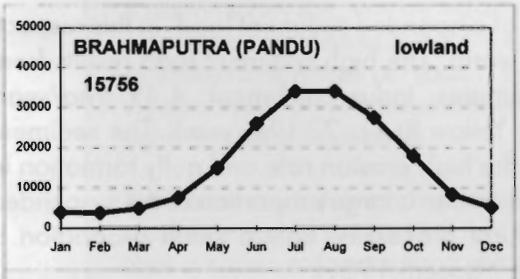
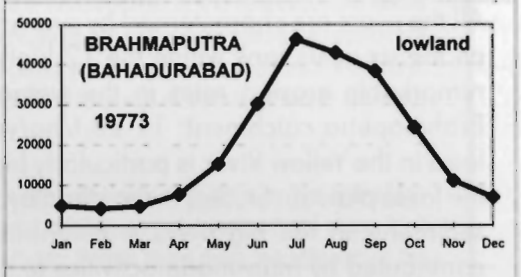
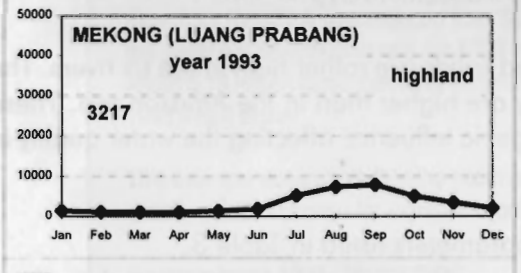
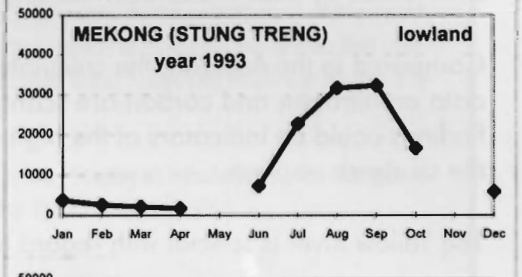
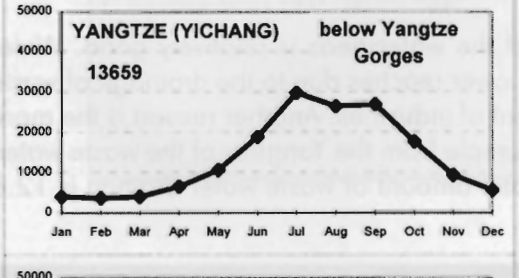


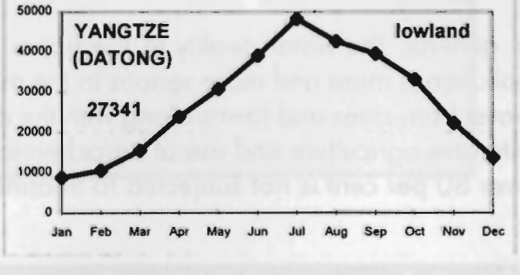


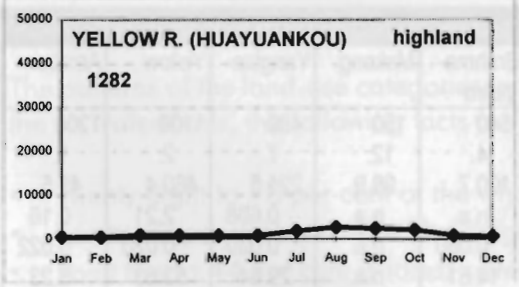












NO STATION AVAILABLE FOR YELLOW RIVER LOWLAND

Figure 2: **Average Monthly and Annual Discharge of Selected Stations in the Six Key Asian Watersheds** (Sources: GRDC, Mekong River Commission 1993, BWDB unpublished, Goswami 1983, GTZ unpublished)

Irrigation	throughout
Domestic use	throughout
Hydropower	highlands
Groundwater recharge	lowlands
Floods (danger as well as profit through deposition of fertile soils)	lowlands
Soil fertility	throughout
Transportation	lowlands
Fisheries	throughout
Waste disposal	throughout
Religion	throughout

Sediment and Water Quality

Table 3 provides some estimates of the discharge of suspended sediments and chemical elements into the oceans by the six major rivers. The Amazon River is included for comparison. The following conclusions can be drawn.

- All the rivers are characterised by a very high load of suspended sediment load. In this respect, all the six rivers rank within the 12 highest in the world. The high sediment load results from remarkable erosion rates in the watersheds (estimates: Indus catchment: 4.49 t/ha/year; Brahmaputra catchment: 11.28 t/ha/year; lower Yellow River: 23 t/ha/year). The sediment load in the Yellow River is particularly high due to the high erosion rate and gully formation in the loess plateau. Studies in the Himalayas have shown that a large proportion of the suspended sediments in the big rivers is contributed by natural processes, only a small proportion is contributed by man-made activities (e.g., Ives and Messerli 1989).

- Compared to the Amazon, the calculated dissolved solids are rather high in the six rivers. The data on nitrogen and carbon are scanty, but they are higher than in the Amazon too. These findings could be indicators of the high anthropogenic influence affecting the water quality in the six rivers.

- The Yellow River is special with regard to all the parameters listed in Table 3.

In general, the water quality in the upper reaches of the watersheds is relatively good. Water pollution is more and more serious in the middle and lower reaches due to the drainage of waste water from cities and towns along with the development of industries. Another reason is the more intensive agriculture and use of agrochemicals. An example from the Yangtze: of the waste water, over 80 per cent is not subjected to treatment. The total amount of waste water drained is 12.8

Table 3: Sediment Load and Water Quality Figures (Discharge into the Ocean) for the Six Rivers and for the Amazon

	Indus	Ganges	Brahma-putra	Mekong	Yangtze	Yellow	Amazon
Suspended sediment load (million tons/year)	250	520	540	150	480	1100	1200
Suspended sediment load (world rank)	9.	5.	4.	12.	7.	2.	1.
Calculated total dissolved solid loads (mg/l)[1]	180.1	185.6	100.7	98.9	221.0	460.4	43.5
Nitrogen (mg/l)[2]	2.2	n.a.	n.a.	n.a.	0.638	2.21	0.16
Phosphorus (mg/l)[3]	0.52	0.075	0.060	n.a.	0.020	0.020	0.022
Dissolved carbon (mg/l)	33.73	28.1	14.61	n.a.	29.54	53.63	8.23

Source: UNEP 1995

1) Ca^{++}, Mg^{++}, Na^{+}, K^{+}, Cl^{-}, $SO4^{-}$, HCO_3^{-}, SiO_2
2) Nitrate nitrogen, ammonia nitrogen
3) Orthophosphate phosphorus

billion tons/year. From the main cities, the drained waste water is about 5.4 billion tons/year, of which 4.3 billion tons/year of that amount comes from factories. A similar situation as for the Yangtze may be true for the other watersheds too.

The high sediment load of the rivers contributes to soil fertility in the lowlands during flood events. High sediment load, however, can create problems for hydropower schemes (see Box 1, Kulekhani).

Box 1
Sedimentation in the Khulekhani Reservoir, Nepal

The Kulekhani reservoir was designed with a gross capacity of 85.3 million cubic metres of which 73.3 million cubic metres is live and 11.2 million cubic metres is dead volume. The designed life span of the reservoir is 50 years, however the expected life period is 100 years, with an anticipated annual sedimentation rate of 7m³/ha.

A siltation survey has, however, indicated that, since the construction of the reservoir, the gross capacity has been reduced by about 14.47 million cubic metres out of the designed total capacity of 85.3 million cubic metres, i.e., about 17 per cent of the gross volume. Up to March 1993, therefore, the annual sediment contribution rate would have amounted to about 42m³/ha, which is six times higher than the anticipated rate.

The siltation rate is even much more dramatic during extraordinary events such as the one which occurred on July 19 and 20, 1993. As a result of extreme rainfall, an outstanding flood event took place in eastern and central Nepal with catastrophic effects. Within three days the lifespan of the Kulekhani Reservoir was reduced from 50 years to about 25 years. As a consequence of this event, the sediment contribution rate for 1993 rose to 415m³/ha, which is 59 times the anticipated rate. About 5.19 million cubic metres of sediment were contributed to the Kulekhani Reservoir by this July 1993 event alone!

This example documents that the sediment transport in the Himalayan tributaries to the Ganges is usually underestimated for extreme events and even for the average situation.

Sources: Hofer 1998, Sthapit 1996

Land Cover

The patterns of the land-use categories in the different watersheds are documented in Map 2. For the six watersheds, the following facts are worth mentioning.

- Twenty-eight to 78 per cent of the whole area is used by agriculture.
- Ten to 62 per cent is covered by rangelands.
- Point five to 44 per cent is forest cover.

In general, the available forest is concentrated on altitudinal ranges between 500 to 3,000m. Above 3,000m, it is usually too cold, below 500m the land is mostly used for agriculture. Forest cover and altitude vary between the river systems (Tables 2 and 4).

Table 4 : **Land Cover Categories in Per Cent of Total Watershed Area**

Land Cover	Indus	Ganges	Brahma-putra	Mekong	Yangtze	Yellow	Total
Forest	0.5	8.2	14.5	44.0	8.5	2.9	11.8
Rangelands *	45.9	10.2	53.6	18.4	25.1	62.2	32.6
Agriculture	37.5	77.5	26.6	36	64.1	27.8	50.0
Others **	16.1	4.1	5.3	1.6	2.4	7.1	5.6
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source: USGS-IGBP Land-cover Classification Project, June 97; 1992-93 NOAA

* Include closed and open shrublands, woody savannas, and grasslands

** Wetlands, urban, snow and ice, barren

Specific Comments on the Different Watersheds

Indus: Almost no forest is left. In the west, it is too dry for the growth of high forest. Rangelands and shrublands are, therefore, the characteristic land-cover types. Agricultural land and natural mixed vegetation areas are widespread.

Ganges: As this watershed has a large area in the lowlands, agriculture is the dominant category.

Brahmaputra: The percentage of rangeland is high due to its vast upper watershed area in the Plateau of Tibet. Compared to the other watersheds, the percentage of forest coverage is also relatively high. However, forest cover in N. E. India has a distinct mixed agriculture and vegetation type, indicating shifting cultivation.

Mekong: The percentage of forest cover is the highest. Even land below 500m in altitude has forests.

Yangtze: Highlands above 3,000m have rangelands and agroforestry was widespread below 1,000m.

Yellow: Above 1,000m, grassland and open shrubland are found. Forest cover is very low. Agriculture and mixed vegetation land is found in the altitudinal ranges between 500 and 3000m. Very few mixed forests are found between 500 to 1,000m in altitude.

Apart from the Brahmaputra and Mekong watersheds, the forest areas are relatively small. The land is either used by agriculture or it is too high or too dry. This means that the potential to increase the forest area in the watersheds is relatively small due to natural as well as anthropogenic factors.

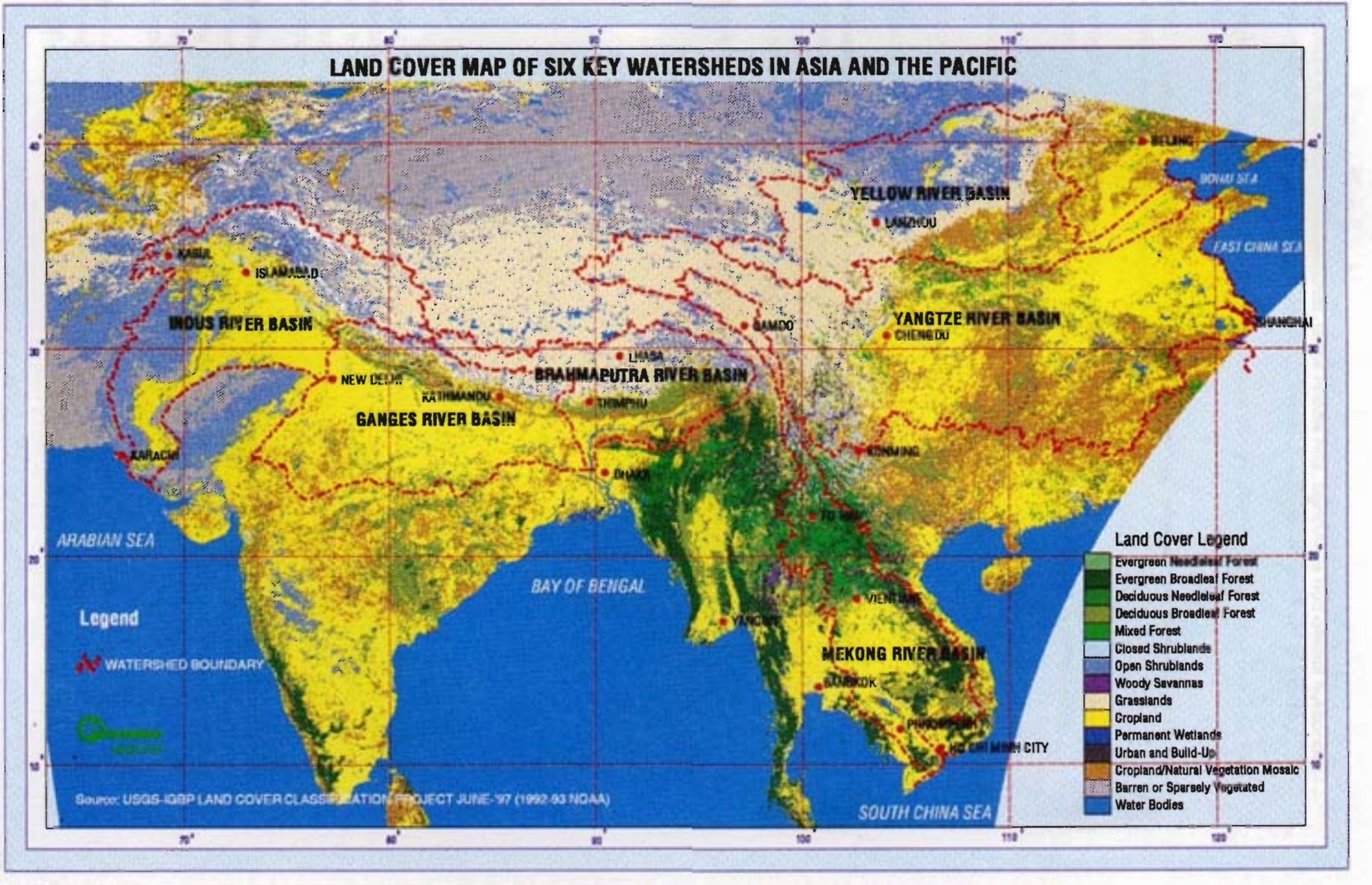
Socioeconomic Conditions

It is impossible to find comparable statistical figures for the different watersheds. The situation is not only variable between different watersheds, but also within a specific watershed. Therefore, this chapter highlights some general considerations and provides some details of the different watersheds.

General Considerations

- For all the watersheds, in many of the upland areas (above 900m) subsistence agriculture and livestock form the most important basis of the economy.

MAP 2


LAND COVER MAP OF SIX KEY WATERSHEDS IN ASIA AND THE PACIFIC
YELLOW RIVER BASIN
LANZHOU
BEIJING
BOHAI SEA
EAST CHINA SEA
KABUL
ISLAMABAD
INDUS RIVER BASIN
GAMDO
YANGTZE RIVER BASIN
CHENGDU
SHANGHAI
LHASA
NEW DELHI
KATHMANDU
BRAHMAPUTRA RIVER BASIN
THIMPHU
GANGES RIVER BASIN
KARACHI
KUNMING
DHAKA
ARABIAN SEA
BAY OF BENGAL
VIENTIANE
YANGON
MEKONG RIVER BASIN
BANGKOK
PHNOM PENH
HO CHI MINH CITY
SOUTH CHINA SEA
Legend
WATERSHED BOUNDARY
Source: USGS-IGBP LAND COVER CLASSIFICATION PROJECT JUNE '97 (1992-93 NOAA)
Land Cover Legend
Evergreen Needleleaf Forest
Evergreen Broadleaf Forest
Deciduous Needleleaf Forest
Deciduous Broadleaf Forest
Mixed Forest
Closed Shrublands
Open Shrublands
Woody Savannas
Grasslands
Cropland
Permanent Wetlands
Urban and Build-Up
Cropland/Natural Vegetation Mosaic
Barren or Sparsely Vegetated
Water Bodies

- Agriculture is dominant in the lowlands. In the middle hills, agriculture and animal husbandry are combined. In high altitude or in dry areas, livestock is the dominant form of farming.
- In the lowland areas, irrigation is a typical feature of agricultural practices (see Box 2 on the Indus Valley).
- Wood, in general, has great importance as fuel. Other uses of wood are for timber, for fruit, for fodder, and for medicinal purposes (see Chapter 3).
- Poverty is a common feature in the six watersheds, in particular in the uplands. The levels of education, the accessibility to health care, sanitation, and safe water are in general low.
- Pressure on the land and on the natural resources in certain areas leads to depletion of the resources and to degradation.
- The conditions highlighted above are different in urban areas or areas with centres of industry.

Some Specific Information on Watersheds

Brahmaputra - The livestock population is a very important part of the economy, either subsistence or commercial. There is a strong impact on the forest by overgrazing of pastures, degradation of forests, depletion of vegetative cover, and compacting of soil. Livestock density varies from 114/km^2 in Bhutan to 1125/km^2 in Meghalaya.

The demographic situation varies considerably within the watershed.

Population density:	Tibet	6 inhab./km^2
	Bangladesh	828 inhab./km^2
Population growth rate:	Tibet	1.6 per cent
	Nagaland	4.6 per cent
Inhabitants/$km^2$of cultivated land:	India, Bhutan	419
	Assam	2388
	Nagaland	3101
	Sikkim	1161
	West Bengal	782

Mekong - The population growth rate is on average two per cent. There are some distinct characteristics of economic growth with the following common trends: transition from central planning to market-oriented economies and efforts to strengthen economic cooperation in the region and internally, which again leads to increased resource use rates. Thirty per cent of the households in the Mekong River Basin live below the poverty line.

Yellow River - In the upper reaches there is a vast potential for hydropower, several stations have already been built. In the middle reaches, over generations, a sophisticated, irrigated agricultural system has been developed comparable to those in the Indus and the Ganges lowlands. In the Hetao Plain, development of industries and mines has led to pollution and salinisation with a severe impact on agriculture.

Ganges - A dense population is observed in the watershed area. The main economic activities are farming, extraction of non-timber forest products, transportation, fisheries, and hydropower generation. The Ganges River is also a very important focus in the Hindu religion.

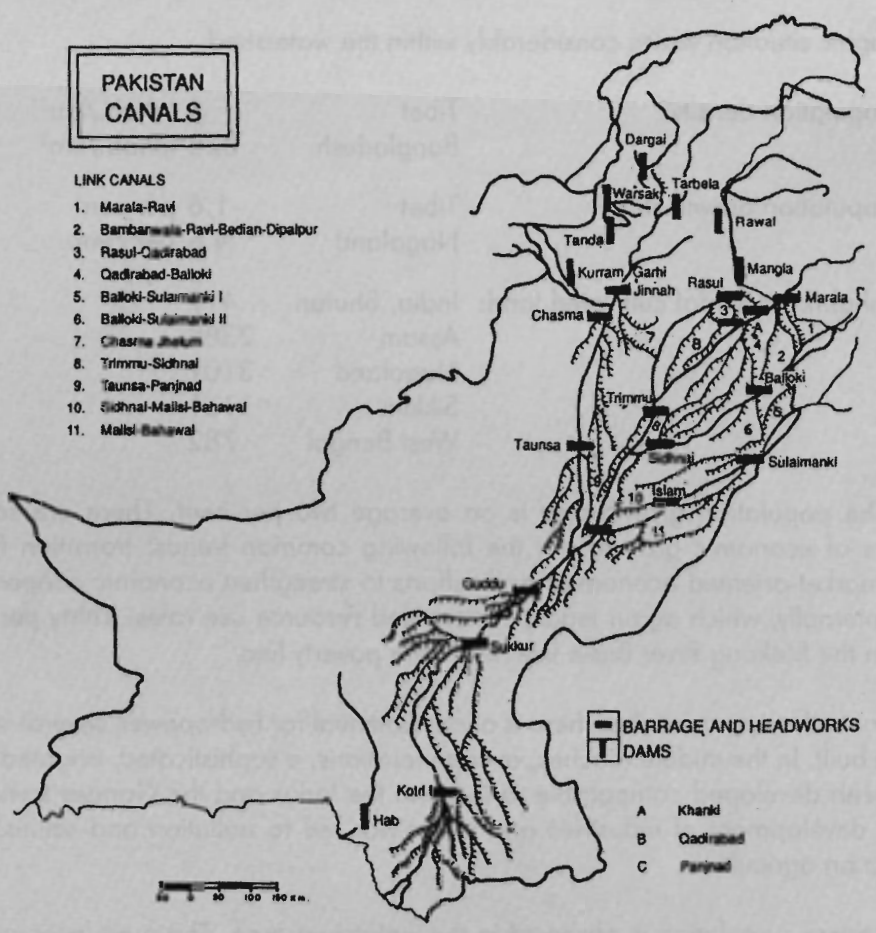
Box 2
Irrigation in the Indus Valley

Irrigation is a very old tradition in Pakistan. Beginning with simple lift irrigation, Pakistan has developed one of the most intricate and complex systems of canal irrigation in the world. The fact is that the development of agriculture in Pakistan is mostly dependent upon irrigation. About 75 per cent of the total cropped area is under irrigation (1984-85). The figures below provide some details about the development of irrigation from 1950 to 1985 and about the different types of irrigation.

Years	Percentage of area irrigated by				Area irrigated (in million ha)
	Canals	Tubewells	Wells	Others	
1950-51	81.4	----	11.7	6.9	9.25
1960-61	82.5	2.4	8.3	6.8	10.41
1970-71	63.2	21.2	12.2	3.4	10.59
1980-81	74.4	18.9	2.1	4.6	14.90
1984-85	72.6	21.3	1.7	4.4	15.62

The irrigated Indus Plain receives 120 billion cubic metres of water per year from the Indus River system. The upland areas of the watershed are the only continuous and reliable source of water for the uplands.

The irrigation system in the Indus Valley is characterised by a dense network of barrages and canals; these are illustrated in the figure below.



Source: Khan 1995

Indus - Livestock farming and agriculture are the major economic activities. Formation of a very large irrigation network is also found. Forestry for subsistence use is another important factor for the communities living in the Indus Basin where the products from farm forests are not sufficient. Community forestry and rehabilitation of degraded lands with the proper participatory practices may be a long-term solution.

Yangtze - Upland forests are degraded due to mismanagement. Not only has the extent decreased but the quality has also declined, resulting in natural disasters. The problem is well recognised and rehabilitation work has been designed and applied successfully. Income-generation factors were also incorporated and found effective in rebuilding the vegetation cover.

Chapter III
Forests

General Considerations

Forest Situation

According to Map 2 and Table 4, the forest cover is rather low in each watershed. The high pressure on forest resources due to expansion of agriculture and the increasing domestic as well as industrial needs, both within and outside the region, has resulted in removal and degradation of forests. Degradation of forests not only takes place by cutting the trees but also by collecting litter (nutrient loss for the forest) and grazing.

A detailed assessment of the forest cover is difficult due to the lack of good data. With advanced remote-sensing techniques, it is possible to assess the forest cover of large river basins (Blasco 1986, Myint 1996, National Remote Sensing Agency 1994, Skole and Tucker 1993, Loveland et al. 1997). For the present study, the overall assessment has relied much on the data of the USGS-IGBP Land Cover Classification Project, based on the 1992-93 NOAA imagery and the individual studies commissioned for each watershed.

Importance of Forests

Forests have a multifunctional importance: timber, fuelwood, fodder, fruits, medicinal plants, and many other non-timber forest products. Forests contribute to the stabilisation of the slopes in the uplands and reduce soil loss. According to Hamilton (1987), not only is the forest important, but the condition of the forest is also significant, i.e., density of trees and canopy. A broad-leaved forest without any ground cover or litter can cause more erosion than an area without any forest due to the size and intensity of the raindrops which fall from the leaves during rainfall.

Good forest is important for reducing runoff and soil erosion and to ensure livelihoods and biodiversity in mountain watersheds. Recent studies have shown, however, that on a large scale, the role of forests, e.g., in the reduction of downstream flooding, has usually been overestimated (Hofer and Messerli 1997).

Mangrove forests are important sources of marine biodiversity conservation. They also protect the coastal erosion and prevent siltation of ports, while providing habitats for marine lives.

Trends

Depending on the watershed and on the region, the reduction of forest cover due to overuse or the increase as a result of various initiatives can be observed. For discussion of trends in forest cover it is necessary to consider individual watersheds.

The Indus River Basin

Forest Situation

According to the USGS-IGBP project, forest cover of the Indus River Basin is 0.5 per cent (Map 4 and Table 5), 2.3 per cent is under farm forestry, shown as cropland and natural vegetation mozaic (Table 5); and this area is in the lowlands (Map 3).

Table 5: **Land Use of the Indus' River Watershed**

No	Land Cover Type	Area	
		'000 sq.km.	%
1	Evergreen needleleaf forest	0.28	0.03
2	Evergreen broadleaf forest	0.19	0.02
3	Deciduous broadleaf forest	3.49	0.37
4	Mixed forest	1.13	0.12
5	Closed shrublands	21.16	2.24
6	Open shrublands	257.11	27.22
7	Woody savannas	2.17	0.23
8	Grasslands	153.40	16.24
9	Permanent wetlands	1.04	0.11
10	Croplands (agricultural lands)	332.49	35.20
11	Urban built-up	1.13	0.12
12	Croplands/natural vegetation mosaic	21.82	2.31
13	Snow and ice	30.60	3.24
14	Barren/ sparsely vegetated	107.30	11.36
15	Waterbodies	11.05	1.17
	Total	**945.00**	**100.00**

Source: USGS-IGBP Land Cover Classification Project June '97, 1992-93 NOAA, (Loveland et al. 1997)

Marjan (1997, background document) estimated the tree cover of the Indus River Basin in Pakistan to be 3.9 per cent (Map 4 and Table 6). The two estimates are quite close. The location of the remaining forest is mainly in the Kashmir area and in the Northwest Frontier Province.

Table 6: **Estimates of Forest/Tree Areas in the Indus Watershed ('000 sq.km.)**

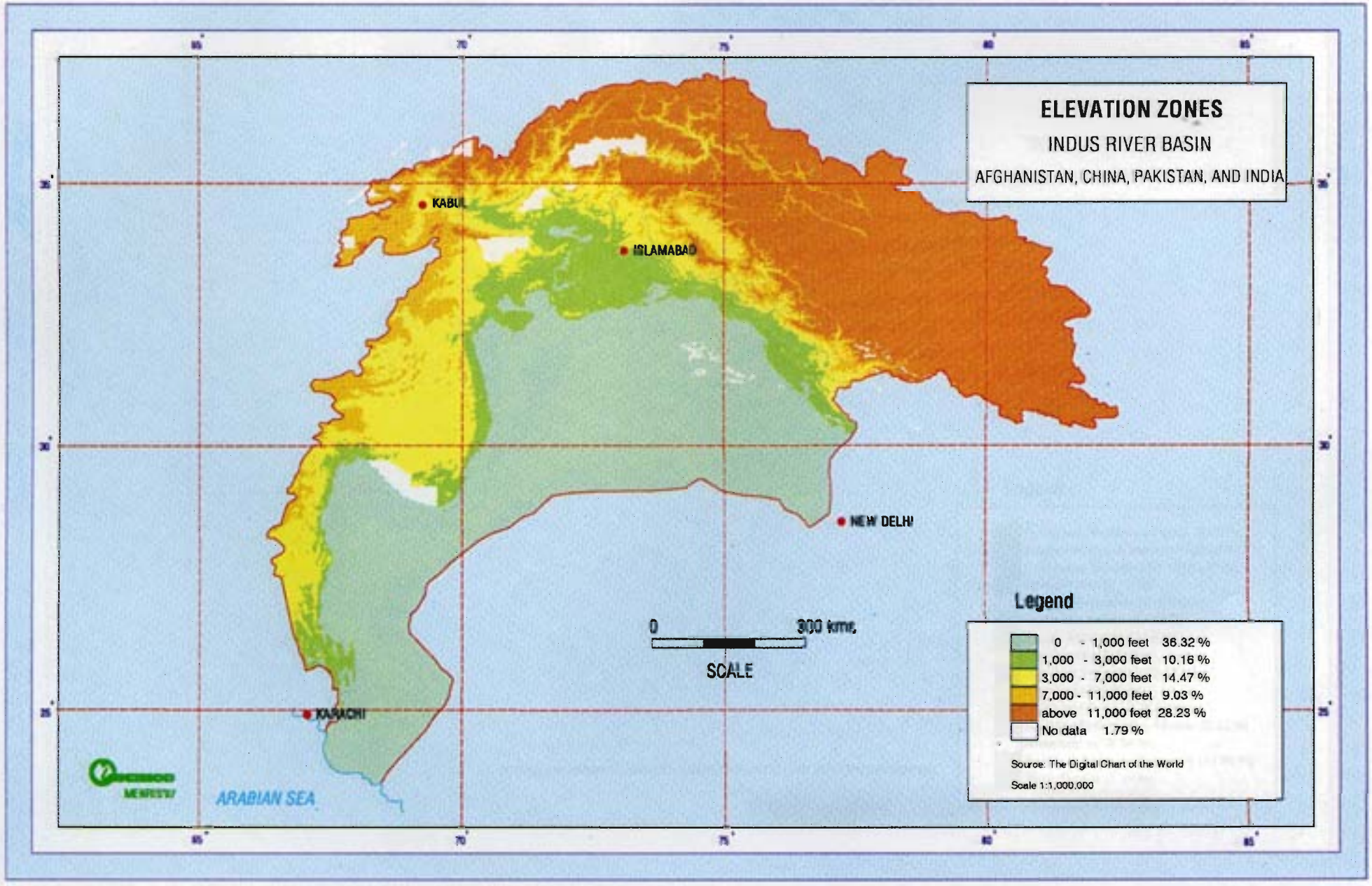
	Azad Jammu & Kashmir	Balochis-tan	Northern Areas	North-west Frot. Pro.	Punjab	Sindh	Afghanis-tan etc. *	Total
Geogr. Area	13.30	155.18	70.40	101.74	206.26	35.51	362.18	944.57
Forest "Area	2.75	2.00	6.66	16.84	6.08	3.39	n.a.	37.72
Forest cover %	20.67	1.28	9.46	16.55	2.94	9.50	4.50	3.99

Source: Adapted from the Forestry Sector Master Plan of Pakistan 1992 (Marjan 1997)

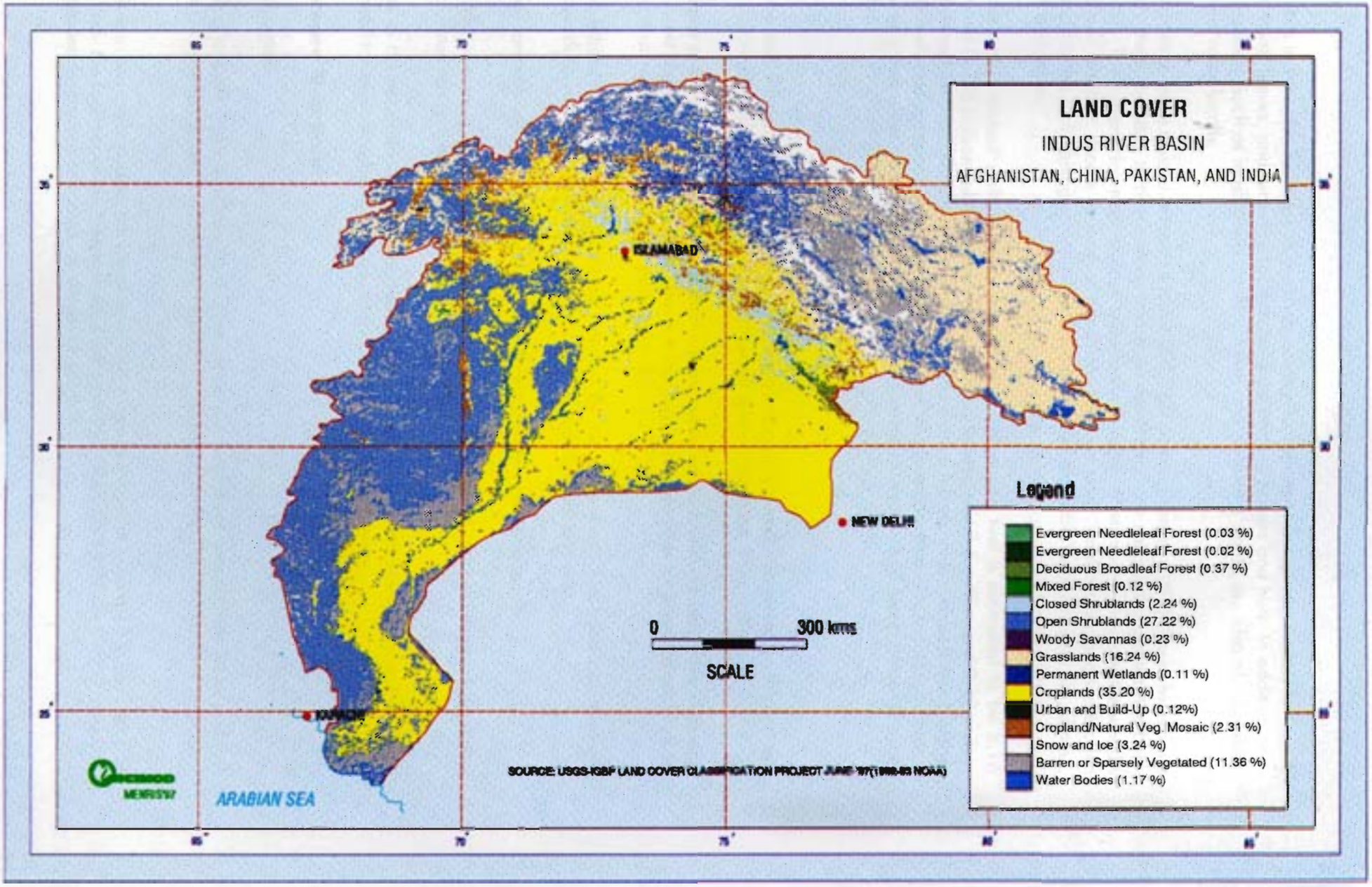
* For Afghanistan, China, and India, the forest and tree areas within the Indus Basin are not available.

** Area under forest (sq.km.) : coniferous forest 1,913 (2.02%), shrub forest 835 (0.88%), riverine forest 112 (0.11%), mangroves 205 (0.21%), irrigated plantations, farmland trees, linear planting, misc. planting

MAP 3 : Elevation Zones of Indus River Basin



MAP 4 : Land Cover Map of Indus River Basin



Significance

The forests in the Indus Basin are of great importance for different types of use: timber, fuelwood, fodder, fruits, leaves, and branches for thatching the roofs of houses and huts. In addition non-forest products, such as mushrooms, tannin, meat, and medicinal plants, are also of substantial economic value locally.

The mangrove forest area is estimated to be 205,000 sq.km. (Marjan 1997). These forests are seriously degraded due to over-cutting and even the *Rhizophora mucronata* species has been wiped out. The current dominant species is *Avicennia marina*. These mangroves are the world's sixth largest in extent. People depend on these forests for fuelwood, small timber, and fodder. Ten thousand families from fishing communities depend on these important mangroves for fish, shrimp, lobster, and crabs.

The sustainable annual yield of forest products for timber and fuel is estimated to be 3.16 million and 0.395 million cubic metres from coniferous forests, and 0.6 million and 0.12 million cubic metres from hardwood forests respectively. The annual harvest of fuelwood is much higher than the fuelwood products available through commercial harvesting. However, local consumption for housing and other infrastructure is not known, as subsistence use of forest products is not recorded.

Trends

- In the mid-9th century, forest management began in an organized way, based on the concept of sustained yields. The focus of these initiatives was on the Indus River Basin.
- In spite of the working plans, exploitation without replacement finally resulted in the depletion of forest resources. The reasons for this are logging, local demands for firewood and timber, and grazing by a dense livestock population (Khan 1995).
- The rehabilitation of degraded lands initiated by the government has been only partially successful due to its locational nature and lack of participatory planning.
- New concepts with pioneer projects (social forestry) show promising results.
- In Afghanistan, it is said that the uncontrolled deforestation in the catchment of the Indus tributaries has had severe ecological consequences.
- Due to the realisation of the importance of mangroves for sustainable fishery and ecology, rehabilitation work is being carried out by Sindh Forest Department.

The Ganges' River Basin

Forest Situation

According to Table 7 (see also Map 6), 8.3 per cent of the catchment area is under forest and 9.9 per cent is mixed cropland and natural vegetation, including shifting cultivation and degraded forests.

According to two other studies, the forest cover of the Ganges' River in India is 13.2 per cent (FSI 1996) and the forest cover in Nepal is 42.2 per cent (HMGN/ADB/FINNIDA 1988), including the degraded forests in both cases, as shown in Table 8.

Table 7: **Land Use in the Ganges' River Watershed**			
No	Land Cover Type	Area	
		'000 sq.km.	%
1	Evergreen broadleaf forest	5.99	0.57
2	Deciduous broadleaf forest	80.12	7.63
3	Mixed forest	1.78	0.17
4	Closed shrublands	20.26	1.93
5	Open shrublands	17.11	1.63
6	Woody savannas	0.10	0.01
7	Grasslands	69.20	6.59
8	Croplands (agricultural lands)	709.91	67.61
9	Urban built-up	1.89	0.18
10	Croplands/natural vegetation mosaic	104.16	9.92
11	Snow and ice	9.24	0.88
12	Barren/ sparsely vegetated	16.59	1.58
13	Waterbodies	13.65	1.30
	Total	**1050.00**	**100.00**
Source : Loveland et al. 1997			

Table 8: **Forest Cover of the Ganges' Watershed in India and Nepal ('000 sq.km.)**					
Description	India	Nepal	China/ Bangladesh	Total	Per cent
Basin area	852	147	51	1050	100.0
Forest cover	113 (13.2 %)	62 (42.2 %)	n.a.	175	16.7
Densed forest	63	55	n.a.	118	11.2
Open forest	47	7	n.a.	55	5.2
Mangroves	2	0	n.a.	2	0.2
Source : FSI 1996 and HMGN/ADB/FINNIDA 1988					

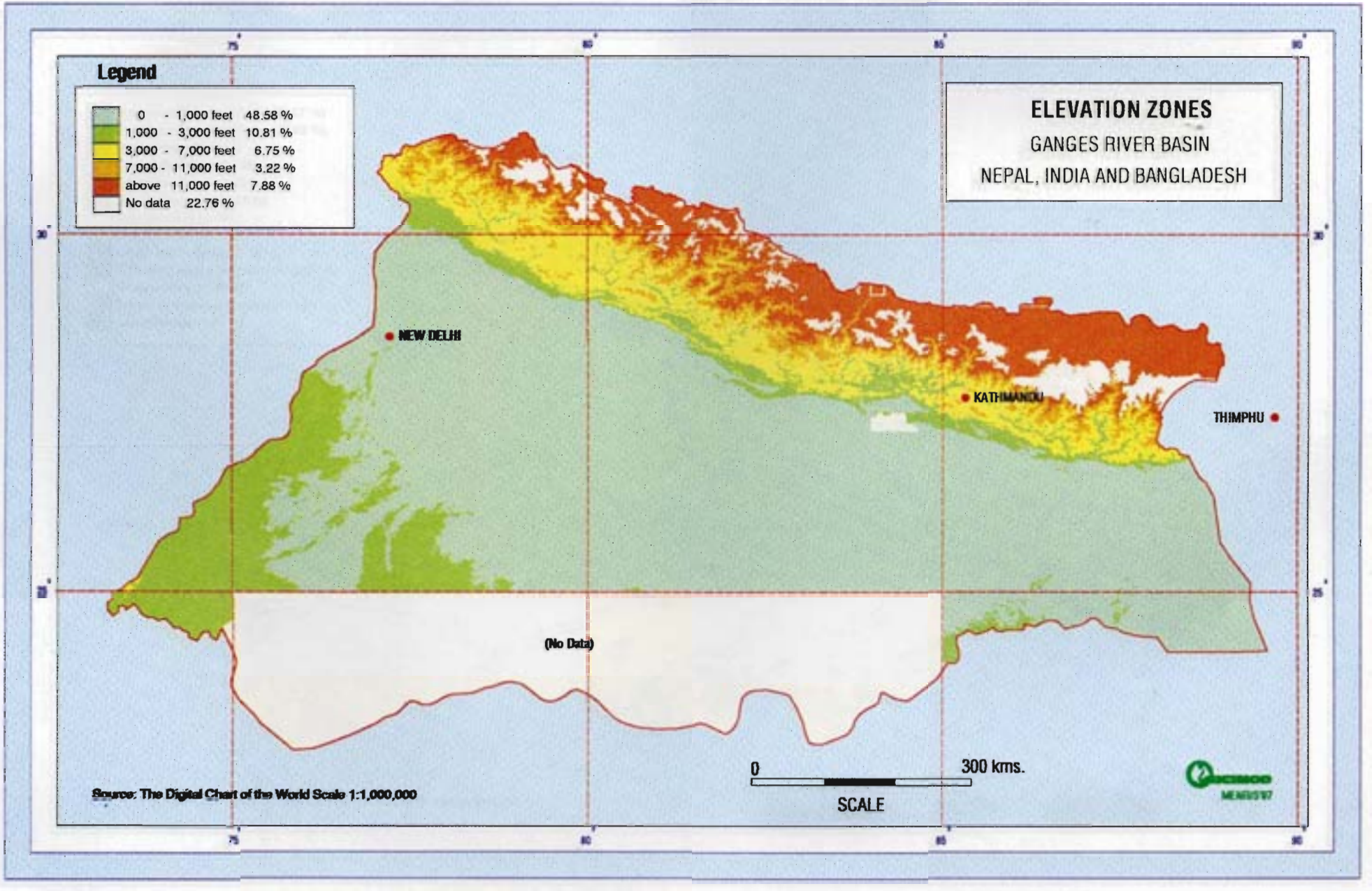
Estimates from these two different sources agree to a large extent that the forest cover of the basin is approximately 16/17 per cent. The areas with more or less dense cover are located in the southern part of the catchment and in the Himalayan ranges, mainly on the first ridges adjacent to the plains. In the middle hills, the forest cover is scattered. In India, below 300m (1,000 feet), there is almost no substantial forest cover left due to the high demand for agricultural land (see Maps 5 and 6).

The mangrove forests of the Ganges in India, i.e., the state of West Bengal, have an extent of 2,119 sq. km. Mangrove forests in Bangladesh at the mouth of the Ganges and Brahmaputra are also shared by the Meghna River, and area differentiation of mangroves between these rivers is difficult.

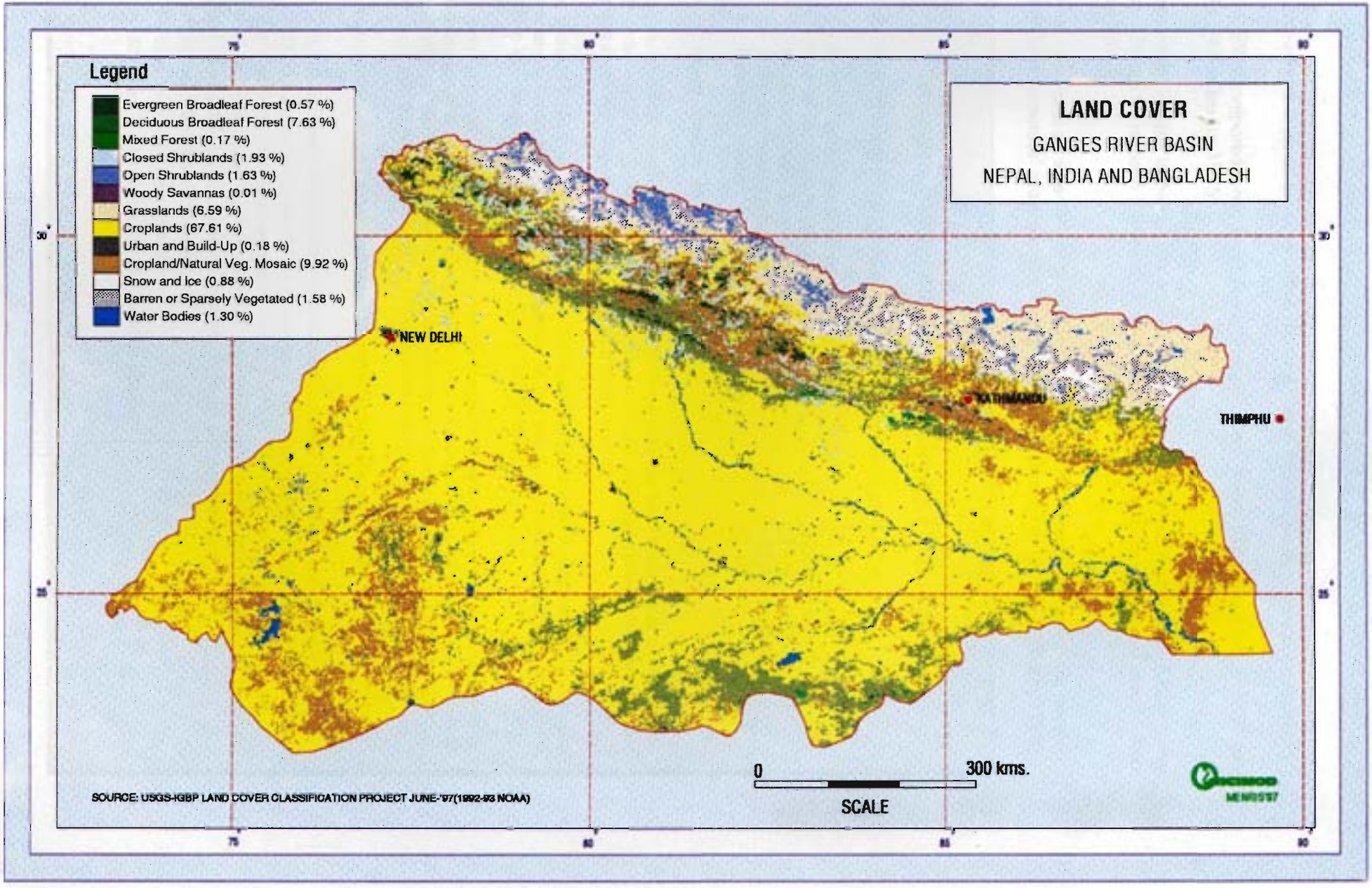
Significance

Forest cover in the Ganges' River Basin is very low and is concentrated mainly in the uplands. In the plains, where population intensity is very high, only degraded forest cover is found in patches. Tremendous problems are already being faced in responding to the needs of households for fuel, fodder, timber, and other forest products. Farm forestry has started to supply some of the wood-based industries. Non-timber forest products are of great significance to local communities. Employment opportunities for local communities are significant in the harvesting of non-timber forest products, forest protection, afforestation, and so on. Forest products are also a source of raw materials to many industries. Non-timber forest products, such as Tendu leaves, Sal seeds, resins, gums, myrobalans, and so on, are important to the community.

MAP 5 : Elevation Zones of Ganges River Basin



MAP 6 : Land Cover Map of Ganges River Basin



- Improvements in forest cover in both India and Nepal through participatory approaches.
- FSI (1996) compared forest cover in the Ganges' River; it was 138,784 sq.km. in 1991 and 144,047 sq.km. in 1995.
- Community forestry in Nepal has gained momentum and already more than 5,000 Forest User Groups have been formed and more than 300,000 ha formally handed over to them (See Box 3).
- Forest cover and an inventory of growing stock, as well as changes over time, are necessary for natural resources' management in mountain areas (Shengji et al. 1994, Bhatta 1990).

Box 3
Community Forestry with Forest User Groups, FUGS in Nepal

The situation of Community Forestry practices in Nepal can be summarised as follows.

Potential Community Forest Land (Forested)	18,763	sq.km.
Potential Community Forest Land (Non-forested)	15,858	sq.km.
No. of Forest User Groups (FUGs) formed	5,316	No.
Community Forests handed over to FUGs	3,523	sq.km.
Households benefitted	563,434	No.

Source : Shrestha 1997.

Successful rehabilitation had been demonstrated in the Andheri *Khola* of the Jhikhu *Khola* Watershed, 50 km east of Kathmandu, Nepal (ICIMOD 1994, Shengji 1995). Importance of forest cover in a small watershed is stressed and degraded sites can be restored through appropriate agroforestry practices.

Case studies in the Baitadi and Achham districts of the Far Western Development Region (FWDR) of Nepal reveal that community forestry through people's participation is the best way to achieve the sustainable use and effective protection and management of forest resources (Chhetri and Pandey 1992).

There is no general rule for implementation of community forestry due to the vast local diversity of situations. Another successful example in the Begnas *Tal*/Rupa *Tal* (BTRT) watershed management area of the Western Development Region (WDR) in Nepal, which started in 1974, demonstrates participatory approaches (Campbell and Denholm 1993, FAO 1996b, 1996c, 1996d, 1997a). FAO (1996a) outlined the integrated approach and its importance.

The following points concerning development and government policies should be noted.

- Up to 1950 the Government encouraged the maximum exploitation of forests and promoted exports.
- In 1957 the Government introduced the Private Forest Nationalisation Act to protect forests. This resulted in rapid forest degradation, forest degradation rates were 5.7% in 1964-1978 and 3.4% in 1979-1986.
- In the 1970s, the Government introduced the Community Forestry Development Programme (CFDP) to hand back the protection and management of forests to the people and organizations.
- In 1980 regulations were decentralised.
- In 1993 a new forest act was approved.
- In 1995 rules and regulations for the forest act were gazetted.

The Brahmaputra River Basin

Forest Situation

The vertical profile of the forest in the Himalayan part of the watershed is very distinct. Tropical evergreen forests are found in the foothills up to elevations of 800m. Subtropical forests, consisting of a great variety of tree species, some of which are rare and endemic, occur at elevations ranging from 900 to 1,800m. The temperate forests are situated at altitudes ranging from 1,800 to 3,500m and include a great variety of coniferous and non-coniferous species (fir, larch, spruce, oak, chestnut). The sub Alpine zone is found between 3,500 and 4,500m and is dominated by fir-rhododendron, while Alpine forests are found at elevations ranging from 4,500 to 5,500m (see Maps 7 and 8).

According to Loveland et al. (1997) (Map 8 and Table 9), 14.5 per cent of the watershed is forested. Croplands/vegetation mosaic (farm forest), which include shifting cultivation, constitute 12.86 per cent. According to the land-cover map, the areas with relatively high forest cover are located in Bhutan, Arunachal Pradesh, Megalaya, and Nagaland.

Table 9: **Land Use of Brahmaputra River Watershed**

No	Land Cover Type	Area	
		'000 sq.km.	%
1	Evergreen needleleaf forest	0.12	0.02
2	Evergreen broadleaf forest	12.12	2.09
3	Deciduous broadleaf forest	67.51	11.64
4	Mixed forest	4.41	0.76
5	Closed shrublands	0.70	0.12
6	Open shrublands	51.62	8.90
7	Woody savannas	3.83	0.66
8	Grasslands	255.20	44.00
9	Permanent wetlands	0.29	0.05
10	Croplands (agricultural lands)	79.58	13.72
11	Urban built-up	0.12	0.02
12	Croplands/natural vegetation mosaic	74.59	12.86
13	Snow and ice	6.32	1.09
14	Barren/ sparsely vegetated	13.17	2.27
15	Waterbodies	10.38	1.79
	Total	**580.00**	**100.00**

Source : Loveland et al. 1997

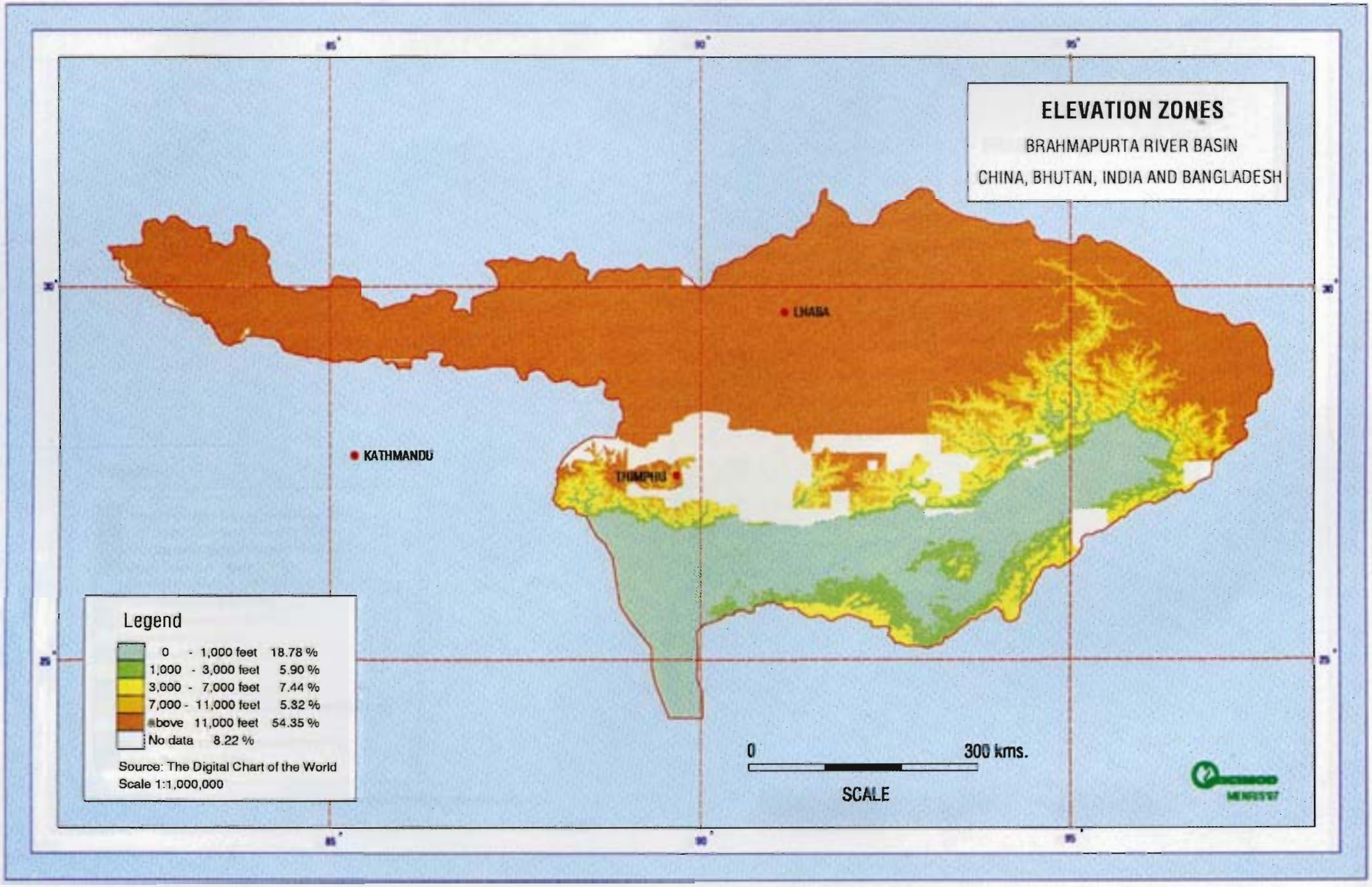
An estimation of the total forest cover of the Brahmaputra Basin had been reported as 55.6 per cent (Goswami 1997) apart from Tibet and Bangladesh (Table 10). The proportion of forest is highest in Arunachal Pradesh, followed by Nagaland, Meghalaya, and Bhutan. It is evident that there are wide regional differences in forest cover. For the whole basin, the forest cover of 14.07 million ha (i.e. 140,700 sq.km.) is about 24.3 per cent - including the shifting cultivated areas.

Table 10: **Estimates of Forest Areas Based on Satellite Data in the Brahmaputra Watershed for India and Bhutan ('000 sq.km.)**

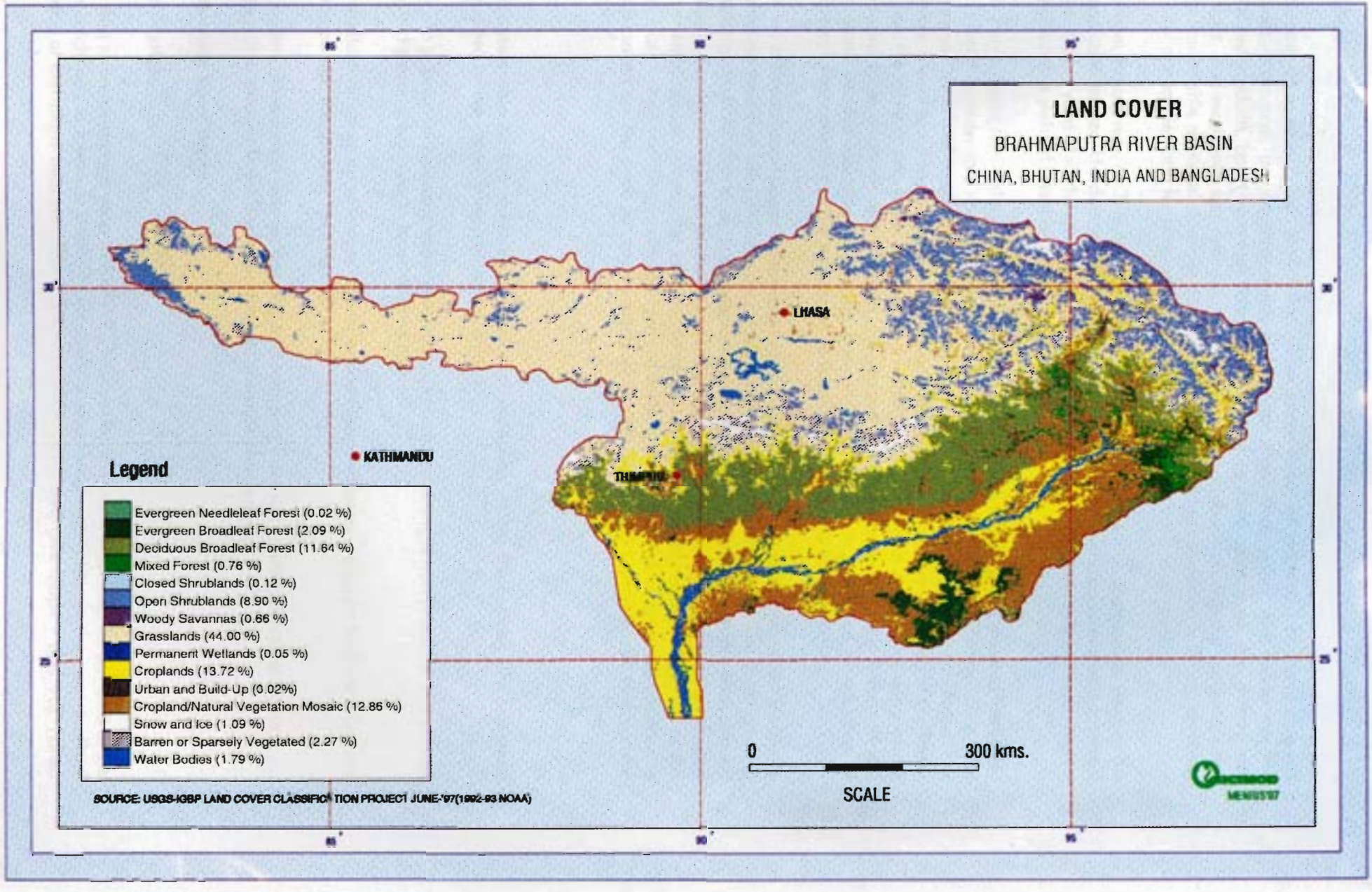
	Arunachal Pradesh	Assam	Meghalaya	Nagaland	Sikkim	West Bengal	Bhutan Bhutan	Total
Geogr. Area	83.7	70.1	22.4	16.5	7.0	12.7	40.0	252.8
Area under forest	69.3	14.4	14.2	11.4	2.8	2.7	25.7	140.7
Percent	82.81	20.56	63.53	68.89	39.52	21.41	64.34	55.67

Source : Goswami (1997, background document), FSI (1996)

MAP 7 : Elevation Zones of Brahmaputra River Basin



MAP 8 : Land Cover Map of Brahmaputra River Basin



Significance

Forest cover of above 50 per cent in the Brahmaputra Basin of India and Bhutan has great economic, ecological, and socioeconomic significance. Fuelwood, timber, and fodder are the major forest products, apart from non-timber products such as cane, gum, resin, dye, tannin, lac, fibre, floss, and medicinal and aromatic plants. The forests in the Brahmaputra catchment are under considerable pressure. Average daily per capita fuelwood consumption is 2.5kg, resulting in an total annual demand for fuelwood of 50 million tons.

Sawmills in Assam require 328 thousand cubic metres, compared to a sustainable yield of 56 thousand cubic metres. The demand for timber in Nagaland is 80 thousand cubic metres, compared to a sustainable yield of six thousand cubic metres. It is to be noted that demands are much higher than sustainable yield of forest resources.

Forests play a major role in the maintenance of ecological health in the upland areas of the basin, and this has a considerable impact on the downstream areas. In addition, the Himalayas intercept the monsoon rains and receive the snowfall that sustains the Brahmaputra and its tributaries. For both these crucial functions, a good forest cover in the basin is necessary. Removal of the forest cover, on the other hand, leads to increased runoff, loss of valuable topsoil, lowering of the groundwater table, destabilisation of slopes, accelerated sedimentation, and a rise in flood potential downstream, besides affecting biodiversity. It is, however, argued that removal or reduction of Himalayan forest cover is not the sole cause of flooding in India and Bangladesh.

Therefore, afforestation of upper watersheds and adoption of extensive soil conservation measures are useful for their own sake and may be crucial for the subsistence hill farmer. The forest cover of the Brahmaputra Basin, therefore, has tremendous potential as a biotic resource base with significant upstream-downstream linkages and as a prime factor for conservation of the rich biodiversity and environmental quality. In fact, the eastern Himalayan region is already identified as one of the sixteen most threatened biodiversity hot-spot locations in the world and increasingly attention is being focussed on this area for conservation of its rich and varied bio-resources and natural habitats.

Trends

- A considerable decline in Assam's forest cover, especially during the last decade, has been reported by the Forest Survey of India (1996).
- Due to population pressure, shifting cultivation, known as *jhuming* is now practised with shorter resting periods, resulting in forest degradation.
- The efforts made so far to restore and redevelop degraded forest areas are far from adequate to cope with the problem (see Box 4).
- A recent Government ban on logging and transport from the Northeast Indian states is an attempt to prevent forest depletion through unsustainable logging.

The Mekong River Basin

Forest Situation

According to the land cover map of 1992-93 NOAA (Table 11 and Map 10), 44 per cent of the whole catchment is forested. Dense forest cover is identified in particular in the area north of Vientiane at elevations between 300-2,300m (1,000-7,000 feet) (see Maps 9 and 10). Forest

Box 4
Status of Joint Forest Management (JFM) in India

Policy initiatives by the Government of India include the following.

- The 1980 Forest Conservation Act (FCA) prohibited conversion of forests to non-forestry purposes. Prior to 1980 45,000 sq.km. of forests had been converted. The annual conversion rate is 1,500 sq.km.

- In 1988, the National Forest Policy stipulates 66 per cent of the hills and 33 per cent of the plains to be under forest cover.

- In 1990, the government of India issued a notification on JFM-Joint Forest Management. In the State of West Bengal JFM has commenced and Forest Protection Committees (FPCs) and Village Forest Committees (VFCs) have been formed. It has so far been successful in West Bengal, Haryana, Rajasthan, Jammu & Kashmir, and Uttar Pradesh.

West Bengal	2,350	FPCs	3,500 sq.km.
Haryana	35	Hill Resource Management Societies	150 sq.km.
Rajasthan	447	FPCs	not available
Jammu and Kashmir	1,000	VFDCs	600 sq.km.
Uttar Pradesh hills	4,806	*Van Panchayat*(s)	3,337 sq.km.

The success of the JFM method should be extended further as the impact is still inadequate at national level. Government policy on tenure may need further action to ensure people's participation

The Supreme Court of India decided to ban exploitation of forest products and restrict their transfer out of the north-eastern region in May 1997. The reason for this is the overexploitation of timber beyond the sustainable yield causing deforestation (Goswami 1997, background document). There are many side effects of this ban, apart from conservation. Communities depending on the timber industry are seriously effected, together with the timber and other industries linked to them.

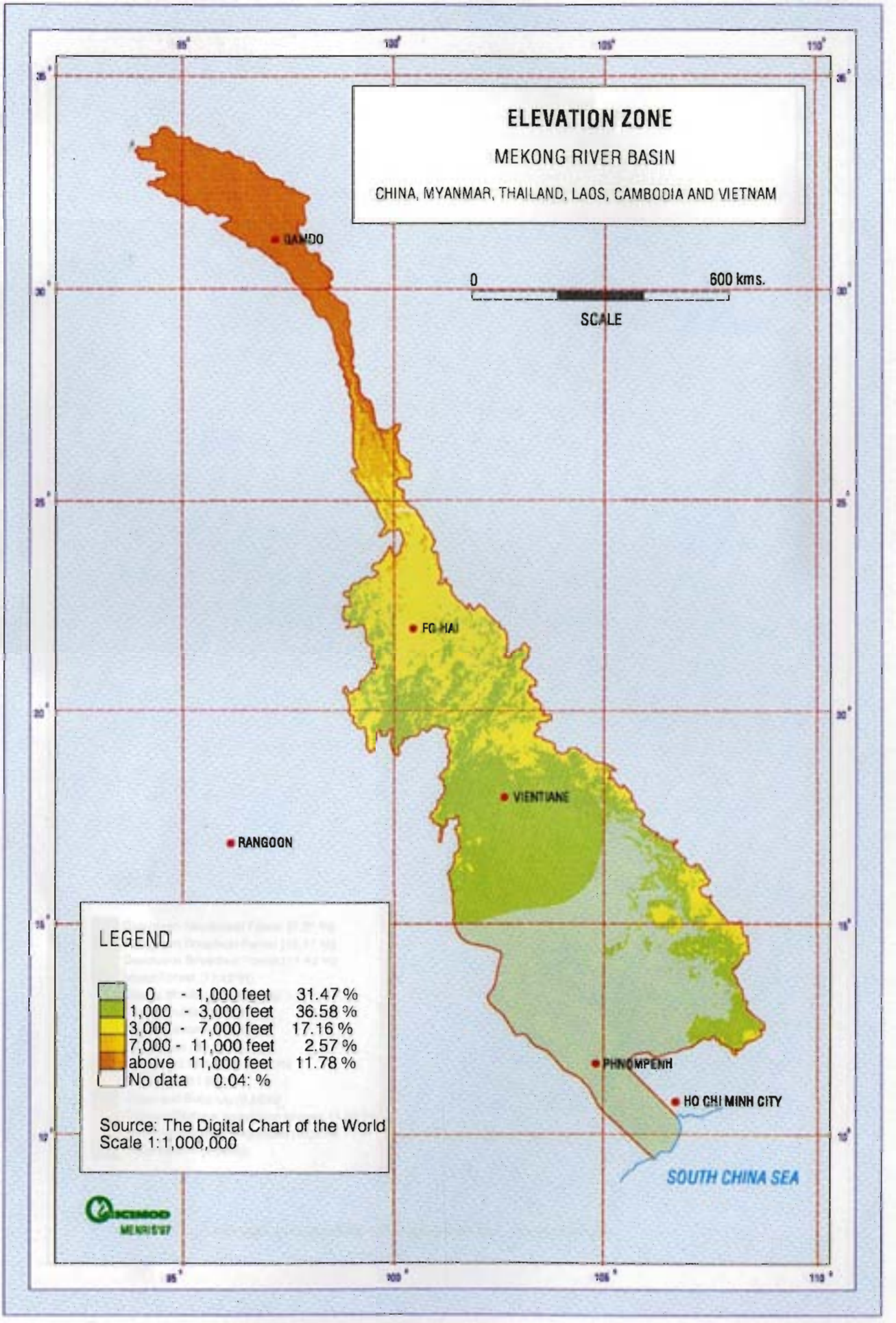
Source : Mr. A. Bhatia, ICIMOD, and Dr. V. N. Pandey, FSI, personal communications

Table 11: **Land Use of the Mekong River Watershed**

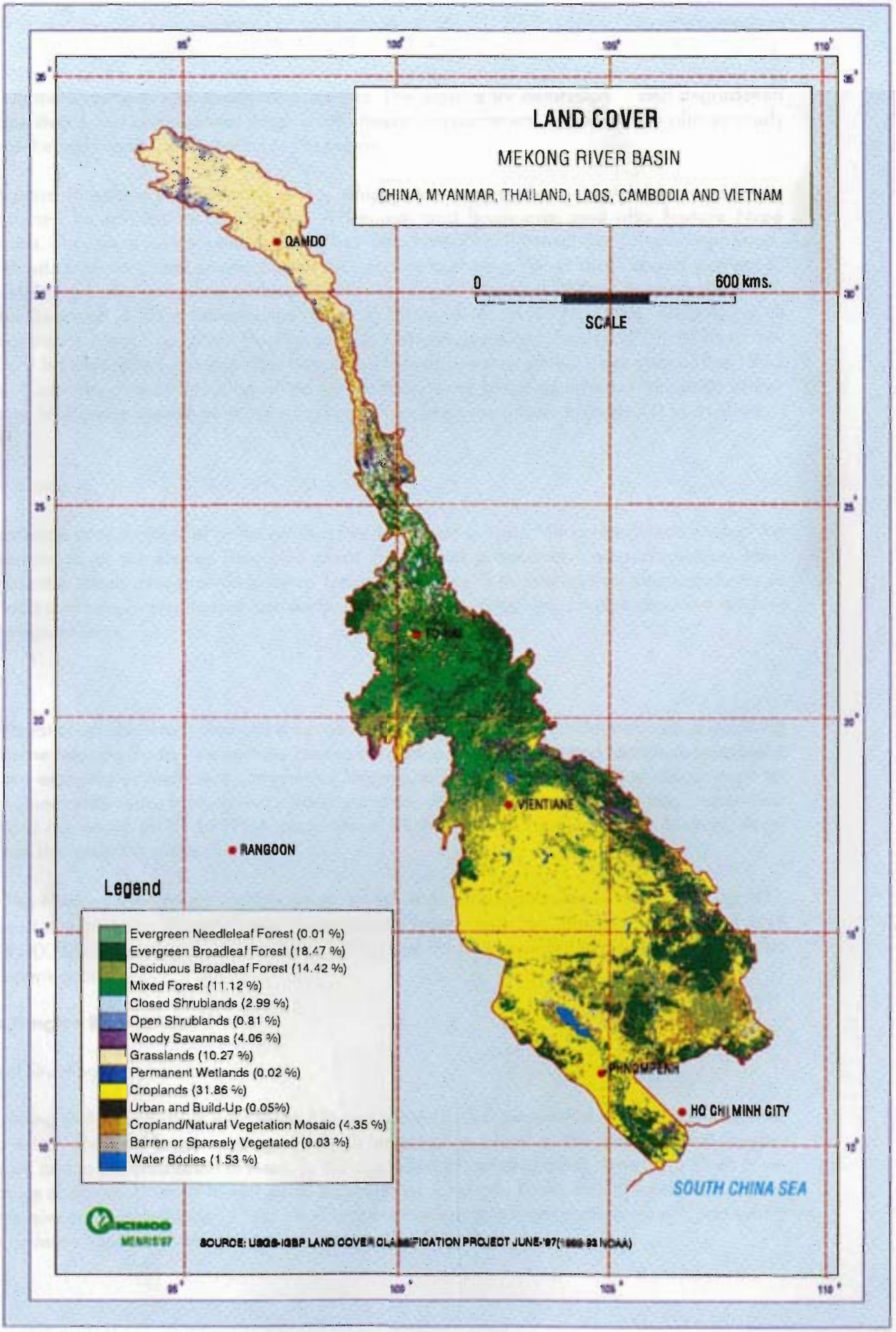
No	Land Cover Type	Area	
		'000 sq. km.	%
1	Evergreen needleleaf forest	0.08	0.01
2	Evergreen broadleaf forest	146.44	18.42
3	Deciduous broadleaf forest	114.16	14.36
4	Mixed forest	89.28	11.23
5	Closed shrublands	24.09	3.03
6	Open shrublands	6.68	0.84
7	Woody savannas	33.15	4.17
8	Grasslands	82.52	10.38
9	Permanent wetlands	0.16	0.02
10	Croplands (agricultural lands)	251.22	31.60
11	Urban built-up	0.32	0.04
12	Croplands/natural vegetation mosaic	34.34	4.32
13	Barren/sparsely vegetated	0.24	0.03
14	Waterbodies	12.32	1.55
	Total	**795.00**	**100.00**

Source : Loveland et al. 1997

MAP 9 : Elevation Zones of Mekong River Basin



MAP 10 : Land Cover Map of Mekong River Basin



cover is also high in the south-east of the watershed. MRC (1997) reported high deforestation rates in China, Cambodia, Thailand, and Vietnam due to heavy and uncontrolled logging. Degradation of the natural forests is caused by logging of commercial species and larger trees, leaving the forest with non-commercial species. The reasons for deforestation and degradation include illegal and unmonitored logging and heavy encroachment. Deforestation also seriously affects the biodiversity conservation in the region.

Mangrove forests in the Mekong Delta, which were among the richest in the world, are dominated by species of *Rhizophora, Avicennia*, and *Bruguiera;* and also feature *Nypa fruticans*. They were severely destroyed by war-time hostilities. Post-war agricultural expansion, fuelwood collection, and conversion of mangroves to shrimp ponds also caused depletion. The Mekong Delta coastline is about 650km in length, of which 350km borders the South China Sea and 300km borders the Gulf of Thailand. From 1978-1988, 40,000 ha of mangroves in Nam Can, Minh Hai Province of Vietnam, were lost. From 1988-1992 another 25,300 ha of forests were lost. The remaining forests are now only 21 per cent of the 1973 level. Currently only 120,000ha of mangrove forests are left, and they are generally of low quality. Mangrove depletion is also causing shoreline erosion, as high as 10 to 100m per year.

Significance

Subsistence consumption of forest products in the region is high. Mangrove forests protect the wave erosion of the shore. They also assist the natural process of land reclamation. Most importantly, mangroves provide habitats for many species of insects and aquatic organisms of the food chain supportive to rare and endangered mammals, reptiles, amphibians, and resident and migrant birds.

Trends

- Forest coverage, which supports the productivity of the watershed catchment area, is declining in the Mekong Basin. The primary causes of degradation of forests and terrestrial ecosystems are excessive or inefficient commercial logging, shifting cultivation, land encroachment for human settlements, farming and infrastructural development, heavy fuelwood use, and unclear land ownership (MRC 1997). Forest cover in all the riparian countries of the Mekong Basin has decreased considerably.

- The Mekong Watershed Classification Project, with an approximate cost of US$ 100,000, and the Mekong Forest Cover Assessment Project, with an approximate cost of US$ 4,000,000, have been initiated (MRC 1995), and they are expected to provide more detailed information.

The Yangtze River Basin

Forest Situation

According to the land cover map (Map 12) and Table 12, 8.5 per cent of the Yangtze watershed is forested. The best forest coverage (>35 % coverage) is found in the area near the Yangtze Gorges and to the area south of them. In the upper part of the catchment, there is no forest cover because of elevation, in the lowest parts, including the Chengdu Basin, lack of forest cover is due to intensive agriculture (Maps 11 and 12). There are many unique forest ecosystems with particularly rich endemic species. Some of them are rare and endangered.

Table 12: **Land Use of the Yangtze River Watershed**			
No	Forest / Land Cover Type	Area	
		'000 sq.km.	%
1	Evergreen needleleaf	0.90	0.05
2	Evergreen broadleaf	3.98	0.22
3	Deciduous needleleaf	3.44	0.19
4	Deciduous broadleaf	117.37	6.49
5	Mixed forest	26.40	1.46
6	Closed shrublands	43.04	2.38
7	Open shrublands	17.90	0.99
8	Woody savannas	17.00	0.94
9	Grasslands	376.17	20.80
10	Permanent wetlands	3.07	0.17
11	Croplands (agricultural lands)	742.21	41.04
12	Urban built-up	1.99	0.11
13	Croplands/natural vegetation mosaic	416.86	23.05
14	Barren/ sparsely vegetated	4.70	0.26
15	Waterbodies	33.28	1.84
	Total	**1,809.00**	**100.00**
Source : Loveland et al. 1997			

Significance

Forests in the Yangtze watershed are highly diverse ecosystems, supporting many species and supplying a wide range of resources. Besides the timber and fuel supplying function, forests in these areas yield large quantities of forage, animals, plant food, medicines, non-wood fibre, furs, skins, essential oils, gums, waxes, latex, and resins as well as a number of other non-wood commodities.

The total volume of these products is difficult to quantify, but they provide substantial amounts of income and employment and are important for the domestic economies of many communities and households. As is evident from scientific research, the forests may have an important influence on the atmosphere and climate.

Forests in this area are concentrated mainly on steep slopes and in the upper reaches of a number of large rivers. Besides supplying timber and other products, forests have vital impacts on the environment. The forest vegetation cover in mountain areas plays an important role, acting as a 'sponge' to regulate and stabilise water runoff and to protect soil. Soil protection by forest vegetation cover and litter can preserve the productive capacity of the reservoirs, prevent landslides and siltation of irrigation channels, and safeguard river banks.

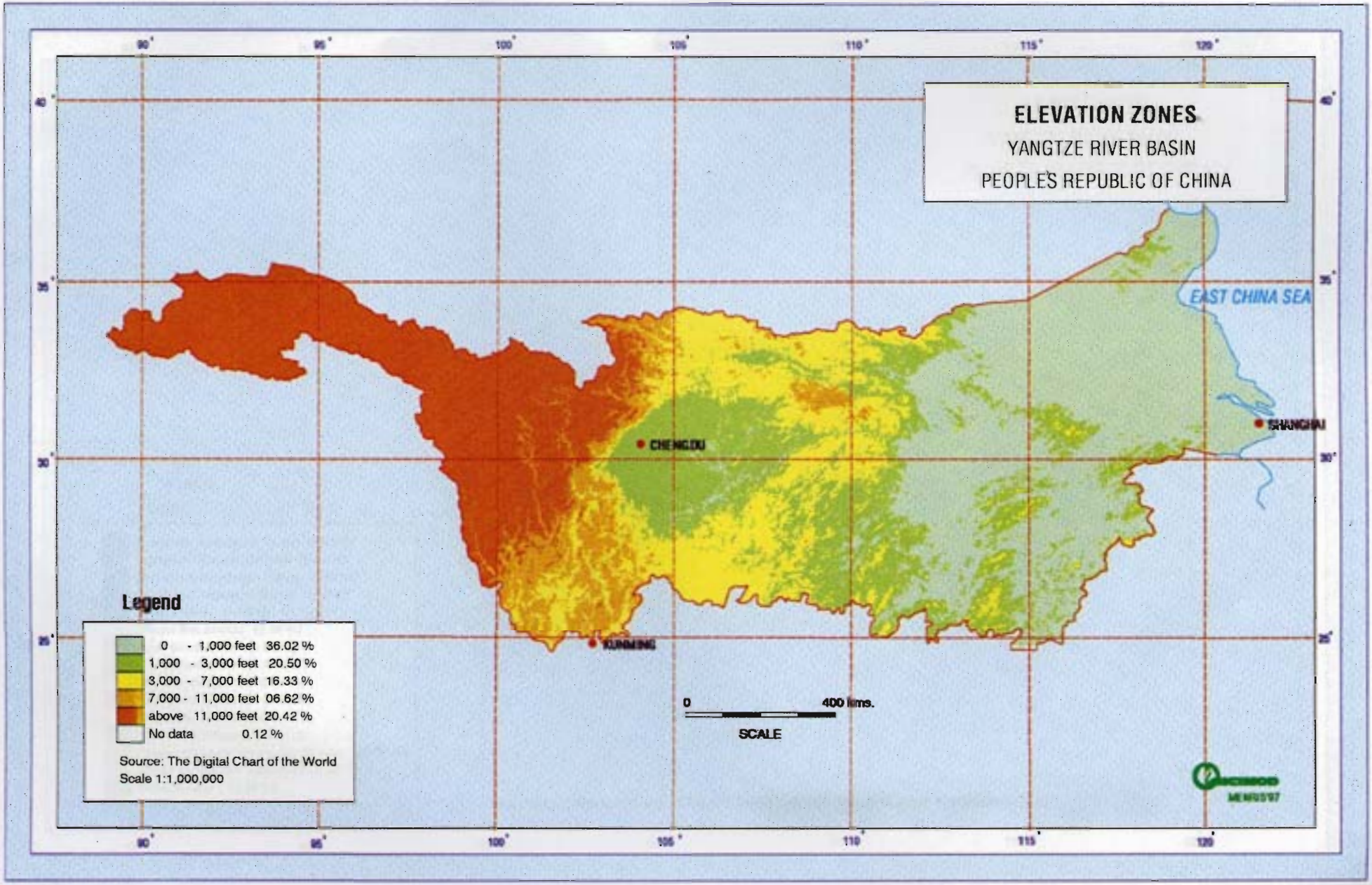
Trends

- In Sichuan Province, the forest cover decreases. The role of the forests in water conservation and regulation in the Yangtze River has decreased significantly.

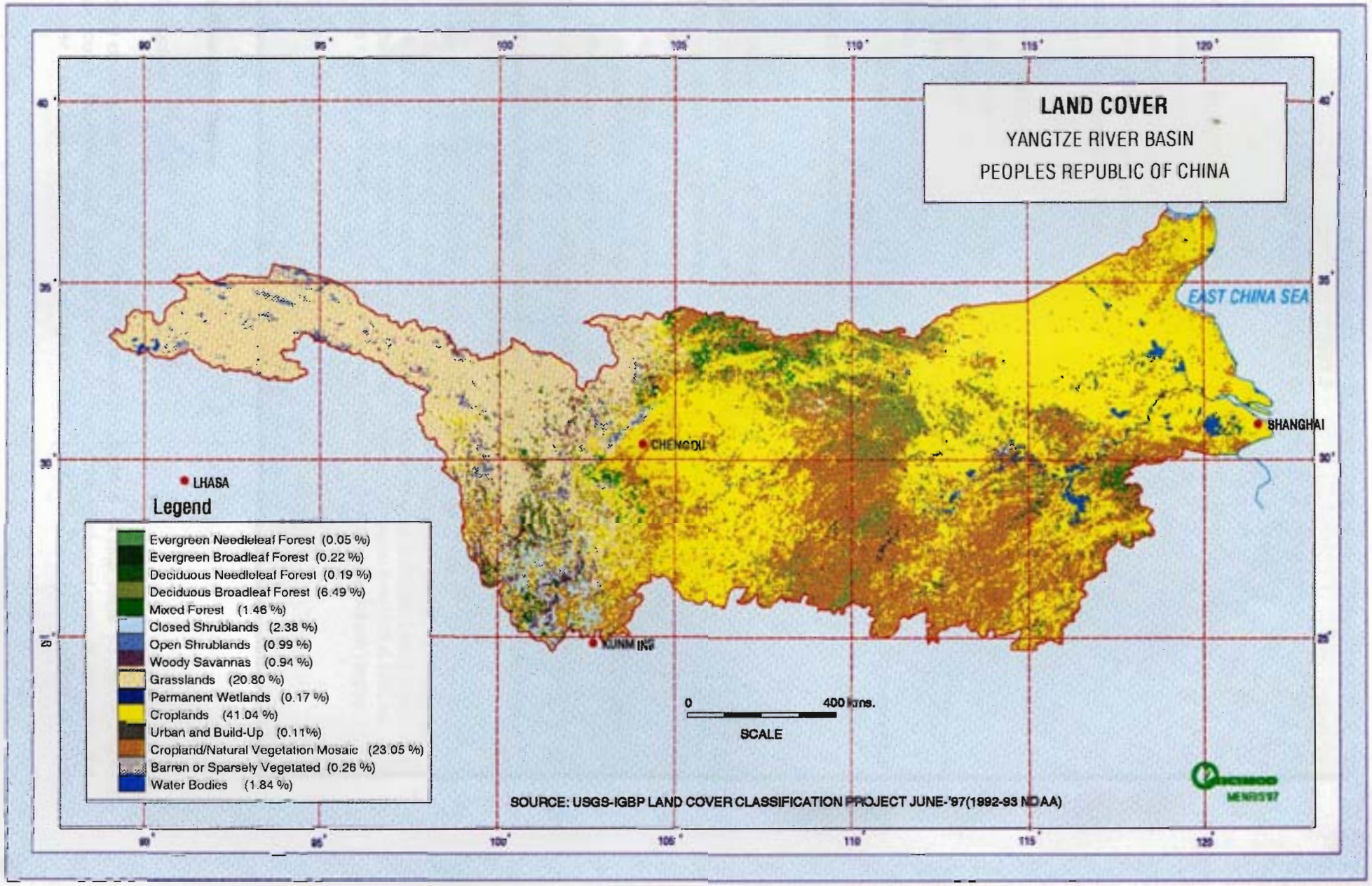
- The degradation in the quality of forests into low-value secondary forests, caused by repeated human disturbance and careless management, is also a serious problem.

- A series of guidelines, directives, laws, and regulations were issued and a Forest Act and Law of Soil and Water Conservation were also adopted. According to these, the existing forests were protected and new protective forests were established and combined with agroforestry practices (see Box 5).

MAP 11 : Elevation Zones of Yangtze River Basin



MAP 12 : Land Cover Map of Yangtze River Basin.



Box 5
Ecological Engineering in the Yangtze River Basin

Causes

Deforestation and degradation in the upper and middle reaches of the Yangtze River Basin are due to:

- population pressure,
- inadequate forest management,
- illegal use of the marginal land, and
- poor economic development of the region.

Effects

Decrease in Forest Cover

• Sichuan Province	1950- 20%	1980- 13%
• Jiangsu Province		1997- 8%
• Anhui Province		1997- 13.5%
• Guizhou Province		1997- 15.1%
• Jialing River Area		1997- 6,000 sq.km. of low density forests (60% of the total forest area)

- Debris flows, landslides, rapid runoff, erosion, and decline in water quality

Measures

- 1979: future of Yangtze River Basin forests received attention
- 1980: afforestation and strengthening of watershed forests carried out
- 1980: a symposium on integrated development of forestry and agriculture held in Sichuan
- The idea of constructing the protective forest system was generated.
- 1981: experiences of Yanting County reveal the great social and economic aspects
- 1986: the Overall Plan for the First Stage Construction Programme was approved by the People's Congress.
- 1989: the State approved the programme.
- The programme integrated protective forest with cash-crop, fuelwood, timber, and other-purpose forests.

This huge forestry ecological engineering programme covered 13 Provinces and 645 counties, with a total area of 4.06 million sq.km. After the year 2050, the total forest cover will be 45 per cent of the land area.

In 1997, after seven years of implementation of the Yangtze River Protective Forest Project, 27,075 sq.km. of protected forest had been improved and stocking became almost double than previously. Overall, the Yangtze River Basin area had an increase of more than five per cent in forest and vegetation cover. In Xingzuo County, Jiangxi Province, the soil erosion area was reduced from 160,000 to 50,000ha and, in the period from 1980 to 1995, the forest cover increased by 20.8 per cent; formerly this area was known as the desert area of southern Yangtze.

Source : Wenhua et al. (1997, background document)

The Yellow River Basin

Forest Situation

The forest cover is very low, only 2.9 per cent according to Map 14 and Table 13. According to another source, the forest cover amounts to four per cent of the catchment area. In any case, the forest cover is well below the national average in China (13.92 %). The regional pattern of forest

Table 13: **Land Use of the Yellow River Watershed**			
No	Forest / Land Cover Type	Area	
		'000 sq.km.	%
1	Evergreen needleleaf	0.08	0.01
2	Evergreen broadleaf	1.91	0.24
3	Deciduous needleleaf	14.45	1.82
4	Mixed forest	6.99	0.88
5	Closed shrublands	0.16	0.02
6	Open shrublands	159.46	20.08
7	Woody savannas	1.27	0.16
8	Grasslands	332.89	41.92
9	Permanent wetlands	0.08	0.01
10	Croplands (agricultural lands)	123.16	15.51
11	Urban built-up	0.87	0.11
12	Croplands/natural vegetation mosaic	98.15	12.36
13	Barren/ sparsely vegetated	45.50	5.73
14	Waterbodies	9.29	1.17
	Total	**794.00**	**100.00**
Source : Loveland et al. 1997			

cover has been documented in Table 14. The highest forest cover is found on the loess plateau where forestry is most important and beneficial (see Maps 13 and 14).

Significance

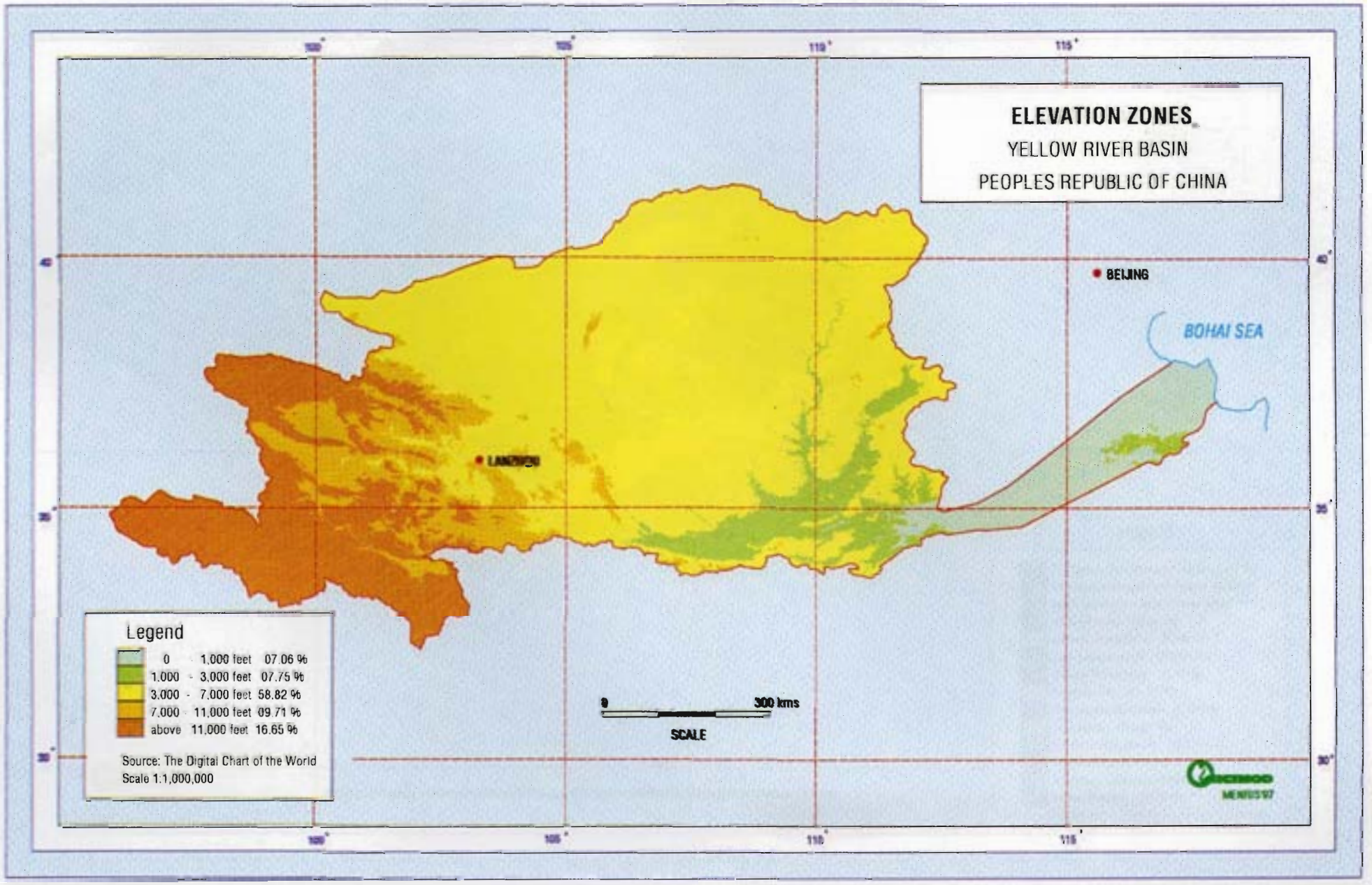
The Loess Plateau is the key area for fruit production. Water and soil conservation measures (biological measures) are very common. Fruit production totalled 1,059,700 tons on the Loess Plateau, and this corresponds to 9.1 per cent of the total production of China.

Trends

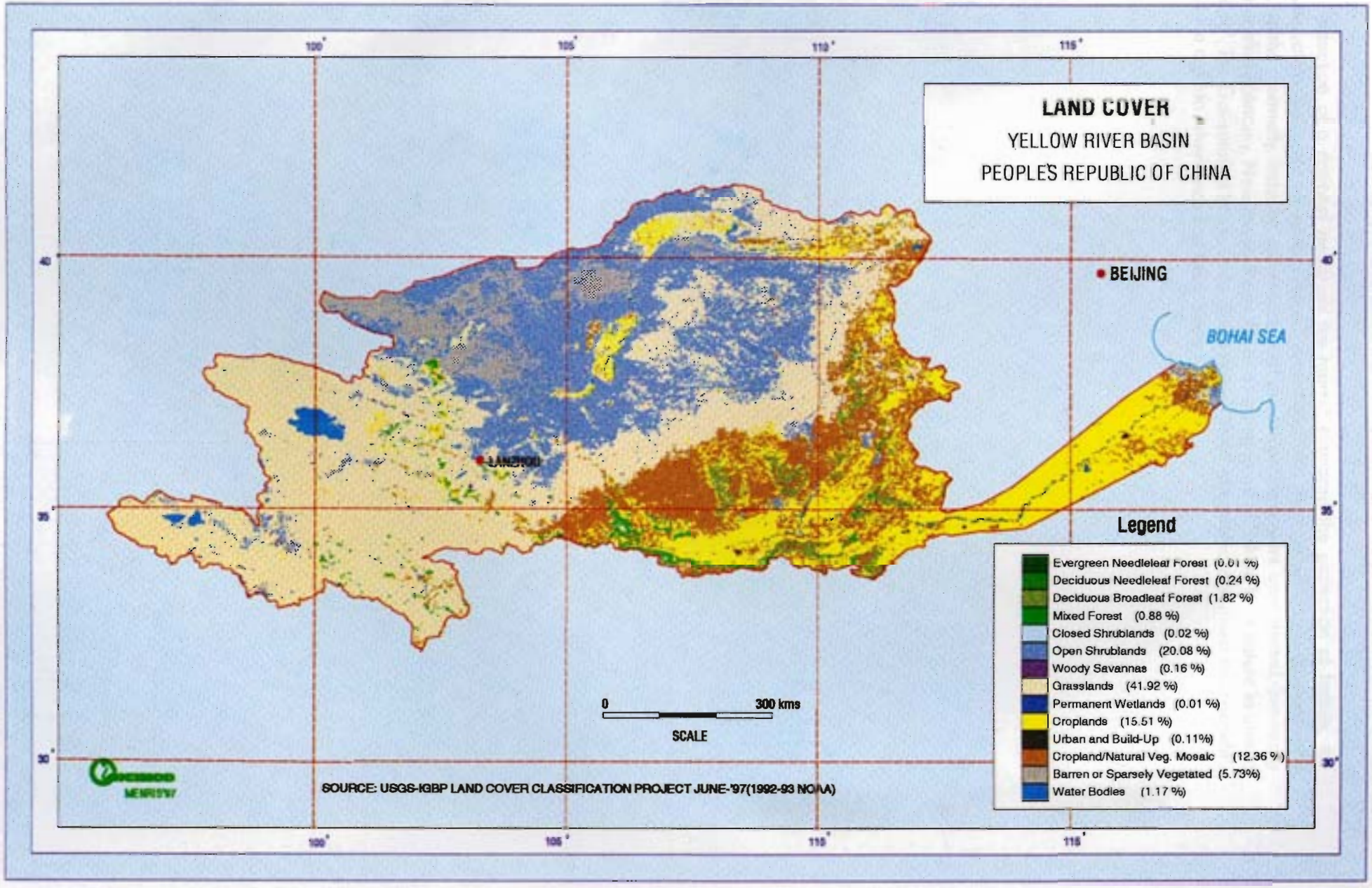
- There are several afforestation projects in the Yellow River Basin. As an example, in the 'three north protection forest project', 61,830 sq.km. were planted from 1978-85 out of which 39,784 sq.km. are located in the Loess Plateau.

Table 14: **Forest Regions of the Yellow River Basin**			
Region	Precipitation (mm)	Climatic zone	Forest Cover (per cent)
Agroforestry Region of Huang-Huai-Hai alluvial plain	500-800	Warm and semi-humid temperate zone	4.4
Agroforestry Region of Fen-Wei alluvial plain	600-800	Warm and semi-humid temperate zone	3.2
Water - Soil Conservation Forestry Region of the Loess Plateau	400-600	Semi-arid temperate zone	8.3
Windy Sandy, Arid Land Forestry Region	200-400	Arid temperate zone, high frequency of drought, strong wind	2.4
The Irrigated Forestry Region of Ningxia and Hetao Alluvial Plain	100-250	Arid temperate zone, dry and sunny, dry and hot wind	4.2
East Qinghai High Plateau and Mountain Forestry Region	300-600	Semi-arid Mountain Temperate Zone, with sharp vertical changes	2.9
Bush Forestry/ Non-Forest Region in the river originating region and upper reaches	400-800	Humid cold mountain climate, with sharp vertical changes	0.0
Source : Wenhua et al. (1997, background document)			

MAP 13 : Elevation Zones of Yellow River Basin.



MAP 14 : Land Cover Map of Yellow River Basin



- The adoption of a national policy on the market economy, the protection of forests, the conservation measures for environmental protection, and the economic development were successful. Formerly, industry, commerce, and private property were unprotected, hindering the market economy. Now it is said that it is at a turning point of 'taking from nature to give to nature'. The Government has issued a directive that 'those who protect and invest must benefit', and the right to inheritance has been given also.

Chapter IV
The Main Driving Forces Affecting Forest Cover in Key Watersheds

Introduction

From the previous chapters it can be noted that there are positive and negative trends with respect to forestry in these watersheds. While there is a general trend of loss of forest cover and forest degradation, there are also signs of hope where innovative forest policies and / or other interventions are slowing down or even reversing the negative trend. The main driving forces affecting the forest cover are the following.

i) National Policies

Many national policies have an impact on forest cover in large watersheds. Those related to land use and land ownership on steep lands are particularly relevant. Specific forest policies, while usually designed for protection and/ or sustainable management, have not always been successful. More recently, there have been indications that policies that enable local communities to manage the forests in their neighbourhood can be effective in halting further deforestation and forest degradation.

ii) Population Growth and Poverty

Population growth leads first of all to agricultural expansion into forest areas and secondly to an increased demand for fuelwood, timber, fodder, and other forest products by the predominantly subsistence economies in the six watersheds. Both factors result in intense pressure on forest resources and, as a consequence, in deterioration of forest quality and even to a reduction in forest area.

iii) Economic Development and Industrialisation

Economic development may relieve some of the pressure on the forestry sector if it leads the population to a certain independence from forest products. This applies, in particular, to the use of fuelwood, as increased income is followed by steps in the energy ladder towards non-biomass

based fuels. Industrialisation and economic development may, however, also lead to increasing demands for timber and increased logging pressures on mountain forests.

iv) Infrastructure and Hydropower Production

The development of hydropower schemes may lead to the increasing protection of forests and/ or afforestation in the upstream watersheds, since a healthy environment in the watershed that discharges into the reservoirs is crucial for the survival of the respective installations. Hydropower production may help to replace fuelwood use in agro-processing and other rural industries. However, there have also been instances in which hydropower development has led to deforestation because of wrongly planned and/or implemented resettlement programmes for people inhabiting the planned reservoir area, or otherwise.

v) Climate Change

In the long term, climate change (e.g., rising temperature or change in rainfall patterns) could be a driving force affecting the forests in the six watersheds. Chalise (1994) reported the climate changes in the Himalayas over time. Gilbert et al. (1991) stressed that the major major threat to the world's forests is human activity rather than climate change.

Among tropical, temperate, and boreal forests, tropical forests are likely to be more affected by changes in land use than by climate changes. They will be affected more by soil water availability than by changes in temperature. Temperate forests are mostly located in developed countries, and the impacts of climate changes are mitigated through integrated fire, pest, and disease management. Boreal forests are more strongly affected by temperature changes. Tree lines are likely to advance slowly into regions currently occupied by tundra (IPCC 1996). In a similar way, some changes may be expected along the altitudinal gradient.

vi) Highland - Lowland Interactions

Highlands and lowlands have multiple and diverse ecological and environmental linkages. The nature of the highlands plays a crucial role due to the constraints imposed by inaccessibility, fragility, marginality, and diversity. The relationship between the highlands and the lowlands can be emphasised in the context of mountains being the source of primary products for lowland economies and societies; and the uncompensated transfer of resources such as timber, biodiversity, and water, have yielded little benefit to highland communities but rather create negative effects locally. Mountain forests need to be conserved for the benefit of the large investment in lowland hydropower installations or for the regular flow of water and prevention of floods downstream. In return, not much consideration is given to upland communities. The resources and commodity flows to the highlands are too small and selective and, for the highlanders, the commodities produced are constrained by poor mobility, perishability, and low bargaining capabilities resulting in fewer benefits.

Chapter V
Prospects for Forestry in Key Watersheds by the Year 2010 and Beyond

In all the countries covered by the six watersheds described in this study, there is an increasing awareness about the importance of forests for environmental stability and economic (local and national) development. As forestry, however, covers only a small part of the overall watershed areas (except for the Mekong Basin), it is unlikely that forests will play a key role on the large scale referred to in the present report. Within the framework of the present study, it has not been possible to make detailed predictions. However, a number of general remarks can be made.

Forestry towards the Year 2010; Assuming the Status Quo

The total population in five of the river basins is about 700 million (Table 15). If a population growth of two per cent is adopted, the population by the year 2010 will be 942 million. Present trends indicate no improvement in wood or fuelwood consumption patterns, and the degradation of forests at two per cent can be applied, resulting in a forest cover of 653,000 sq.km.; a drop in current forest cover of from 14.7 to 10.9 per cent.

Table 15: Population and Forest Cover in Each River Basin

River Basin	Drainage Area ('000 sq.km.)	Population (million)	Forest Cover ('000 sq.km.)
Yangtze	1809	100.4	152.09
Yellow	794	81.7	23.43
Indus	945	n.a.	37.72
Ganges	1050	378.4	175.00
Brahmaputra	580	72.2	140.70
Mekong	795	62.0	349.96
Total	**5,973**	**694.7**	**878.90**

Source: USGS-IGBP, MRC 1997, Jizheng 1993, Bruijnzeel and Bremmer 1989, FSI 1996, FAO 1997b & 1997c, Wenhua et al. 1997 (background document), Shengji et al. 1995

As the population densities and forest cover of watersheds vary, the forest depletion may be more serious in areas like the Ganges' watershed.

Forestry situations in the river basins have been summarised (Chapter 3). Deforestation in the Indus River Basin resulted in soil erosion and high sedimentation rates for water reservoirs in Pakistan. Government policy support for community forestry is weak. High population and extremely heavy sedimentation in the Ganges' River Basin in India also need rehabilitation measures. Agroforestry practices and fuelwood deficiency problems have been solved by using manure in the lowland Ganges' watershed in India. The Indian joint forest management system has been successful, but extension on a national scale is needed. Heavy loss of forest cover in the Northeast Indian states has resulted in a supreme court order banning timber production and removal. *Jhuming* is also a problem and ways to solve this problem are being tried in the Brahmaputra River Basin in India. Poverty among the rural poor of the Mekong River Basin, making the local community more dependent on existing resources, needs to be considered in developing major projects and agreements between the Mekong River riparian governments. Serious erosion problems in the Yangtze River Basin and good examples of rehabilitation were found. Programmes for planting trees and improving the deteriorating natural forests were started in the Yangtze River Basin and shelter belt tree planting was introduced. There is environmental degradation and heavy erosion in the Yellow River as well as very low vegetation cover. Poverty and deficient natural resources and pollution of water due to industry and mining are also evident. With these scenarios, it is likely that the forests in the key watersheds in Asia and the Pacific will be reduced by another five per cent by the year 2010 if proper measures are not taken.

Forestry towards the Year 2010; Assuming an Optimistic Scenario

With government funding and policy changes the forest cover of all the six key watersheds might be raised by another five or 10 per cent through community participation and appropriate agroforestry systems. Agricultural products will be increased in production and income generated through marketing of the extra yield benefits from the improved techniques and market opportunities. Economic conditions will be better for the community living in the watersheds.

Awareness of poor mountain communities about water and soil conservation and environmental conservation will be generated through extension. Proper management of forests through participatory community forestry will be very effective and successful.

Mangrove forests will be rehabilitated and ecology will be improved.

Forestry towards the Year 2010; Assuming Specific Deterioration in Policy and Action

In the somewhat unlikely event of a further deterioration in policies and actions related to the forestry section, there is a serious danger that the forest cover of the lower and middle hills of many of the watersheds will suffer from agricultural expansion and deforestation. This may have a significant impact on siltation levels of the upper reaches of the lower parts of watersheds in which agriculture plays a predominant role.

Chapter VI
Implications for Future Action

From the foregoing, it may be concluded that forestry sector policies as such will not have a major impact on the overall land-use patterns in Asia's Key Watersheds. Action should be focussed on approaches in which the forestry section can play an important role. The major areas of attention should be the following.

i) Focus on Elevation Zones between 300 and 3,000 Metres

The percentage of forest cover is still relatively high in the altitudinal ranges between 1,000 and 3,000m, especially in the Brahmaputra and Mekong watersheds. In addition, the lower hill slopes of from 300-1,000m are often the most fragile ones and their deterioration could have a negative impact on lowland agriculture. Therefore future action in forestry should pay particular attention to forests in altitudinal zones between 300 and 3,000m within the respective watersheds.

ii) Forest Management for and by Local Communities

Because of the remoteness of many villages and the intimate role of forests and trees in mountain farming systems and in rural households, forest management has to be practised by and for the local communities. In Nepal, it has been shown that this approach is viable. Forests are coming back in many areas and more than 5,000 user groups are active in managing the forests.

iii) Integrated Area Planning

Although several studies have now rejected the myth that floods in Bangladesh and other floodplains are caused by deforestation in high mountain areas thousands of kilometres away, it is also clear that for small- and medium-sized watersheds, forests are essential for maintaining the regular flow of water so essential for human consumption and irrigation.

Integrated area planning, acknowledging this important role of the forests, is crucial. Various policies such as National Forest Policies, National Environmental Policies, National Land-use Policies, and so on are usually not integrated. Integration within and between nations is an important factor for the development and success of the programmes.

iv) Economic Benefits based on Forestry Products and Environmental Conservation

The fragile environment of this, the youngest geological formation in the world, does not allow for intensive logging practices. The upland areas should never be considered a substantial source of timber for the surrounding plains. Satisfying the timber needs of their own populations is already a major challenge to sustainable forest management. Any economic gains should be based on the trade of sustainably-managed, mountain-specific non-timber forest products of high-value, low-volume, and low perishability.

v) Development of Other Sectors

Development of other sectors, such as energy, will be desirable for mountain communities. One example will be the development of mini- and micro-hydropower for production of electricity, and this will have many positive effects on mountain communities. These efforts will also create job opportunities, in addition to providing higher living standards. Another example is the production of raw materials based on agricultural or forestry products. This will yield income-generating opportunities for mountain communities.

vi) Downstream Benefits for Upland Conservation

New methods have to be devised to ensure that quality water remains available in perpetuity for both upstream and downstream societies and economies. This would include the payment by downstream economies for upstream conservation measures so that infrastructural development for irrigation and hydro-electricity downstream can proceed and no unnecessary level of sacrifice is required from those upstream. Where large rivers cross international boundaries, this will call for cooperation in sharing benefits and costs. The South Asian Association for Regional Cooperation (SAARC) and the Mekong River Commission could be considered as platforms to initiate such dialogues.

vii) International Conventions

The following international conventions have been signed and acceded to.

- *Convention on Biological Diversity*, signed by 168 member countries by 4th June 1993
- *Convention on Climate Change*, signed by 107 countries by 14th August 1997
- *Convention to Combat Desertification*, signed by over 100 nations
- *Convention on International Trade in Endangered Species* (CITES), signed by 134 countries by 16th February 1997
- *Basel Convention on Transboundary Movements of Hazardous Wastes*, signed by 113 countries by 22nd July 1997
- *Convention on Migratory Species* (The Bonn Convention), signed by 51 nations by 1st September 1997
- *Montreal Protocol on Substances that Deplete the Ozone Layer*, 110 governments are Party Members and attended a meeting in September 1997 in Montreal.

Source : UNEP web site on the internet, http://www.unep.org/unep/convent.

The conventions prescribe international collaboration. Most conventions, such as those on Biodiversity, CITES, Climate Change, Ozone, and the Bonn Convention, emphasise environmental conservation. The Combating Desertification Convention is directly concerned with depletion of

forests and forest conservation. Adherence to these international obligations will require considerable investment.

vii) Mangrove Forests

Mangrove forests are important resources existing in the tropical regions of key watersheds. Except for the Yellow River, all the other rivers had mangroves in their deltas. The conditions and extent of mangroves vary, they mostly urgently need rehabilitation. Since these are very important ecological resources, high priority should be given to rebuilding the once severely damaged mangrove resources.

ix) Assistance of the Global Community in the Maintenance of Biodiversity

The very high level of biodiversity in the region of the six key Asian watersheds, ranging from mangroves and tropical vegetation to mountain forests and grasslands, is of global importance and warrants the assistance of the global community, national governments, regional organizations, and local NGOs and community-based organizations. A major factor in preserving the region's biodiversity for the use and enjoyment of future generations will be its linkage with development and income-generating opportunities for the mountain people, the custodians of this diversity.

Chapter VII
Recommendations for Follow-up

The present study, within its limited timeframe and budget, has brought together a considerable amount of information on forestry and key watersheds in Asia. It has also revealed an urgent need to carry out additional studies on the role of forestry at altitudinal zones between 300 and 3,000 metres. Two different approaches are recommended.

i) Assessment of the extent of forest cover and the role of forests in **Key Asian Watersheds** between 300 - 3,000 metres

By focussing on this particular zone, a clearer picture can be obtained about the relative importance of forestry in these areas. Differentiation by three altitudinal zones can be carried out and criteria established for guidance on which subzones would require specific attention from the forestry sector. More detailed analysis of satellite imagery and demographic data would have to be carried out.

ii) Analysis of the role of forestry in selected meso-watersheds originating from the Tibetan Plateau

The purpose of this study would be to review the different roles that forestry plays in watersheds with different rainfall and socioeconomic patterns. For this purpose, in each of the six watersheds described in this report, one to three watersheds, with areas of from 5,000 - 20,000 sq.km., that are representative of major land-use patterns in this region, will be selected. Forest cover assessments will be carried out and socioeconomic relationships between forests and local development will be described.

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Participating Countries of the Hindu Kush-Himalayan Region

 Afghanistan

 Bangladesh

 Bhutan

 China

 India

 Myanmar

 Nepal

 Pakistan

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