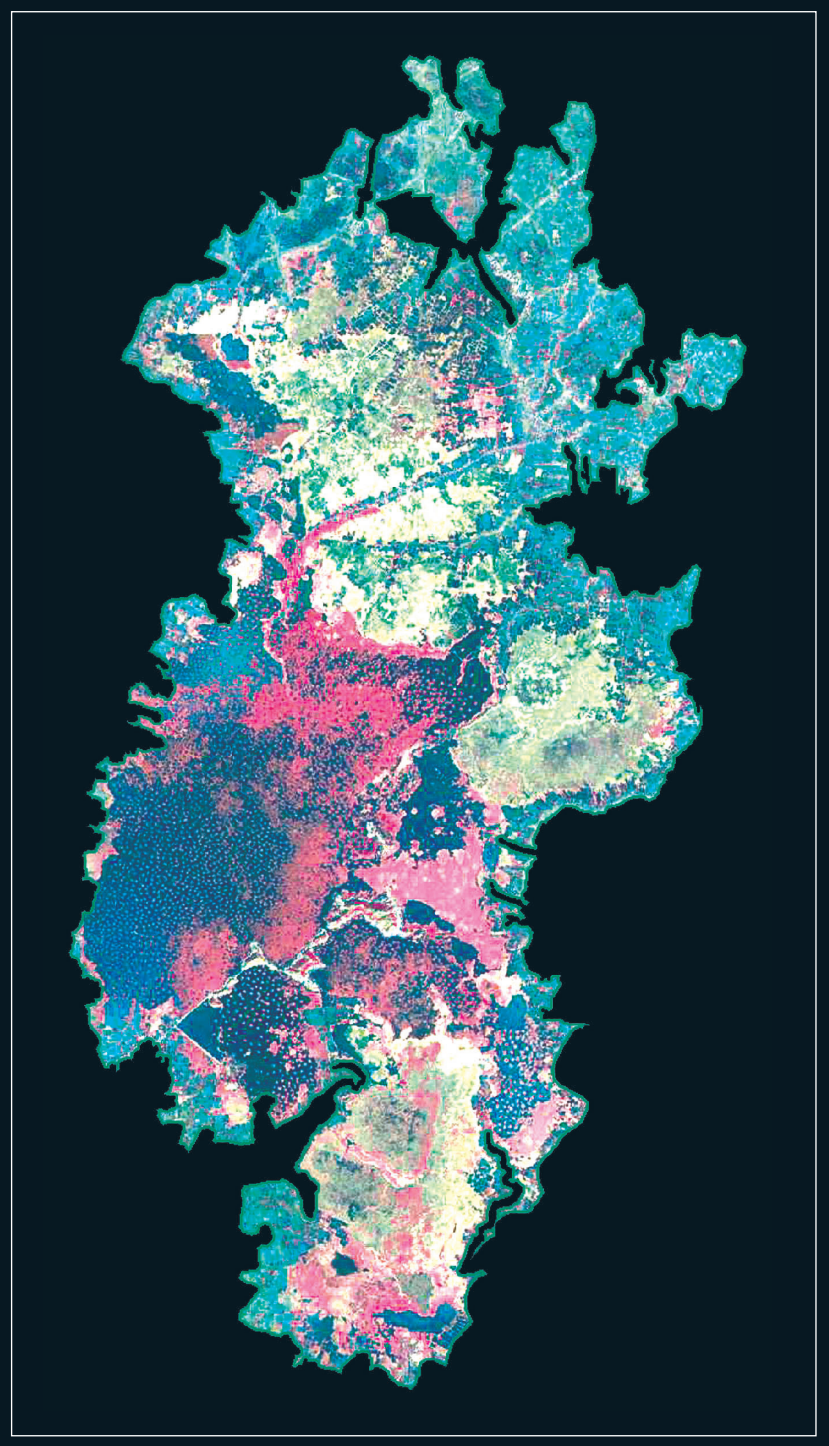
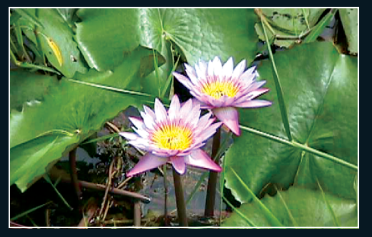
LOKTAK

THE ATLAS OF LOKTAK





Wetlands International ◆ Loktak Development Authority ◆ India-Canada Environment Facility

Sustainable Development and Water Resources Management of Loktak Lake

The goal of Sustainable Development and Water Resources Management of Loktak Lake is to improve water management of the lake and sustain its resources for the benefit of the local communities on a long-term basis. The purpose is to build capacity within Loktak Development Authority, other concerned institutions and local communities for effective management of lake. The ultimate purpose is to provide livelihood security to the local communities while ensuring conservation of the Loktak Lake.

Sustainable Development and Water Resources Management of Loktak Lake adopts an integrated approach based on sound scientific principles of wetland management to ensure conservation and sustainable utilization of resources at basin level. Restructuring of planning process involving local communities at all levels and in all sectors to ensure sustainable management of the lake and its catchments is the underlying objective.

The strategy adopted addresses the root cause problems on the basis of understanding the structural and functional aspects of the ecosystem and assessing the impacts of unsustainable developmental activities leading to deterioration of the lake. The strategy emphasizes on shifting the focus from sectoral approaches to an integrated management of wetlands with a focus on catchment conservation, water regime management, sustainable resources management and community development.

India Canada Environment Facility provided financial support for Sustainable Development and Water Resources Management of Loktak Lake. Ministry of Environment and Forests, Government of India under its ongoing programme on Conservation and Management of Loktak provided support to catchment conservation.

LOKTAK

THE ATLAS OF LOKTAK LAKE

C.L. Trisal and Th. Manihar

Wetlands International ◆ Loktak Development Authority ◆ India-Canada Environment Facility

CONTRIBUTORS

Ch. Rajagopal Singh	:	Technical Officer (WISA)
Ritesh Kumar	:	Technical Officer (WISA)
Chandrima Sinha	:	Technical Officer (WISA)
T. Brajeshwari Devi	:	Community Specialist (LDA)
Salam Santosh	:	GIS Specialist (LDA)
Ch. Bidan Singh	:	GIS Specialist (LDA)
Y. Ambika Devi	:	Systems Analyst (LDA)
Ng. Sanajaoba Meitei	:	Hydrologist (LDA)
L. Kosygin Singh	:	Water Quality Specialist
Shyamjai Singh	:	Botanist (LDA)
Ajo Singh	:	Hydrologist (LDA)

ISBN number : 81-87408-02-2

Citation: Trisal, C.L. and Manihar, Th. 2004. The Atlas of Loktak Lake

Published by
Wetlands International - South Asia Programme (A-127, Second Floor, Defence Colony, New Delhi - 110 024, India) and Loktak Development Authority (Leiren Mansion, Lamphelpat, Imphal, Manipur - 795 004, India)

This Atlas has been published with the financial support of the India-Canada Environment Facility, New Delhi through a project on **Sustainable Development and Water Resources Management of Loktak Lake**

Cover Page : Satellite imagery of Loktak Lake (IRS 1D 2002)

Designed & Printed by :
InPrint Exclusives India Private Limited, New Delhi
Ph: +91-11-29213101, 29212893

CHIEF MINISTER
MANIPUR

Imphal, Manipur

MESSAGE

It gives me immense pleasure to learn that Loktak Development Authority (LDA) and Wetlands International have brought out a publication on ATLAS OF LOKTAK LAKE, which provides spatial information on lake catchments, water regimes, sustainable fisheries development and wildlife conservation.

Natural resources form the base of economy of Manipur and Loktak Lake plays an important role in the ecological and economic security of the region. The increasing pressures on the lake and its catchments have led to degradation of the echo system thereby effecting the livelihood security of a large population dependent upon the wetland resources for their sustenance.

Loktak Development Authority and Wetland International South Asia have done a commendable job in documenting baseline information on ecological and economic aspects of Loktak Lake which will be of great use for future planning and management of the Loktak Lake and its catchments. The relevant information provided spatially in the ATLAS ON LOKTAK, I am sure, will be of immense use to the developmental planner and conservationists to ensure sustainable development in all sectors particularly water resources, fisheries, agriculture, forestry and eco-tourism.

I congratulate Loktak Development Authority (LDA) and Wetlands International and wish the publication all success.

(O Ibobi Singh)

Canadian Embassy Ambassade du Canada

New Delhi

MESSAGE

I am proud to learn about the achievements of Loktak Lake Project in Manipur, implemented with support from the India Canada Environment Facility (ICEF). The project has helped develop a long-term approach to conservation of the endangered lake system, also a Ramsar site, in the remote part of the country.

The focus of the project has been on building the capacities of the implementing agency and the local communities to promote sustainable development of the lake resources and to conserve its rich biodiversity for the benefit of the local communities. The project has displayed innovative community-based interventions in identified thrust areas for conservation of this large common property resource.

Management of a complex wetland system like the Loktak Lake, requires careful resource inventory and monitoring their utilization pattern. Application of GIS technology has been very effective in this endeavour. The approach has been useful in providing a comprehensive understanding of the biodiversity of the lake and its surrounding catchment area.

The Atlas, with a wealth of data and their analysis, goes a long way in our understanding the challenges of a dynamic wetland like the Loktak Lake. I extend my warm greetings and felicitations to all those associated with the project and wish the implementing agencies all success in their endeavour in conserving and judiciously managing the Loktak Lake for the benefit of the people of Manipur.

Lucie Edwards

Lucie Edwards
High Commissioner

Canada

W. LEIMA DEVI
Minister (INF & LDA)
Manipur

Phone : 2442156 - (O)
2228059 - (R)
Imphal - 795001

MESSAGE

I am glad that Loktak Development Authority and Wetlands International has brought out a publication on **Atlas of Loktak Lake** documenting information on ecological, hydrological and socio-economic aspects of Loktak Lake and its catchments. The publication is the outcome of the implementation of a project on Sustainable Development and Water Resources Management of Loktak Lake for which financial support was provided by India Canada Environment Facility.

The Atlas highlights key features relating to hydrological regimes, catchment status, community relationships, resource utilization pattern and wildlife conservation. The critical areas of concern have been advocated based on the experiences gained in implementing conservation and sustainable development activities in close collaboration with local communities and NGOs. Special emphasis has been laid in the publication on habitat improvement of Keibul Lamjao National Park, which is the natural refuge for highly endangered ungulate species locally called *Sangai*.

I congratulate Loktak Development Authority and Wetlands International for the publication on **Atlas of Loktak Lake**, which I am sure, will be an excellent basis for the development of future strategies and comprehensive action plan for conservation and sustainable development of Loktak Lake. This publication will be also a valuable reference for all regional, national and international organisation and communities dedicated to integrated water resources management and sustainable development of wetlands at the river basin level.

W. Leima Devi

(W. Leima Devi)
Minister (INF. & LDA)
Manipur

Wetlands International
P.O. Box 471, 6700 AL Wageningen
The Netherlands
Tel: +31 317 478854,
Fax: +31 317 478850
E-mail: post@wetlands.org

Visiting Address:
Droevendaalsesteeg 3a6708,
PB Wageningen
Reg. No: 09099028

MESSAGE

I am delighted with the production of the Atlas of Loktak Lake. This Atlas is one of the outcomes of the productive partnership between Wetlands International, Loktak Development Authority and the India-Canada Environment Facility. It is the result of a tremendous team effort of a large number of contributors, including strong participation of local communities. I would like to congratulate all of them and especially the main authors, for bringing this information together in such a clear and attractive way. The book will be of great interest to wetland ecologists and conservationists internationally as well as a valuable resource in India and in Manipur.

The document is comprehensive and provides an excellent account of this spectacular wetland that is internationally important for biodiversity. It explains the history of the lake and explains its full range of wetland values for biodiversity and human use, as well as providing clear maps and data on the current status of the wetland ecotypes and natural resources. Importantly, significant gaps in information are also identified. The Atlas will be an invaluable resource for local people as it will increase understanding of the ecological processes affecting the status of biodiversity and the other products and services (such as fisheries and water storage capacity), that the lake provides to local people. The Atlas will inform the future planning and management of the whole catchment and help to identify priorities for action and for monitoring changes in ecological character.

It is important to note that the Loktak Development Authority and Wetlands International needed to work with local people to take action to address the environmental degradation of Loktak Lake before this Atlas was produced. It is also undoubtedly true that there are still many things to be discovered and understood about the ecology of the Lake and how human interactions may influence its ecological status and hence people's livelihoods. So, while I warmly welcome the production of this Atlas I would also like to encourage all those involved in securing a positive future for the Lake to continue to build on this work!

Jane Madgwick

Jane Madgwick
Chief Executive Officer

ACKNOWLEDGEMENTS

The information presented in this publication is based on detailed surveys and assessments carried out under the project on 'Sustainable Development and Water Resources Management of Loktak Lake'. We wish to thank all those who worked for the project and in particular to Ch. Gojendro Singh, Sanajaoba Meitei, W. Bimolkishore Singh, Ajo Singh, Th. Hemchandra, Bidya Bhusan, Bimolendro, Maniton Singh, Iboyaima Singh, Ayub Khan, T. Romi Singh, Dr. L. Kosygin, Y. Ambika Devi, Shyamjai Singh, Brajeshwari Devi, Ramashankar, Gopa Kishore, Premananda, Manoj Chandra, M. London, Ram Kumar, Falguni Sharma, H. Rishikesh Sharma, Bhagya Singh and Somorendro Singh who provided commendable technical assistance in bringing out information on Loktak Lake and its resources. We extend our special thanks to Salam Santosh and Ch. Bidan (GIS Specialists) who devoted considerable time in preparing maps and figures.

We extend our thanks to several NGOs, youth clubs, local community groups, women groups and all those with whom we interacted all along the project implementation to collect baseline data and develop strategy for sustainable development of the lake.

Our special thanks are due to Dr. S. Kaul, Director, Ministry of Environment and Forests, Government of India for his constant and valuable support throughout the project implementation.

Our gratitude is due to Smt. W. Leima Devi, Hon'ble Minister, Information and Loktak Development Authority and Shri. Saichhuana, Additional Chief Secretary, Goverment of Manipur and for their constant support and advice throughout the project implementation.

We are thankful to Dr. Max Finlayson, President, Wetlands International for his encouragement and strategic direction to this initiative on Loktak Lake. The support of Chief Executive Officer, Wetlands International is gratefully acknowledged.

We wish to thank former ICEF Director, Mr. Alan Ferguson and Mr. Bernard Boudreau for their support in the implementation of the project. Mr. Ferguson particularly was instrumental in conceiving and promoting initiative on the Loktak Lake. Our thanks are also due to Mr. Ujjawal Chaudhary, the present Director, ICEF for providing useful advice in implementation of strategies for conservation of Loktak Lake and developing specific programmes for livelihood improvement of local communities. We also wish to thank Dr. Mihir K. Maitra, Sr. Project Officer, ICEF for his continued technical support and encouragement all along the project implementation.

We wish to thank Mr. Salam Rajesh, Member State Board for Wildlife of Manipur and Journalist for providing valuable information regarding wildlife and some useful comments.

The assistance of Mr. Kamal Dalakoti in GIS mapping and selection of photographs and Ms. Meena Kumari, Office Secretary, Wetlands International in meticulously typing the manuscript is gratefully acknowledged.

PREFACE

Wetlands are highly complex ecosystems due to interactions of diverse factors relating to land and water resources. The increasing demands and pressures on wetlands have often led to their degradation, thereby threatening livelihoods of the communities dependent upon their resources particularly in developing countries.

Conservation and sustainable development of wetlands essentially involves integrated planning and management at the river basin level recognizing the interconnectedness of wetlands with their catchments. River basin level planning requires understanding of the values and functions of the wetlands within river basin with a view to produce desired outputs (goods and services) from limited resource base and achieve equitable quality of life while maintaining desired environmental quality in the region. Planning for sustainable development calls for trade-offs between desired production and consumption levels. It also emphasizes on the development of supportive mechanisms within the generative capacity while maintaining the environmental quality. The challenge, therefore, is to conserve wetland ecosystems and their rich biodiversity while providing sustained economic benefits to the communities.

Loktak Lake, the largest wetland of northeastern region of India, was traditionally used for agriculture and fisheries. Local people sustainably managed its rich biodiversity and derived benefits through its natural functioning. However, onslaught of unsustainable developmental activities without understanding the nature of the wetland ecosystem has led to its degradation and loss of benefits accrued from the ecosystem. The denudation of lake catchments due to jhum farming, deforestation and increasing demands for fodder, fuel and other forest products contributed to enhanced siltation and reduction of water holding capacity of the lake. Construction of hydraulic structures for irrigation and hydropower generation further compounded the problems of lake siltation, nutrient enrichment and reduced migration of fish fauna.

Though several action plans are in place for management of Loktak, they are either sectoral in nature or have proposed some prescriptions without adequate database. A project on Sustainable Development and Water Resources Management of Loktak Lake with financial support of India Canada Environment Facility (ICEF) was undertaken by Loktak Development Authority (LDA) and Wetlands International - South Asia (WISA) to integrate ecological, social and economic dimensions for conservation and wise use of Loktak Lake. The focus of this project was to develop a comprehensive database involving several research organizations, local communities and NGOs. A well designed temporal and spatial database on Loktak Lake and its catchments has been created for use of Loktak Development Authority and various agencies involved in conservation and wise use of the wetland. Based on the information collected, Atlas of Loktak Lake has been prepared which gives spatial and temporal information on Loktak Lake and its catchments. The information is expected to be of great use to the developmental planners, scientific communities, NGOs, and stakeholders particularly local communities for planning and management of Loktak.

February, 2004

CLT and TM

CONTENTS

CONTENTS

List of Maps:

INTRODUCTION

India is one of the twelve mega biodiversity countries of the world with Western Ghats and North East as the two identified global hot spots of biodiversity. Manipur, a mountainous state in the North East is replete with wetlands harbouring rich biodiversity and providing sustenance to a large population dependant upon their resources for livelihoods. Manipur is generally referred as the 'Jewel of India' and Loktak Lake as its lifeline.

Manipur is bordered by Nagaland in the north; Assam in the west; Mizoram in the south and; Myanmar in the east. It has a central oval shaped valley covering about one tenth of its total area surrounded by mountains on its all sides, ascending from 800 to 3,000 m above MSL. The state extends over a geographical area of 22,327 sq km with a total population of 2.38 million, as per the census of 2001. Administratively the state is divided into nine districts out of which four are in the valley and five in the hills (Map 1).

The state has a lopsided population distribution with 59% of its population living in the valley and 41% thinly distributed in the hill areas (Economic Survey, Manipur, 2000). The valley is one of the most thickly populated areas in the country with a density of 633 persons per sq km as compared to an all India average of 324 persons per sq km. The hills are sparsely populated with 52 persons inhabiting per sq km. The state experienced a rapid growth of population, registering a decadal population growth rate of 30.02% during 1991-2001 against the national average of 21.34%.

Natural resources form the base of economy of Manipur. Forests account for 78% of the total geographical area of the state. Agriculture forms the single largest source of livelihood and is the mainstay of the state's economy. Farming systems in Manipur can be broadly categorized into shifting cultivation or *jhum* (*Paamlou* in Manipuri language) practised in the hills and a more settled form of agriculture in the valley region. The natural resource base of the state provides livelihood security to the entire region as well as employment to 68% of the working population. The rugged topography of the hilly regions of the state covered with forests and consequent lack of agriculture opportunities have made Manipur valley, comprising 12% of the state's area as hub of the economic activity of the state.

Manipur has two distinct river basins, namely the Manipur River Basin and the Barak River Basin. Manipur River Basin is blessed with an enormously rich and diverse heritage of wetlands, locally known as *pats*. There are 155

A panoramic view of Loktak Lake

wetlands in the state covering a total area of 47,020 ha, accounting for 2.1% of the total geographical area of the state. Most of the wetlands are concentrated in the four valley districts and only 2 man made reservoirs are found in the two hill districts of Senapati and Tamenglong. Loktak Lake is the largest wetland of the North East.

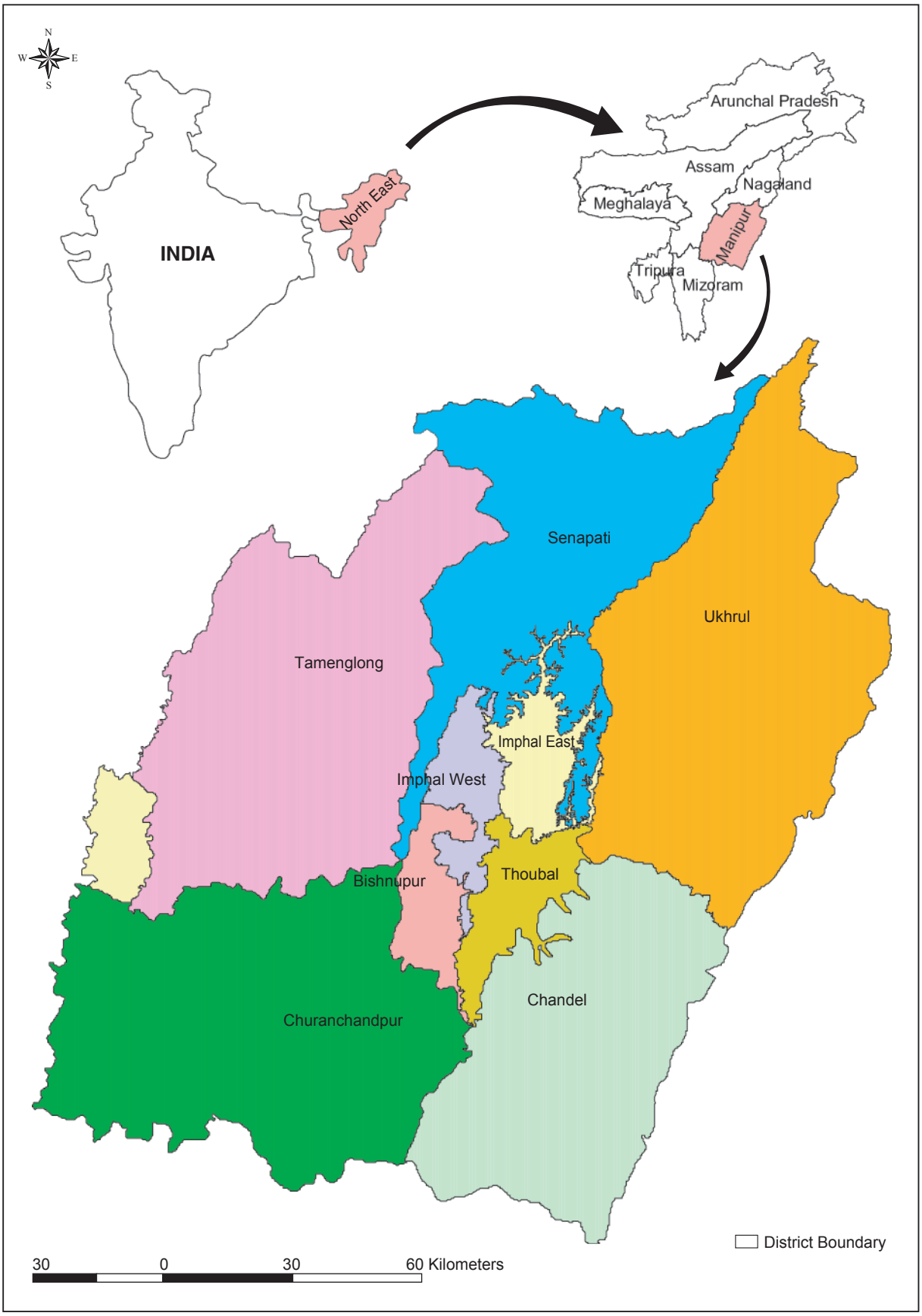
Loktak Lake - Lifeline of Manipur

Loktak Lake is considered as the lifeline of the people of Manipur due to its importance in their socio-economic and cultural life. It is the largest natural freshwater lake in the northeastern region and plays an important role in providing ecological and economic security to the region. A large population living in and around the lake depends upon its resources for their sustenance.

The lake is rich in biodiversity and has been designated as a Wetland of International Importance under Ramsar Convention in 1990. The Keibul Lamjao National Park located in the southern part of the lake is a unique floating wildlife reserve and is refuge of the highly endangered brow antlered deer, locally called *Sangai*. The lake has also been the breeding ground of a number of riverine fishes and continues to be a vital fisheries resource. It supports a significant population of migratory and resident waterfowl.

Threats and Impacts

The lake is under stress mainly due to anthropogenic pressures. Deforestation and shifting cultivation in the catchment area has promoted soil erosion resulting in increased lake siltation. The problem has further been aggravated due to prolific growth of floating weedmats locally called as *phumdis*. Besides nutrients from the catchment area and domestic sewage from Imphal city is



Map 1: **LOCATION MAP OF MANIPUR**

carried by Nambul River, which finally discharges into the lake. Pesticides used in the agricultural fields are also washed off into the lake. In addition to above threats, encroachments through construction of fishponds, roads and settlements have gradually led to degradation of the lake ecosystem.

In 1983, a multipurpose project was commissioned for generation of hydel power and irrigation by construction of a barrage at Ithai. This has brought about drastic changes in hydrological regimes and converted a natural wetland with fluctuating water level into a reservoir with more or less constant water level. This lead to inclusion of Loktak Lake in the 'Montreux Record' by Ramsar Convention which highlights the priority attention to be accorded to restoration of the lake ecosystem.

The root cause problems of the Loktak Lake can be traced to loss of vegetal cover in the catchment area and construction of barrages in the upstream and particularly Ithai Barrage in the southern part of the lake. The degradation of the catchment area has led to the problems of siltation and increased inflow of nutrients. The serious implications of construction of Ithai Barrage has led to :

(a) changes in hydrological regimes thereby affecting ecological processes and Loktak Lake

(b) inundation of agricultural lands and displacement of people from flooded lands

(c) loss of fish population and diversity

(d) decrease in the thickness of *phumdis* in the Keibul Lamjao National Park thereby threatening the survival of *Sangai* deer

The specific issues of the Loktak Lake are :

- ***Siltation*** - *Jhum* cultivation, extensive deforestation and unscientific land use practices in the catchment area are responsible for deposition of 650,000 tonnes of silt annually in the Lake.
- ***Weed Infestation*** - Rapid proliferation of *phumdis* and aquatic weeds have led to reduced water holding capacity, deterioration of water quality, interference in navigation, and overall reduction in aesthetic values of the lake.
- ***Decrease in Power Generation*** - The decrease in water holding capacity due to siltation, construction of fish farms and proliferation of *phumdis* has reduced power generation capacity of the lake.
- ***Loss of Biodiversity*** - The populations of migratory and resident waterfowl have declined during last few decades due to poaching and changes in ecological character of the lake. The habitat of *Sangai* deer in Keibul Lamjao National Park is threatened due to thinning of *phumdis* and poaching. Thirty five animal species (5 mammals, 3 birds, 9 reptiles, 3 amphibians, 12 fishes, 2 molluscs and 1 annelid) which were reported occuring abundantly in the past, have declined and are now disappearing gradually.
- ***Decrease in Fisheries Production*** - Over exploitation, indiscriminate methods of fishing, extensive growth of *phumdis* and weeds are responsible for decrease in fisheries production. Construction of Ithai Barrage across Manipur River has interfered with the migration of fishes from Chindwin-Irrawady River system of Myanmar and consequently brought changes in the species composition.
- ***Flooding*** - The construction of Ithai Barrage and decrease in absorption capacity of the lake has resulted in inundation of the peripheral agricultural and settlement areas.
- ***Pollution*** - Inflow of organo-chlorine pesticides and chemical fertilizers used in the agricultural practices around the lake, municipal wastes brought by Nambul River from Imphal, soil nutrients from the denuded catchment area and domestic sewage from settlements in and around the lake are responsible for deterioration of water quality.

Lake Management

Realizing the problems of Loktak Lake, the Government of Manipur constituted Loktak Development Authority (LDA) in 1986 for the overall improvement and management of the Lake. The objective of the Authority is to check deteriorating conditions of Loktak Lake and to bring about improvement of the Lake along with the development in the fields of fisheries, agriculture, tourism and afforestation in consultation with the concerned departments of the State Government. Initially management of Loktak Lake was mainly focused on removal of *phumdis*, desiltation and availability of water to ensure sufficient generation of power. North Eastern Council (NEC), engaged Water and Power Consultancy Services (WAPCOS) for the preparation of Problem Identification Report of the Loktak Lake. The WAPCOS report highlighted inadequacy of the data for management and suggested undertaking necessary surveys and studies

Phumdis in Loktak

to build baseline data. The NEC provided financial support to LDA for undertaking the surveys and collection of baseline data along with some activities for removal of weeds. Subsequently NEC again engaged WAPCOS for preparation of a comprehensive management action plan for Loktak Lake. The report submitted by WAPCOS was sent to the Ministry of Environment and Forests (MoEF), Government of India, for financial support. The proposal was, however, not approved and it was pointed out that the Action Plan prepared had emphasised more on economic development rather than conservation aspects. The ecological aspects had been ignored despite recognition of the lake as biodiversity rich area.

The MoEF constituted a Technical Advisory Committee in 1994 to identify the problems of Loktak Lake and suggest measures that could be taken up immediately to promote conservation of Loktak Lake on the basis of information already collected. The LDA in consultation with MoEF prepared a Management Action Plan (MAP) at a total cost of Rs. 10.9 million in 1996 for a period of five years. The action plan could not be implemented as proposed in the plan due to lack of funds.

With the limited funds mainly provided by Finance Commission and MoEF, LDA undertook activities such as afforestation in critical micro-watersheds, horticulture plantation, small scale engineering measure for erosion control, limited desiltation and dredging of channels, removal of *phumdis* from selected pockets of lake, peripheral bunding in the low-lying areas and widening of Moirang - Sendra road.

Currently action plans focused on several specific issues are in place but an overall integrated management action plan at river basin level considering ecological, social, economic and cultural features of the lake is lacking.

The issues of concern relating to management planning of the Lake are :

- Absence of baseline data on hydrology , ecology, socioeconomic aspects, catchment area, flora, fauna and their interrelationships
- Lack of community involvement in the conservation and development programmes
- Encroachment pressures on lands created from dredged and excavated material and construction of fish ponds in the lake
- Absence of policy and regulatory regimes at the government level for conservation of lake and its resources
- Emphasis on engineering measures rather than integrated approach involving social, economic and ecological aspects
- Inadequate technical and managerial skills and lack of coordination among different agencies concerned with Loktak Lake management leading to sectoral approaches and conflicting interests
- Lack of institutional development for conservation and sustainable livelihoods
- Lack of appropriate strategies including ineffective implementation of developmental programmes

Sustainable Development and Water Resources Management of Loktak Lake

A project on Sustainable Development and Water Resources Management of Loktak Lake (SDWRML), jointly formulated by WISA and LDA was initiated in 1997 to address the root cause problems and develop strategies for sustainable management of the lake. The main objective of the project was to develop and implement technical know how for conservation and management of Loktak Lake involving local communities, NGOs, research organizations and government agencies.

The strategy followed for implementation of the project emphasized on addressing the deteriorating conditions of the lake and providing livelihood security to the communities dependant upon its resources. The project essentially involved integration of social, ecological and economic dimensions, which are inter-related and inter-dependant for the sustainable development of the lake. Special emphasis has been given for the role of women in community development vis-a-vis conservation of Loktak Lake.

Project implementation for last more than six years has focussed on capacity building within Loktak Development Authority, other concerned stated government agencies in Manipur and the local communities for effective conservation and management of lake and its catchments. Strong linkages have been developed with stakeholder groups, particularly local communities, through elaborate participatory rural appraisal exercises (PRA) and consultation meetings for their involvement in planning and implementation of the project. The project has also developed linkages at international level with Ramsar Convention and other related environmental conventions. The project contributed significantly to formulation of guidelines for management planning of wetlands based on an elaborate process involving assessment of ecological, social, economic and cultural aspects of wetlands with close interaction of local communities and other stakeholders.

Based on the information collected on the wetlands and its catchments as well as implementation of demonstration projects, an atlas of Loktak Lake has been prepared which gives information on Loktak Lake and its catchments for use of development agencies, scientific community, NGOs, and other stakeholders, particularly local communities, for integrated management of Loktak.

MANIPUR RIVER BASIN

The hill areas of Manipur constituting catchments of Loktak and associated wetlands fall within Manipur River Basin covering an area of 6,872 sq km, which represents 31% of the total geographical area of the state. Geologically, the hills of the state comprise of rocks of tertiary age belonging to Disang and Barail formation. They are predominantly argillaceous comprising of shales with bands of siltstone, sandstone and mudstone (Map 2) giving rise to clayey soils in the valley. The shales are well bedded, highly cleaved, jointed and intensely folded and faulted. Hill soils are red in colour and vary in depth from deep to shallow. The base of the hills surrounding Manipur valley is highly weathered and oxidised. Valley soils are deep with texture ranging from silt loam to clay. They are slightly permeable, grey to brown in colour and acidic in reaction.

The broad characteristic features of the Manipur River basin including drainage pattern, watershed features, land use and wetlands are briefly highlighted in this section.

Drainage Pattern

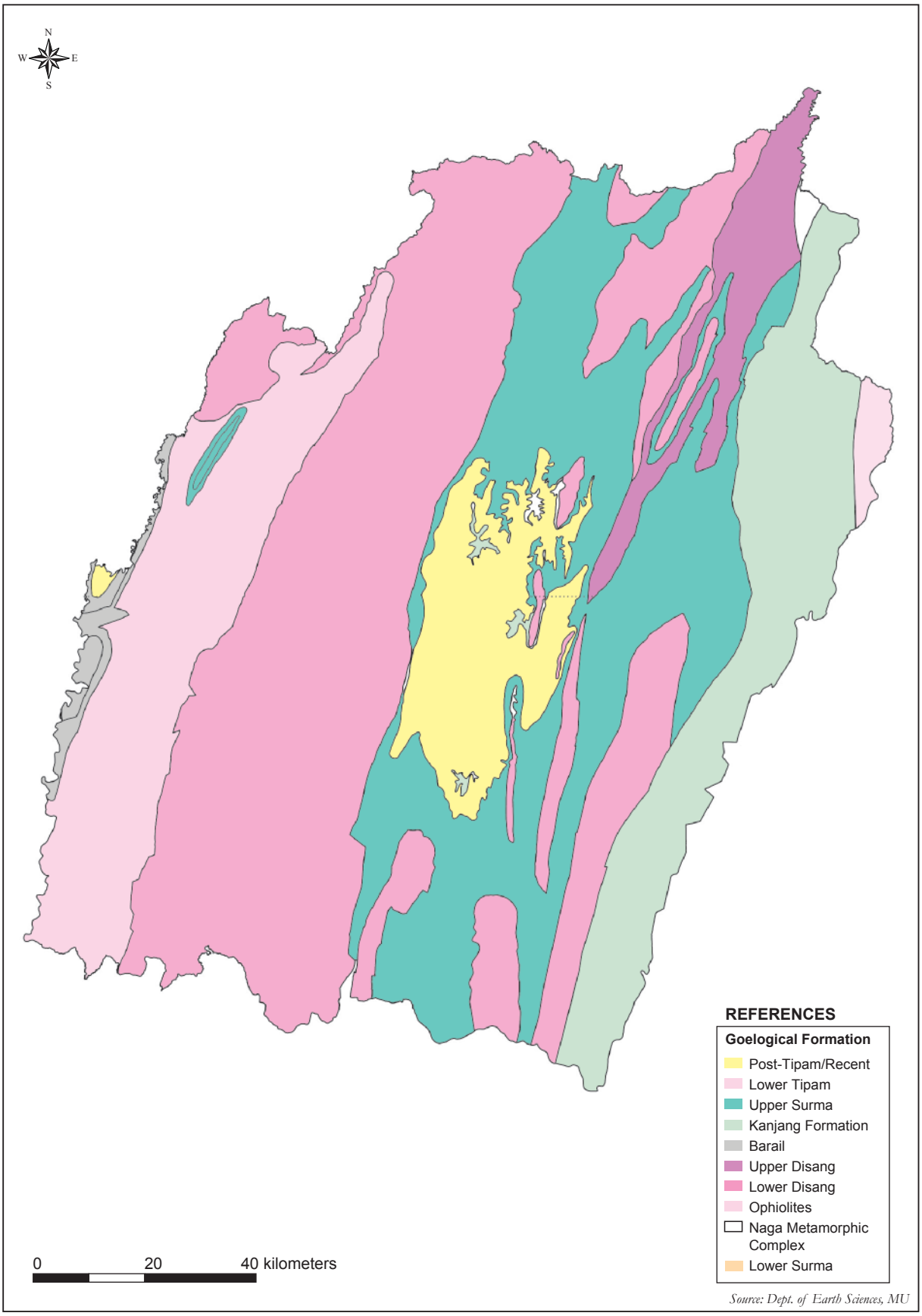
Manipur River arises in the north at Karong and flows southwards of Imphal city where it is known as Imphal River. Iril River joins Imphal River on its left bank about 10 km south of Imphal. Further downstream, Thoubal River also joins it on the left bank at Irong Ichil. After another 10 km it is joined by Sekmai River near village Sekmaijin and thereafter, it is known as Manipur River. Further downstream, Khuga River joins the Manipur River on its right bank. Later, the Manipur River flows south through a narrow gorge and undulating terrain of about 26 km where it meets the north flowing Chakpi River near village Sugunu. It continues flowing south to Myanmar where it joins the Chindwin River, a tributary of the Irrawaddy River (Map 3).

Along its course through the valley downstream of Imphal, the riverbed slopes very gently. The bed level is 773 m at Imphal and 768.6 m at Lilong (near its confluence with Iril River) and 762.2 m at Ithai, downstream of the confluence of the Manipur and Khuga rivers located 65 km. south of Imphal.

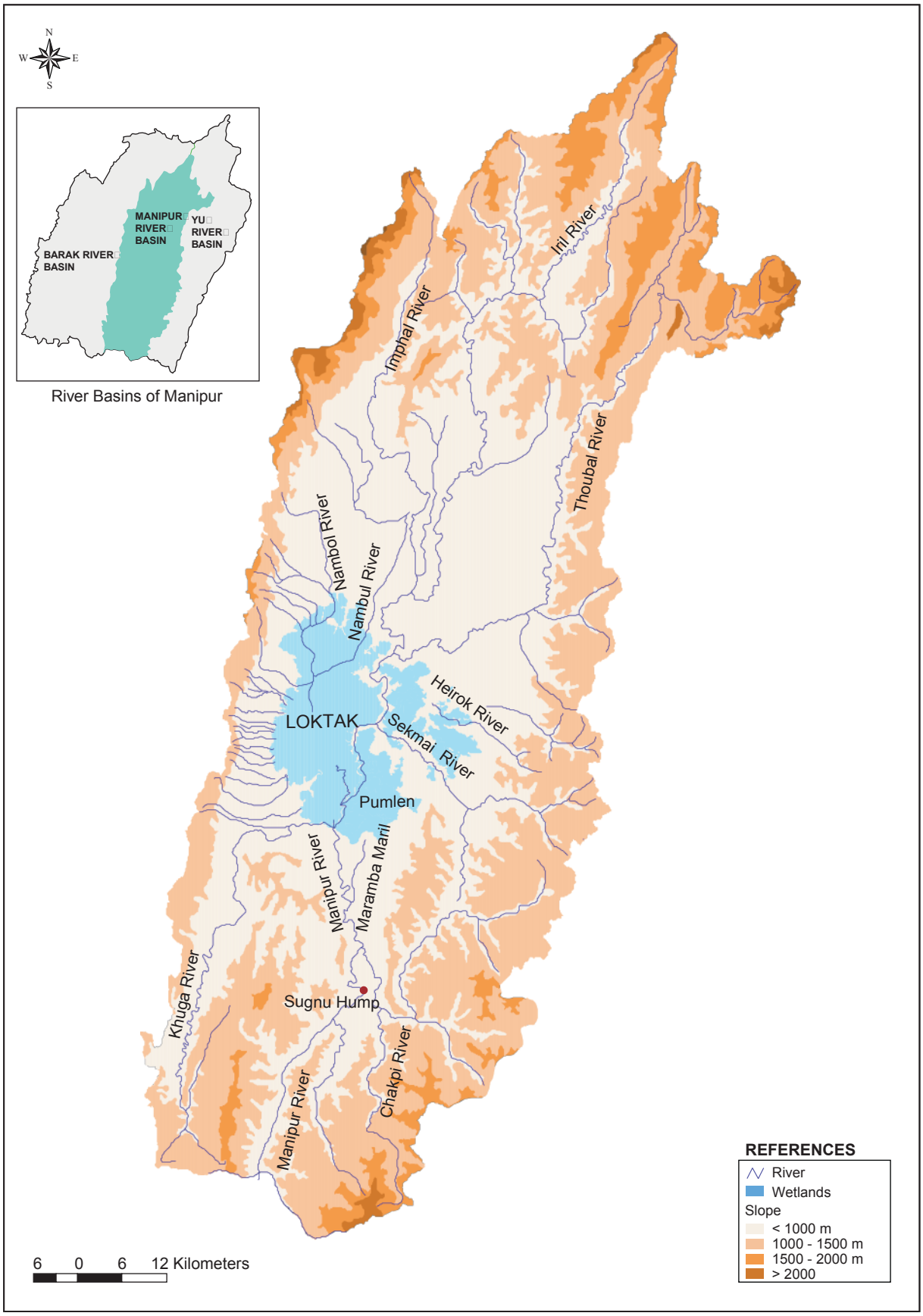
The important feature of the Manipur River from the hydrological point of view is the natural blockage of flow in its lower reaches. About 27 km downstream of Ithai barrage, after sloping down to 756.7 m, the river bed suddenly rises by 8 m within a distance of 800 m and remains above 762.5 m for about 2.5 km. This rocky barrier to the flow is known as 'Sugunu hump', named after Sugunu village. It reduces the capacity of Manipur River to discharge its flow. Chakpi River drains a large part of the southern hills and meets the Manipur River at a right angle in its full capacity during the rainy seasons. During such times it acts as a barrier to the flow of the Manipur River. On the other hand sometimes the Chakpi river discharges into Manipur River earlier in the season filling the section between Ithai barrage and the Sugunu hump thereby creating an obstruction to its flow. The excessive flow of both Chakpi and Manipur rivers spreads backwards flooding large areas of the southern parts of the valley. Besides, this barrier also causes siltation in the river during receding floods.

A stream from the western hills

The Imphal River has a total discharge of 6550 cumecs which is partly utilised at the Imphal Barrage for irrigation purposes through left and right bank canals with a maximum expected discharge of 30 and 70 cusecs respectively and an irrigation potential of 6400 ha. Even though this river does not flow directly into the lake, it is connected to the Loktak Lake through Khordak and Ungamel channels. In years of low floods whenever the water level in the lake is lower, water from the river enters the lake and vice- versa. The two way flow of water to some extent gets modified by creation of the Ithai barrage. In years of high floods, the Loktak Lake, Pumlen Lake on the left bank of Imphal River and Khuga and Manipur rivers merge together to become one sheet of water just upstream of Ithai barrage site. The Manipur River during this period functions as a discharge channel only.



Map 2: **GEOLOGICAL MAP OF MANIPUR**



Map 3: **DRAINAGE MAP OF MANIPUR RIVER BASIN**

Thoubal River with an annual discharge of 12,900 cumecs has an ongoing multipurpose project with an irrigation potential of 33,400 ha.

Sekmai barrage on the Sekmai River, another tributary of Imphal River, is used to irrigate 8094 ha culturable command area (CCA).

Watershed Features

Manipur River basin has been delineated into nine watersheds based on land use and drainage features (Map 3). The salient features of watersheds are briefly outlined in this section.

Khuga watershed

The Khuga watershed covers an area of 504.76 sq km and is drained by Khuga River. This watershed is further delineated into 6 subwatersheds. Degraded forests constitute 70% of its geographical area, comprising mainly of open (28%) and scrub forests (42%). *Jhum* cultivation is the main contributory factor for degradation of this watershed. Abandoned *jhum* occupies 16% of the total geographical area of the watershed. Khuga multipurpose project with an irrigation potential of 4,000 ha, besides supply of 4 MGD water for domestic use and power generation of 1.75 MW is operational in this watershed.

Heirok watershed

The Heirok watershed, drained by the Heirok and Sekmai rivers, extends to an area of 860.82 sq km and comprises of 11 subwatersheds. Forest cover in this watershed is low and the vegetation is mostly degraded. Seventeen percent of this watershed is under shifting cultivation. Pumlen and Ikop *pats* are located within this watershed. A medium irrigation project is operational in this watershed on Sekmai River.

Thoubal watershed

The Thoubal watershed extends to a total area of 911.61 sq km and is drained by the Thoubal River. The watershed consists of 10 subwatersheds, and has two third of its area under forest cover. The watershed has the highest intensity of shifting cultivation among all 9 watersheds of the basin and one fifth of its area is under present or abandoned *jhum* cultivation. The Thoubal multipurpose project with an irrigation potential of 29,400 ha, water supply of 10 MGD and power generation capacity of 7.50 MW is operational on Thoubal River.

Imphal watershed

The Imphal watershed with an area of 474.8 sq km is the smallest watershed of the basin and consists of 7 subwatersheds. The watershed has 66% of its area under forests and only 2% under shifting cultivation.

Upper and Lower Iril watersheds

The Iril River drains two watersheds, viz., the Iril Upper watershed with an area of 758.09 sq km and Iril Lower watershed with an area of 633.28 sq km. The upper watershed consists of 10 subwatersheds and has 81.49% of its area under forests cover. The lower watershed has relatively lower area under forests (51.16%) with absence of dense forest cover. The two watersheds have a high intensity of shifting cultivation, with 12.74% of their area under present or abandoned *jhum*. The Doloithabi medium irrigation project with an irrigation capacity of 7,545 ha is operational in the lower watershed. The Chakpi and Manipur River watersheds below Ithai barrage cover a total area of 1,681.27 sq km and are drained by Chakpi and Manipur rivers.

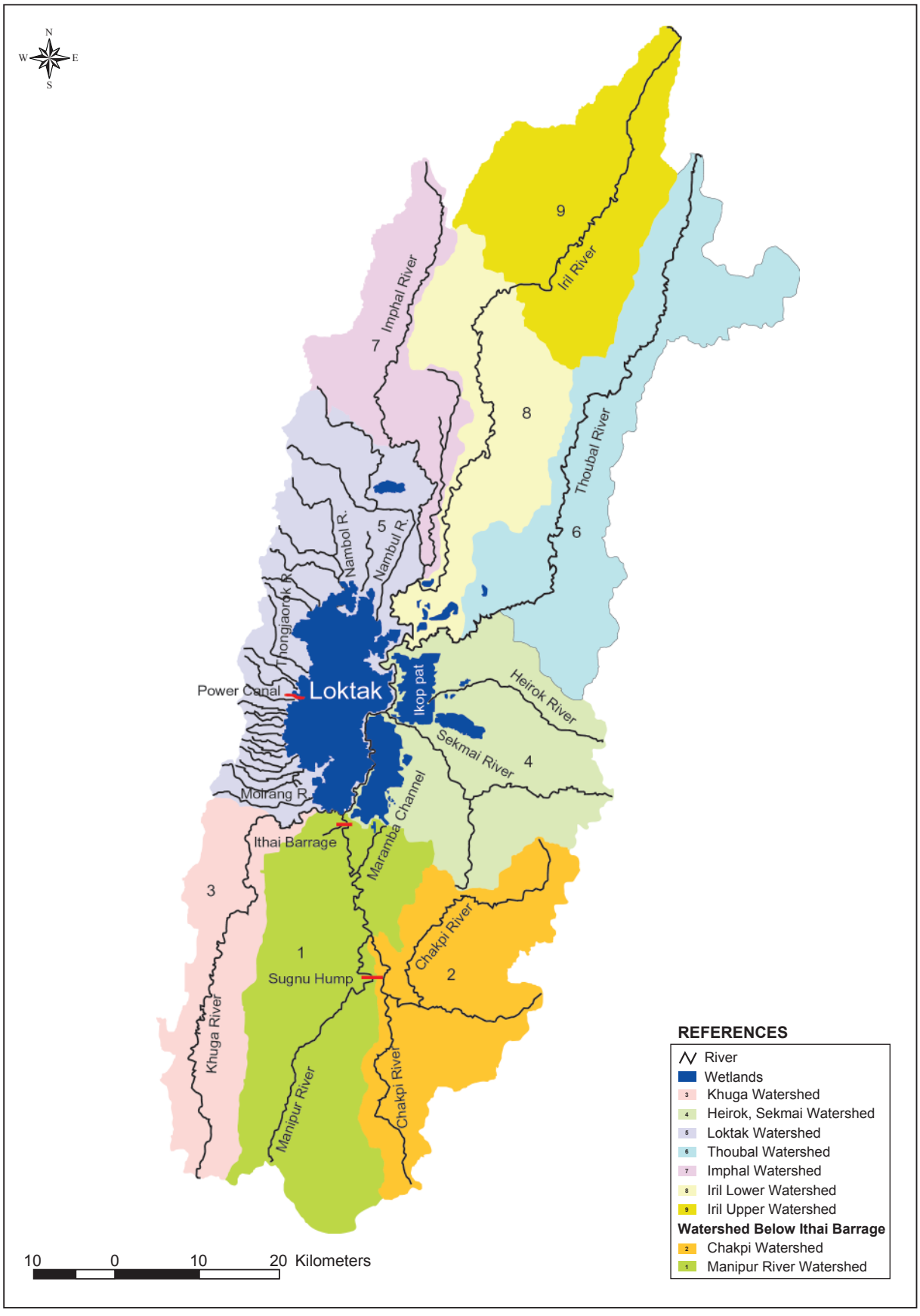
Loktak watershed

Loktak watershed is the largest watershed of the Manipur River basin. The watershed comprising 13 subwatersheds has the lowest forest cover (21%) among all watersheds of the basin. In these watershed, 516 sq km is classified as reserve forests. Loktak Lake forms 27% of the total geographical area of the watershed. The details of the watershed are given in Chapter 3.

Watersheds after Ithai Barrage

Two watersheds of Chakpi and Manipur rivers after Ithai barrage do not drain directly into Loktak lake. However they contribute significantly to the back flow of water due to Sugunu hump near Sugunu village.

Forests in Manipur River Basin



Map 4: **WATERSHEDS OF MANIPUR RIVER BASIN**

Land Use

Forest

The land use of the basin broadly comprises of forests, agriculture and settlements. Forests constitute 73.6 % of the total land area of the basin. The degraded forests constitute 42% of the total forest area of the basin, followed by dense forests (38 %) and medium dense forests (20%) in decreasing order. Major forest types occurring in the basin are tropical semi evergreen, subtropical pine, and montane wet temperate forests. A large part of forests is barren and denuded, primarily due to large scale shifting cultivation practised in the hilly regions of the basin. Rapid deforestation has led to severe erosion problems as well as reduction in flood cycle and drying of streams. There has also been reduction in the availability of timber and non timber forest products.

Agriculture

Agricultural land occupies 15.1% of the basin area. There are two broad farming systems prastised in the basin. Shifting cultivation is the characteristic feature of agriculture in the hilly regions whereas a more settled form of agricultural is practised in the valley.

The valley region contributing to 65% of the overall paddy production of the state is also known as Rice Bowl of Manipur. Overall 54% of the valley area is under paddy cultivation. Pulses, tobacco, potato, chilies and vegetables etc are other important crops grown in the valley area.

The major crops grown in the hills are paddy, maize, foxtail, finger millets, beans, cassava, yam, banana, sweet potato, chillies, sesame etc. Citrus fruits and sugarcane are important cash crops of the hills and valley region respectively. Rapid increase in population has induced severe pressures on agriculture. The area sown more than once in the valley region has increased at an annual rate of 6.23% during 1990-2000. Similarly, the intensity of fertilizer usage has also increased tremendously. The area of paddy under shifting cultivation has also expanded at an annual rate of 5.9% during 1995-2000.

Jhum cultivation in the hills

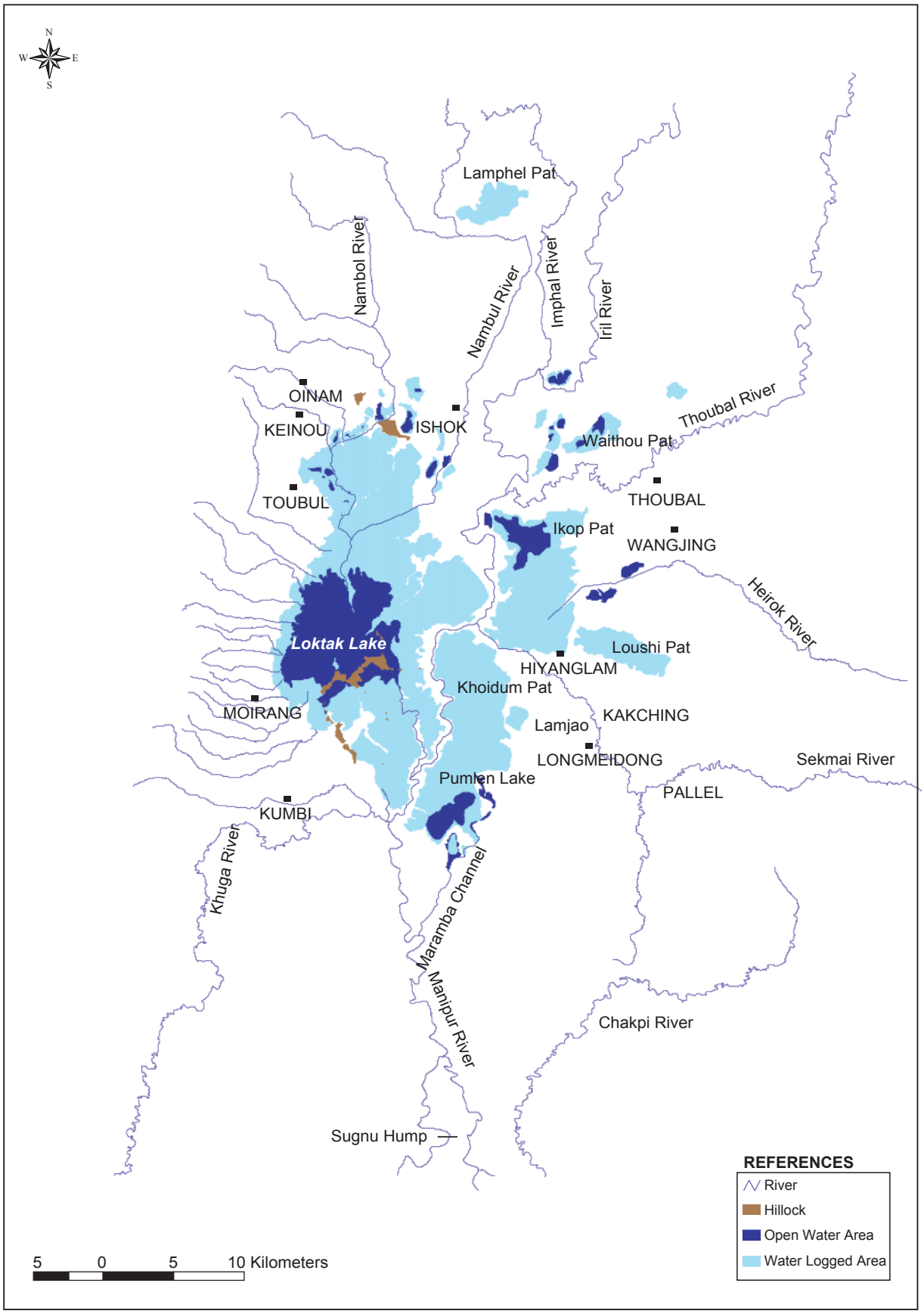
Settlements

Manipur River Basin with 1429 villages and 30 towns accounts for 66% of total settlements of the state as per 1991 census. The hills are sparsely populated and are inhabitat by 29% of overall population. The valley region with 455 villages and 29 towns are inhabited by 71% of the total basin population and is one of the most densely populated regions of the country. Most of the settlements in the valley region are concentrated near water bodies, out of which 14% is located in and around Loktak Lake alone. Rapid growth of population in the valley region, especially in its 29 urban areas has led to tremendous pressure on civic amenities and high amount of wastes being dumped into water bodies.

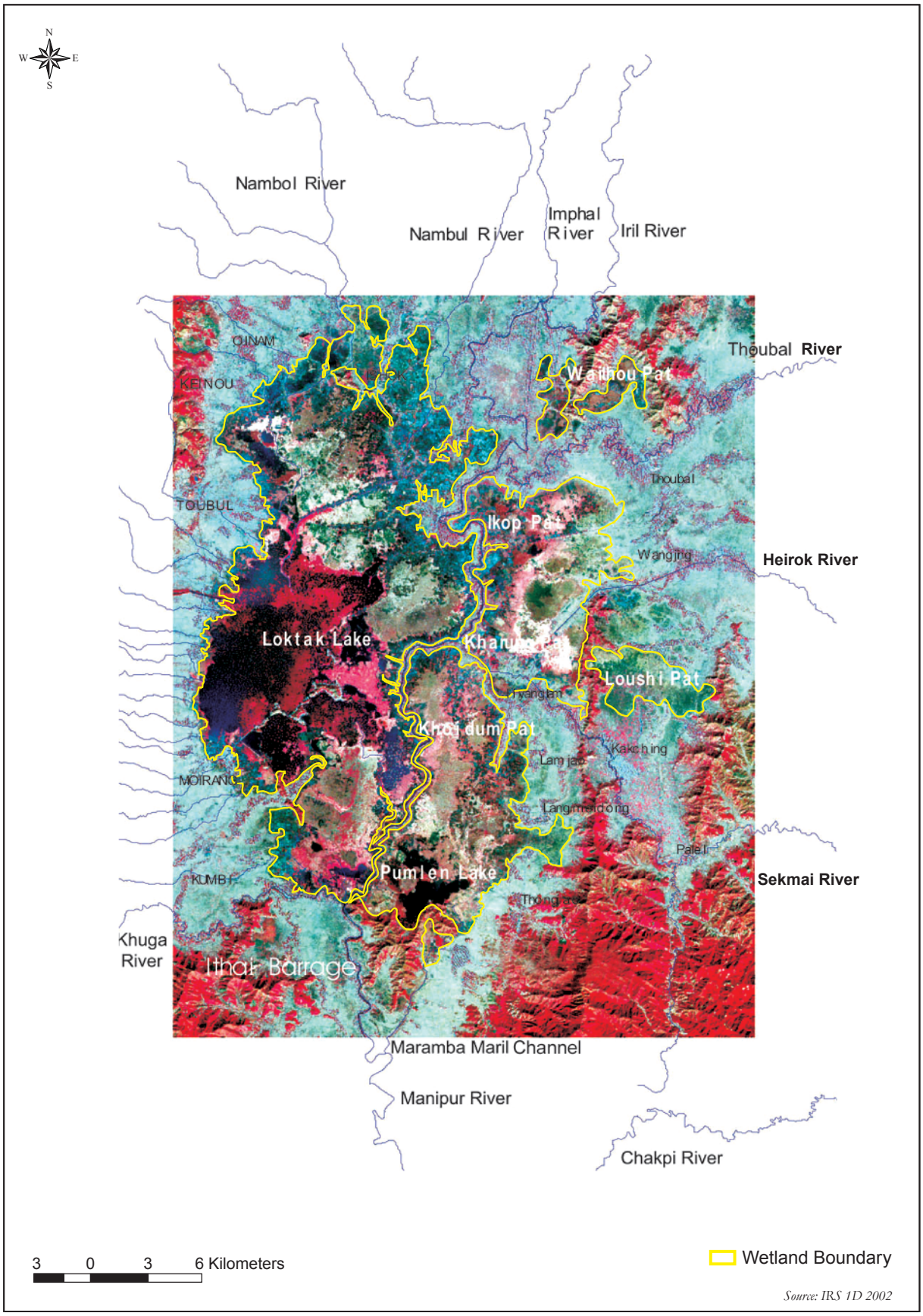
Wetlands

Wetlands constitute 6.8% of the total land area of the Manipur River Basin. The important wetlands locally called *pats* are : Loktak, Lamphel, Waithou, Ikop, Kharung, Lousi, Khoidum, Lamjao and Pumlen.

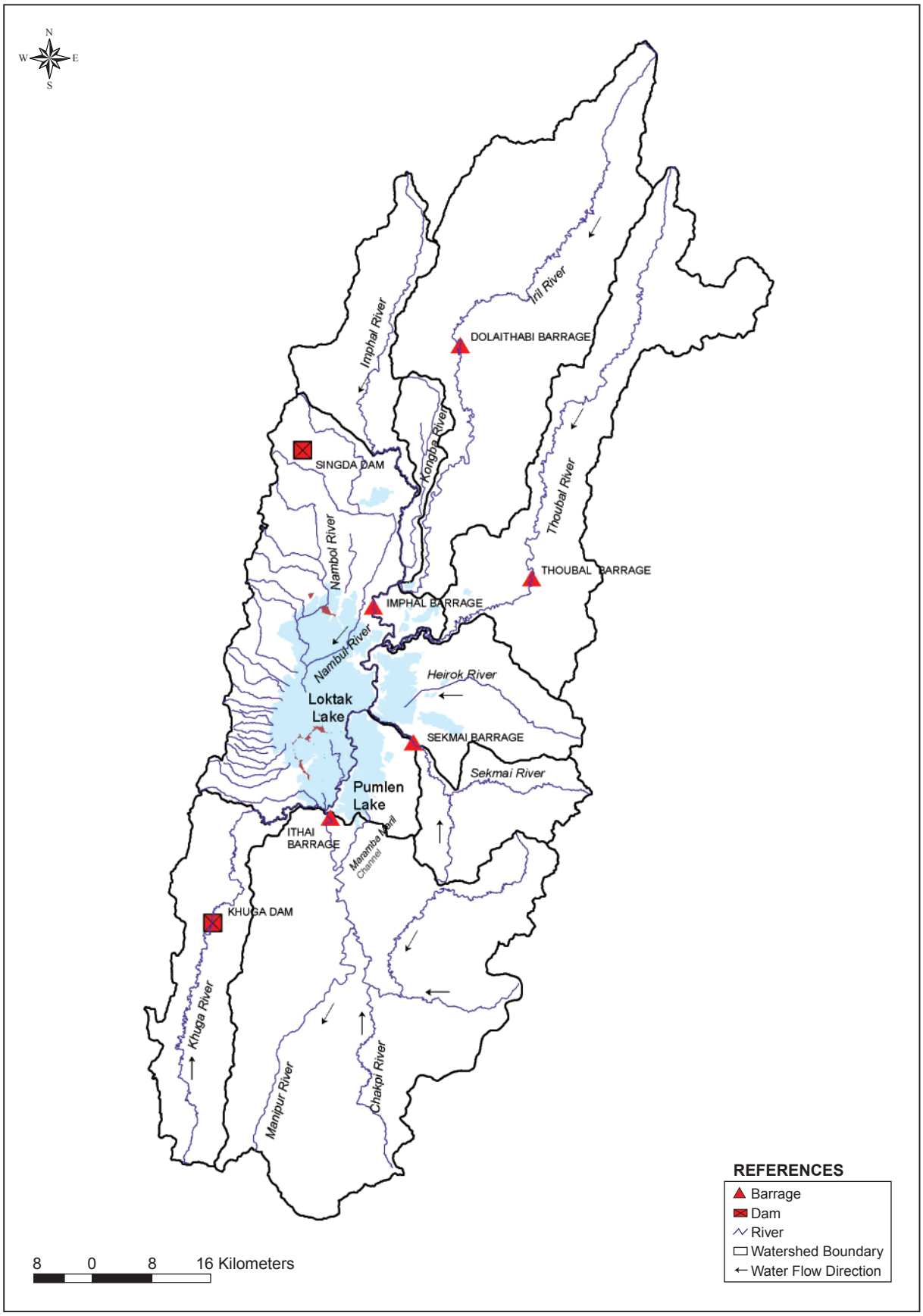
The Loktak Lake is the largest *pat* within Manipur River basin covering 61% of the total identified wetlands of Manipur. About 20 small and large *pats* including Loktak, Takmu, Ungamen, Laphupat, Thammumacha, Khulak, Yena, Sana pat, Utra pat and Tharopokpi are part of the Loktak Lake which are quite distinct during lean period. During the rainy season, most of these *pats* become contiguous and merge under as one sheet of water but can be distinguished separately during the dry season at 766 m above MSL. The wetlands covered an area of 340 sq. km in 1970 which has increased to 469 sq. km as estimated in 2002 after the construction of Ithai barrage (Maps 5 and 6). These wetlands play an important role in providing livelihood support to the people food, fodder, fuel, timber, medicines and other products. They also harbour a rich biodiversity and are of great cultural importance to the people of Manipur.



Map 5: **WETLANDS OF MANIPUR RIVER BASIN - 1970**



Map 6: **SATELLITE IMEGERY OF WETLANDS OF MANIPUR RIVER BASIN - 2002**



Map 7: **HYDRAULIC STRUCTURES IN MANIPUR RIVER BASIN**

Developmental Activities and their Impacts on Wetlands

Wetlands of Manipur River Basin are essentially floodplain wetlands. People living in and around the wetlands have wisely used these wetlands for agriculture and fisheries before the construction of hydraulic structures and other water resources development projects. These wetlands through provisioning of fisheries, aquatic vegetation and other resources supported livelihoods of a large population living in and around them. The periodic inundation bringing nutrient rich sediments ensured highly productive agriculture and thus served as the lifeline of the region.

The developmental activities with emphasis on water resources development particularly flood mitigation led to modifications of hydrological regimes seriously impacting the processes, functions, and attributes of wetlands. The regulation of Manipur River and its tributaries without assessing the environment impacts has seriously impacted the health of wetlands which are inter related and inter dependant of the Manipur River. The sectoral approaches adopted by the concerned state government agencies within the basin have compounded the problems of water quality deterioration and loss of biodiversity.

Increasing demands of water for irrigation has led to development of several water resources development projects in the basin. At present, there are seven river valley projects out of which three (Singda Dam Project, Thoubal Dam Project and Khuga Dam Project) are multipurpose, one is major (Loktak Lift Irrigation Project) and the remaining two (Imphal Barrage Project and Sekmai Barrage Project) are medium irrigation projects (Map 7). These multipurpose projects have drastically altered hydrological regimes thereby adversely impacting the Loktak Lake and associated wetlands as well as the livelihoods of communities living in and around these wetlands.

Rapid growth of population in the hills has led to expansion in area under shifting cultivation. The increase in population and almost insignificant increase in the net cultivated area has led to tremendous increase in intensity of fertilizer usage in the valley region. During 1999-2000, the region accounted for more than 93% of the total fertilizer consumption of the state. Run-off from agricultural fields has also contributed significantly to pollution in several water bodies. The shifting cultivation cycle, which until a few decades was more than 20 years has been reduced to five years or less due to increasing population and declining land availability. This reduction has led to land degradation, and increased soil erosion resulting in sedimentation of water bodies. Area under paddy cultivation in the hill villages has also increased by 2.3% per annum, creating pressures on the forest resources.

Urbanization in the basin, especially in the valley region is the causative factor for deterioration of the water bodies. The urban population of the basin has grown at an annual rate of 3.02% during 1981-1991 as compared to the total population growth of 2.6%. Imphal city alone accounts for 40% of the urban population of the basin generating 126 MT of wastes/day of which 40% remains untreated. Rapid urbanization has led to severe stresses on the civic amenities especially safe drinking water and sanitation. Lack of adequate sewerage and solid waste management systems in the urban area lead to high amount of wastes being leached to the water bodies. Rivers Nambul and Nambol flowing through highly urban stretches consequently have very high levels of pollutants, nutrient loads, solid wastes especially plastics, which are directly discharged into the Loktak Lake.

Developmental activities, in general, have led to shrinkage of wetland area, changes in biodiversity and overall loss of socioeconomic benefits derived by virtue of their natural functioning. Overall, wetlands have been fragmented due to their conversion into settlements and agricultural lands. Lamphelpat and Porompat, once large wetlands, have been encroached upon for settlements and now are shrunk to some remnants within Imphal city. Significant proportion of wetlands especially in the eastern side of Manipur River has been permanently drained for agriculture.

There has been significant change in the biodiversity due to modifications and increasing human pressures on wetland resources. It has been reported that 35 animal species (5 mammals, 5 birds, 9 reptiles, 3 amphibians, 12 fishes, 2 molluscs and 1 annelid) which were abundantly found in the past have declined and are disappearing gradually. The fauna of Manipur River Basin includes some rare and endangered species like Python, Barking deer and Brow antlered deer. At least one species of bird is reported to have completely disappeared (WWF, 1994). Loss of migratory fish species from Chindwin River, which provided livelihood support to the people has significantly contributed to poverty in the region.

GENERAL FEATURES OF LOKTAK LAKE

Loktak Lake located between 93° 46' and 93° 55' E and from 24° 25' to 24° 42'N is a floodplain wetland of Manipur River, which is flooded by its lateral flows as well as back flow of water from Sugunu hump. Further, confluence of several rivers, particularly Chakpi, are responsible for inundation of large areas. The lake earlier used to experience large fluctuations in the water level during the year and several *pats* with the Loktak were distinct during the low water phase and merged into one sheet of water during high floods. The commissioning of Ithai barrage in 1983 has brought about drastic changes in the character of the wetland from fluctuating water levels to more or less constant water level.

The lake is oval shaped with maximum length and width of 32 km and 13 km respectively. The depth of the lake varies between 0.5 and 4.6m with average recorded at 2.7m. The lake covers an area of 287 sq km which is mainly dictated by maintenance of water level at Ithai at 768.5 m above MSL.

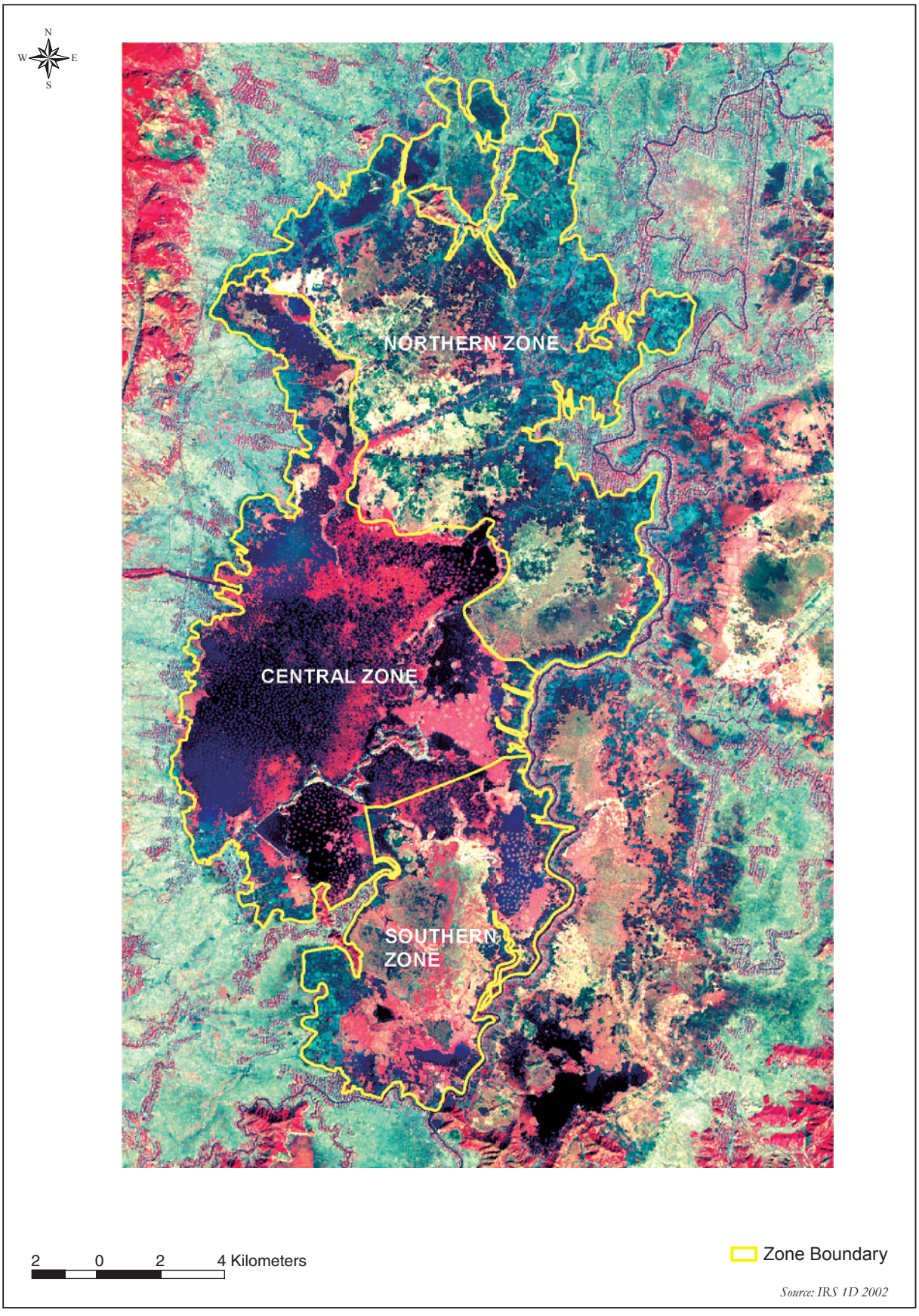
There are 14 hills located in the Lake varying in size and elevation appear as islands in the southern part of the lake. The most prominent among these are Sendra, Ithing and Thanga islands.

The characteristic feature of Loktak is the presence of floating islands, locally called *phumdis*. They are a heterogeneous mass of soil, vegetation and organic matter at various stages of decomposition. *Phumdis* occur in various sizes and thicknesses, occupying almost half of the lake area. Southern portion of Loktak Lake (south of Thanga, Ithing and Sendra islands) forms the Keibul Lamjao National Park, which is unique floating wildlife national park in India. The park covers an area of 40 sq. km. out of which approximately 15 sq. km is covered by thick *phumdis* constituting the core area of the National Park. The park is the natural habitat of the most endangered ungulate species, the brow antlered deer.

Phum huts in Loktak Lake

The lake is an important source of water, fisheries and vegetation providing sustenance to a large population dependent upon lake resources for their sustenance. The lake water is used for irrigation, domestic purposes and power generation. The Lake vegetation is harvested for use as food, fodder, fiber, fuel, handicrafts and medicinal purposes. National Hydro Electric Power Corporation (NHPC) is an important beneficiary using lake water for power generation with total installed capacity of 105 MW.

Loktak with its several islands located inside the lake and surrounded by floating *phumdis* of different geometrical shapes makes it a unique destination for tourism. Based on its rich biodiversity and socio economic importance, Loktak Lake has been designated by India as a Wetland of International Importance under Ramsar Convention in 1990. It is also included in the list of priority wetlands identified by Government of India for intensive conservation and management purposes.



Map 8: **ZONES OF LOKTAK LAKE**

Lake Zonation

The lake can be broadly divided into northern, central and southern zones (Map 8). The three zones are characteristically different in terms of biodiversity and pressure of human activities. The main features of the three zones are :

Northern Zone - This zone extends from eastern side of Nambol River near Ngaikhong Khunou to Phabakchao including Maibam Phumlak. Five main streams / rivers viz. Nambol, Merakhong, Ishok, Waishel and Nambul flows through the northern zone. This leads to inundation of the peripheral areas. The problem has been further compounded by choking of the drains by the proliferation of *phumdis*, construction of embankments, fish farms and Toubul - Mayang Imphal road (IB road).

Phumdis in Southern Zone (KLNP)

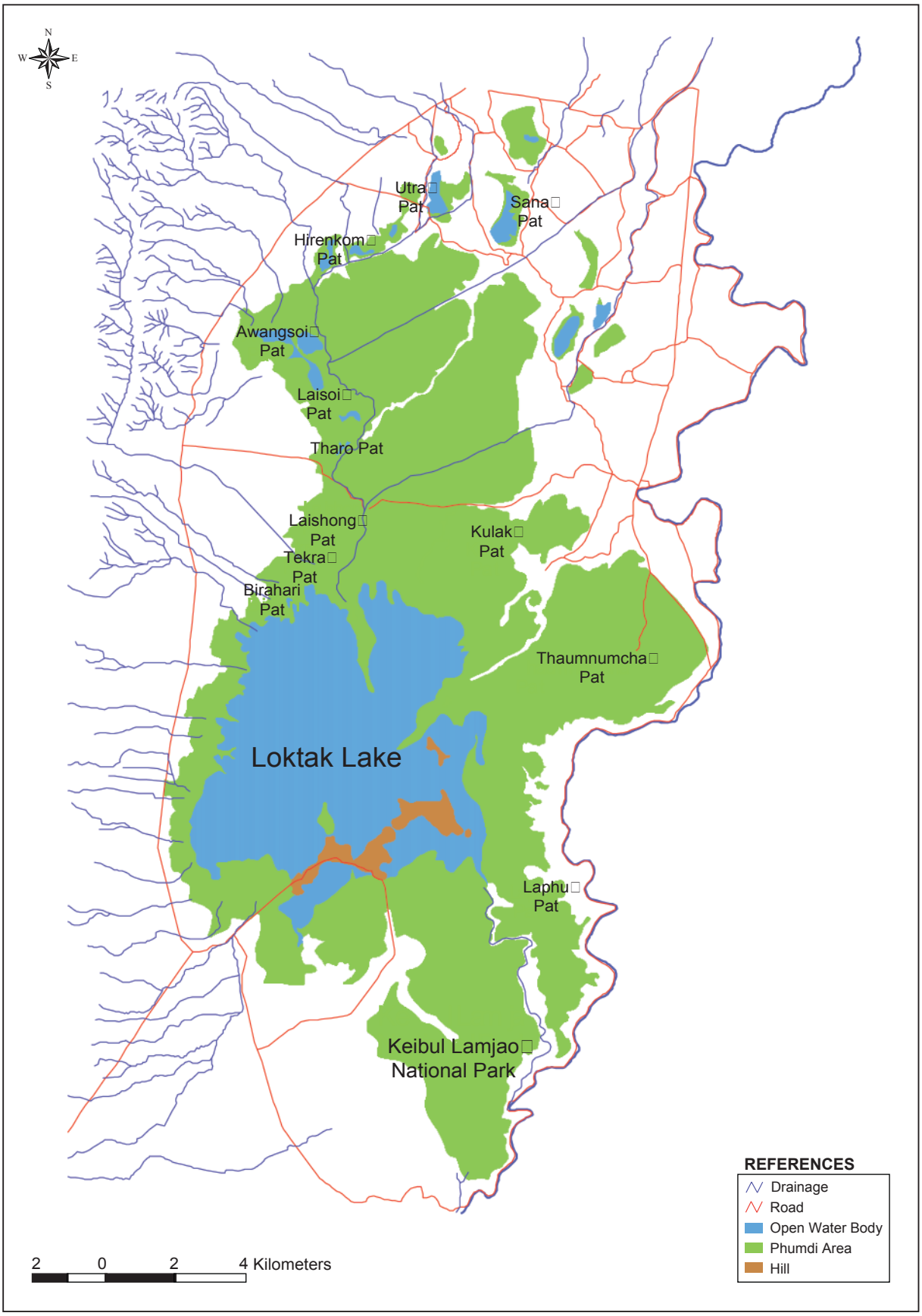
A large thick chunk of *phumdis* extending from the northwest to the southeast separates this zone from the central zone. The thickness of the *phumdis* in this area ranges between 0.4 m and 2.5 m. *Phumdis* from this area are usually burnt annually during January to March for construction of fish cum paddy farms. Several large fish farms with raised embankments have been constructed in this area.

Central Zone - This zone extends from Awang Laisoi pat (western side of Nambol River near Ngaikhong Khunou) to Laphu pat (between Khordak channel and Imphal River). The prominent islands of Thanga, Karang and Ithing are located in this zone.

The central zone is the main open water zone in the lake. This zone was earlier relatively free from *phumdis* but over a period of time it has been used by the neighbouring villagers for *athaphum* fishing (refer P-55 for details). The number of *athaphums* in this zone has considerably increased during last decade choking the entire lake. Takmu pat, almost an isolated pocket within central zone has been specifically managed for fisheries development by the State Fisheries Department.

Athaphums in Central Zone

Southern Zone - This zone includes Keibul Lamjao National Park, Ungamel and Kumbi pats, which are located in the southernmost part of the lake. Ungamel channel links this zone with Khuga River. Similarly Khordak channel links Imphal River with this zone. Kangshoibi River, which originates from the western catchment, drains into this zone. Young *phumdis* are increasing near the mouth of Ungamel channel, Kumbi pat, Nongmaikhong and Khordak area. About □ 9 sq km area in this zone is filled with young *phumdis*.



Map 9: **LOKTAK LAKE AREA - 1970**

Changes in Lake Area

Significant changes have occurred in the lake after the construction of Ithai barrage. The lake area in 1970 and 2002 are presented in Maps 9 and 10. The area covered by *phumdis*, open water and fish farms-cum-agriculture during 1989 and 2002 are given in Maps 11 - 14. Table 1 indicates changes in the areas of *phumdis*, open water area, islands and fish farm-cum-agriculture. A comparative analysis of these indicates the following :

- The area of Loktak Lake has increased from 207 sq km in 1970 to 287 sq. km in 2002 (Map 15).
- Overall *phumdis* have proliferated throughout the lake leading to enhancement of *phumdi* area during 1989-2002 from 116.4 to 134.6 sq km. The significant trends observed are :

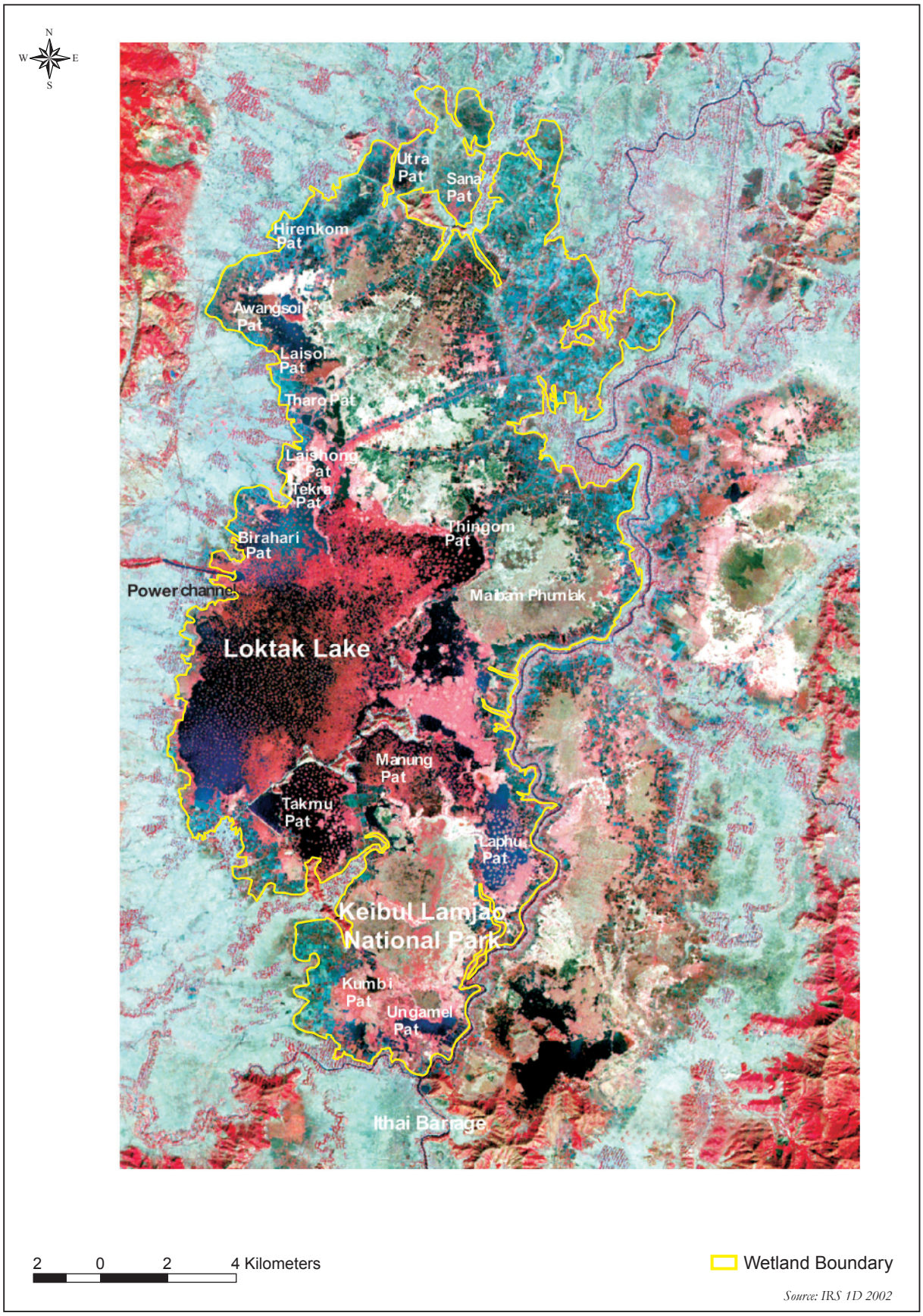
  - *Phumdis* have significantly increased in the central zone by 105%, whereas reduction has occurred in the northern zone by 24%. The coverage of *phumdis* in the southern zone has slightly increased by 3%.

  - Proliferation of *phumdis* in the central zone has led to the reduction of open water area by more than 50%.

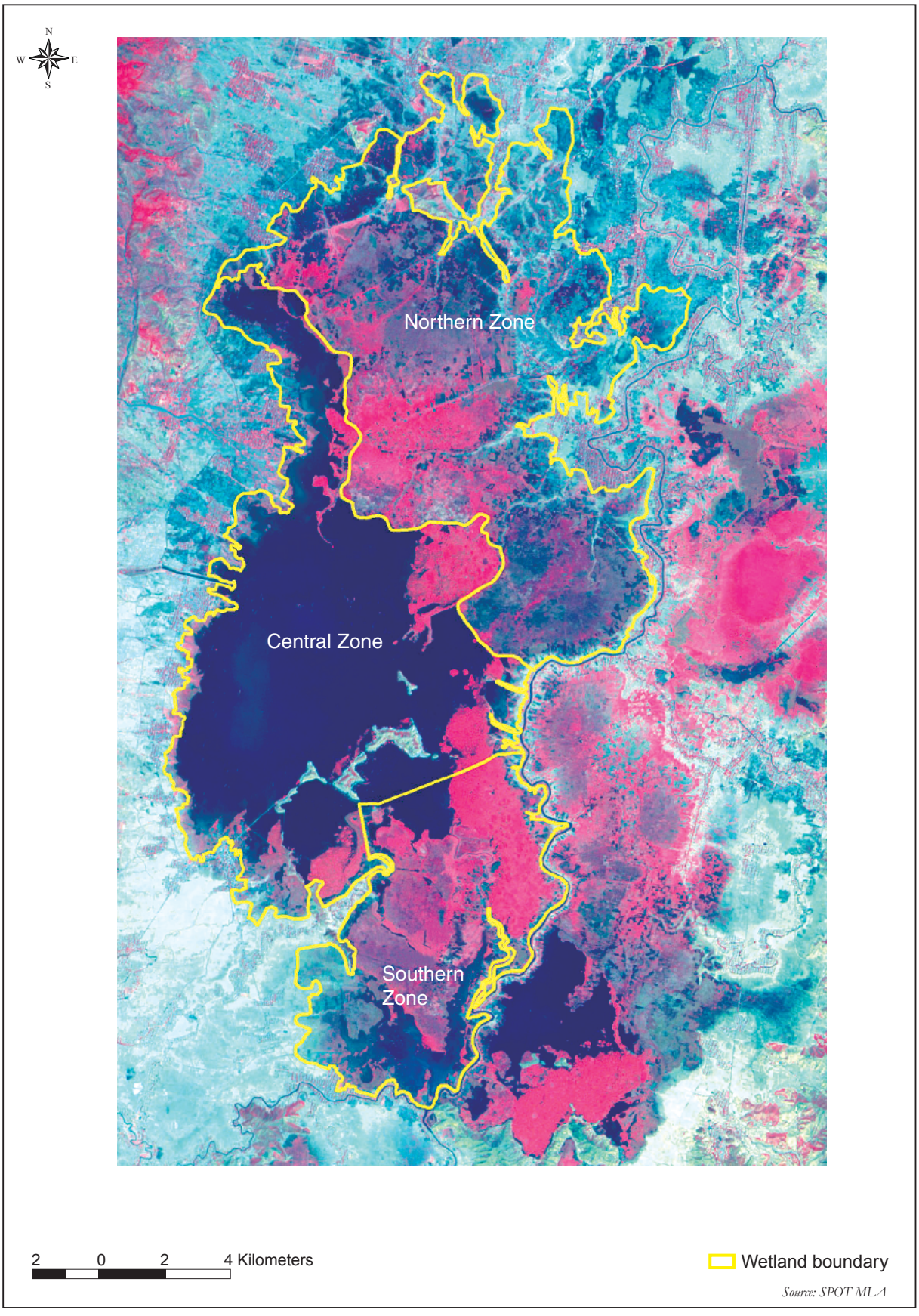
  - Fish farming/agricultural area has significantly increased in the northern zone by 20%.

Table 1: Changes in Loktak Lake (1989 - 2002)

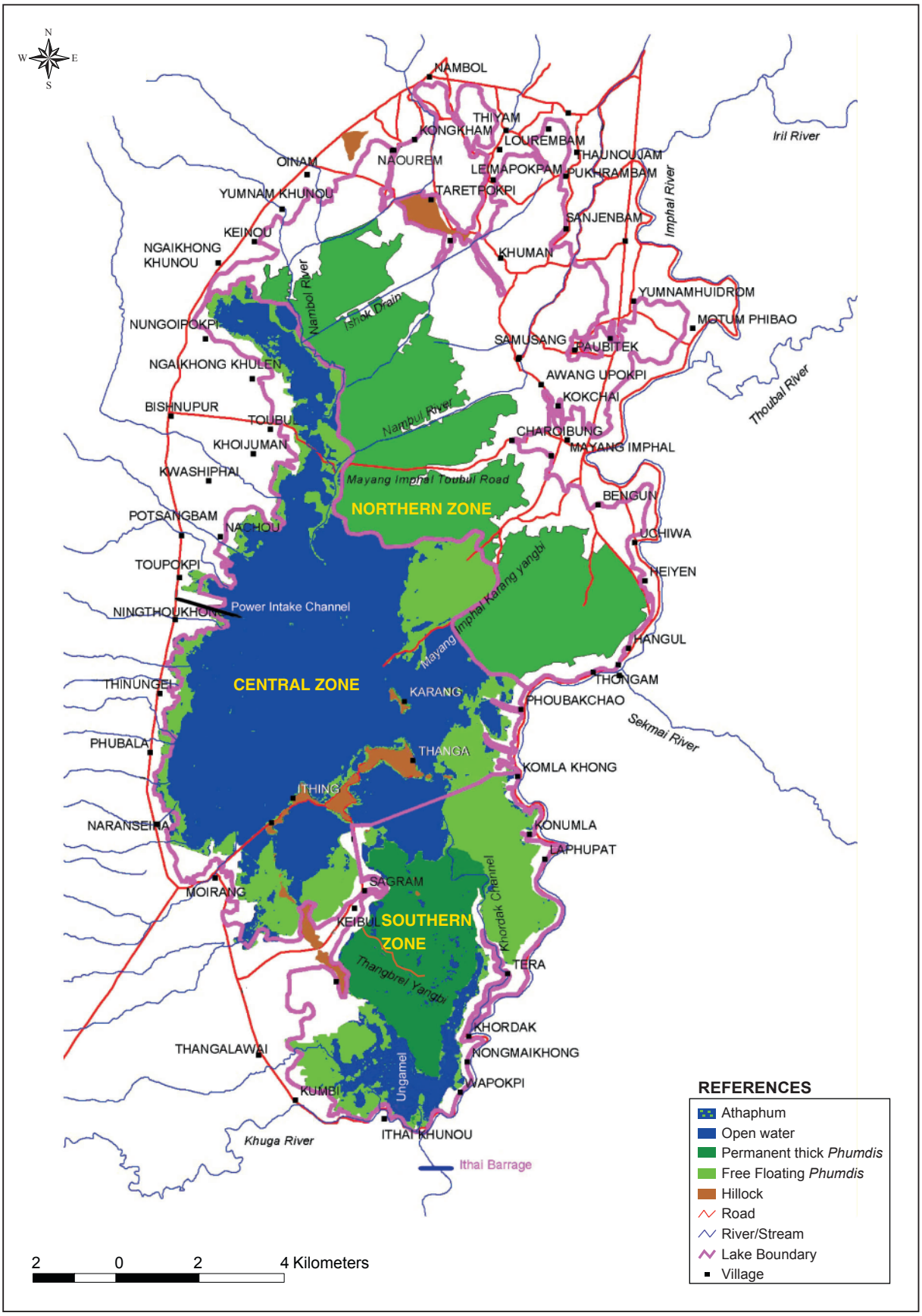
Year	Zone	*Phumdi* (sq km)	Open water (sq km)	Fish farm-cum-agriculture (sq km)	Island (sq km)	Total (sq km)
1989						
	Northern Zone	55	-	67		122
	Central Zone	29	75.5	5.5	2.0	112
	Southern Zone	32.4	9.1	11.5		53
	Total	**116.4**	**84.6**	**84**	**2.0**	**287**
2002						
	Northern Zone	41.6	-	80.4		122
	Central Zone	59.6	37.5	12.9	2.0	112
	Southern Zone	33.4	6.4	13.2		53
	Total	**134.6**	**43.9**	**106.5**	**2.0**	**287**



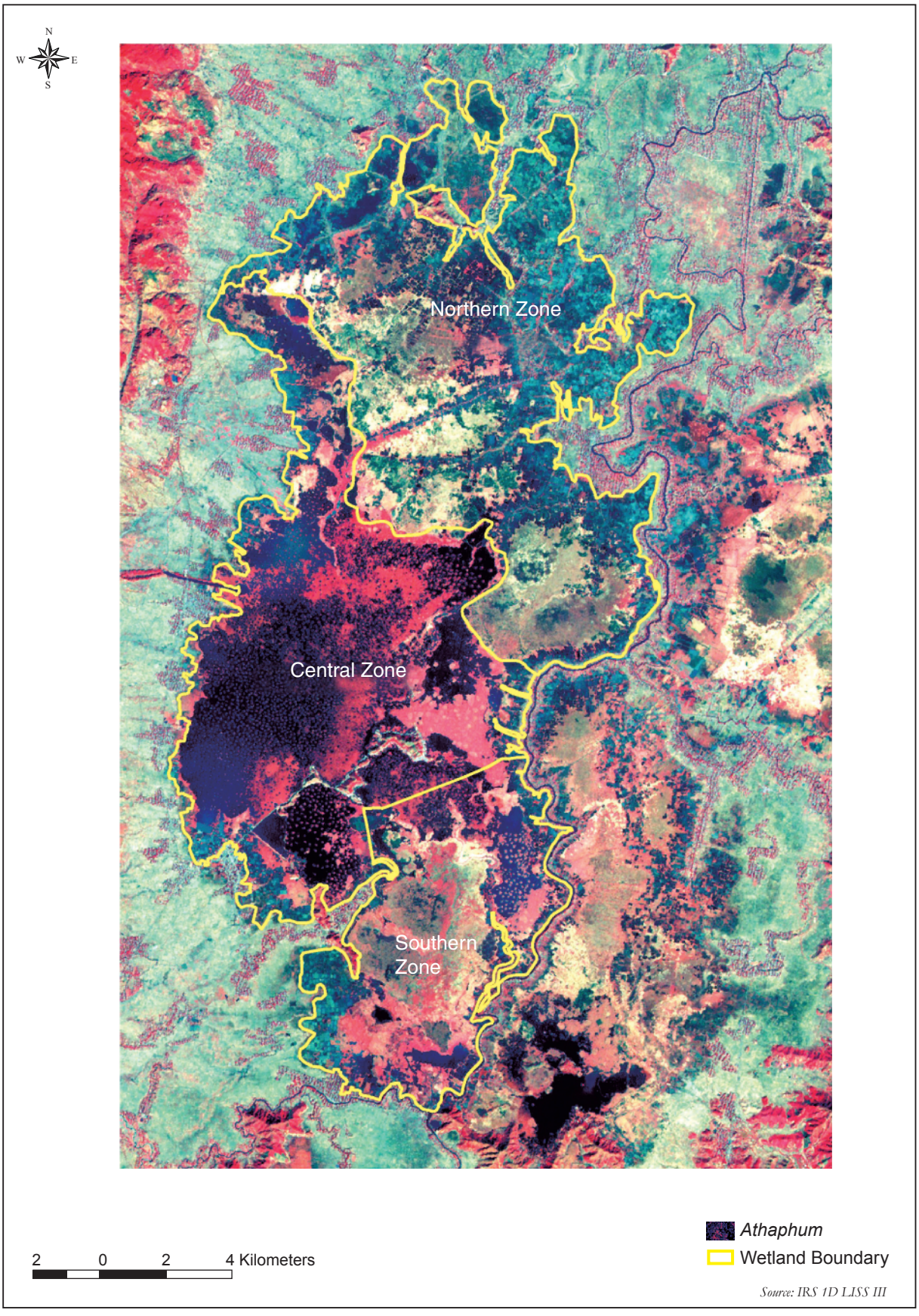
Map 10: **LOKTAK LAKE AREA IN 2002**



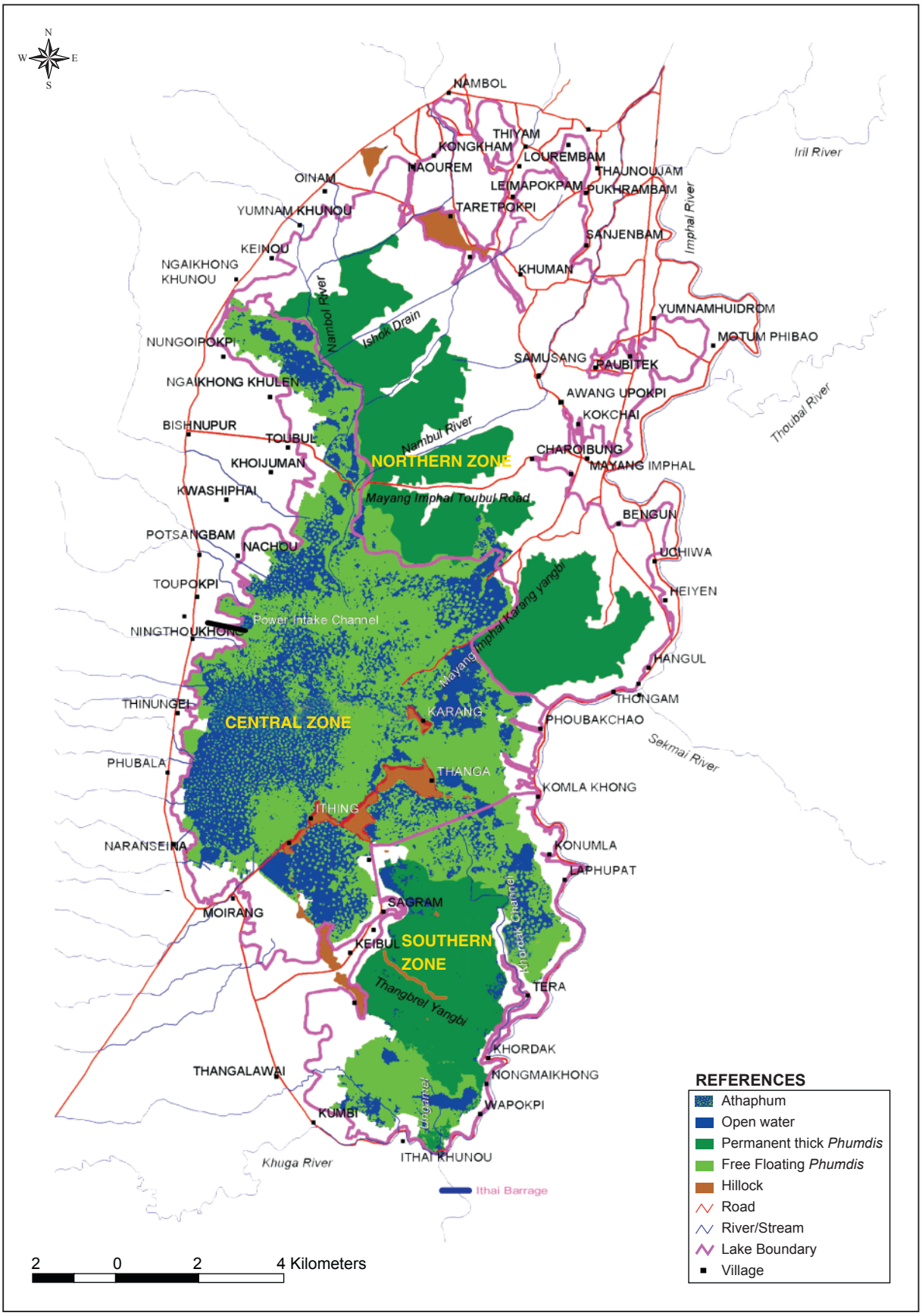
Map 11: **DISTRIBUTION OF PHUMDI - 1989**



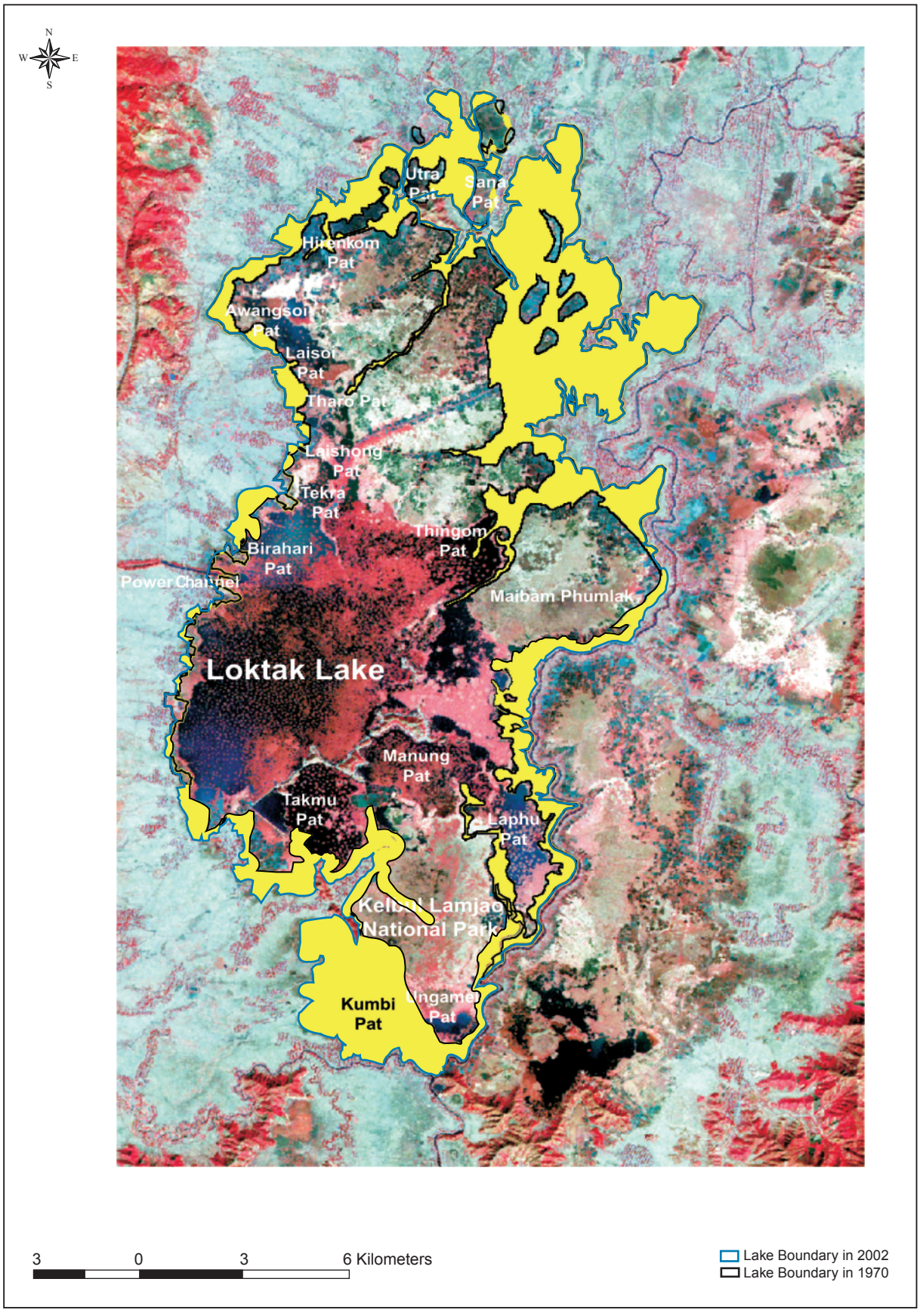
Map 12: **AREA OF PHUMDI IN LOKTAK LAKE - 1989**



Map 13: **DISTRIBUTION OF PHUMDI - 2002**



Map 14: **AREA OF PHUMDI IN LOKTAK LAKE - 2002**



Map 15: **CHANGES IN LOKTAK LAKE AREA DURING 1970 TO 2002**

LAKE CATCHMENTS

Sustainable management of Loktak Lake, essentially involves minimizing impacts of developmental activities within catchments and developing strategies for effective land and water resources management. Loktak Lake catchment can be considered as a sub basin of the Manipur River Basin. The drainage pattern of this sub basin is sub-dendritic to sub-parallel. The western hills, covering an area of 1046 sq km, and varing in altitude from 780m at the foothills adjoining the central valley to 2068m above MSL at the peak of the hills. The watershed is also drained by a network of streams originating from the hills immediately to the west of Loktak Lake. Of these, Nambul, Nambol, Thongjaorok, Awang Khujairok, Awang Kharok, Ningthoukhong, Potsangbam, Oinam, Keinou and Irulok contribute maximum discharge and silt load into the Loktak. All these important rivers join together and flow towards the south bypassing the Loktak Lake and drain into the Chindwin River, a tributary of the Irrawady River in Myanmar.

Land use and Land Capability

The Loktak watershed has Montane Subtropical Forests; Group 8 Subtropical Broadleave hill Forests according to the Champions Classification of forest type. The common species found in the forests are *Quercus serrata, Castanopsis spp. , Schima wallichii, Alnus nepalensis, Litsea* etc. The jhum fallow have large blanks of *Imperata* mixed with *Azzeratum, Eupatorium, Odoratum* and *Artimisia* etc. The swamps are infested with association of aquatic plants like *Cymbopogon spp., Eichhornia crassipes, Nymphaea spp. , Euryale ferox, Cynodon spp. , Phragmites, Typha, Scirpus, Carex, Eleocharis, Friglochin, Azolla, Pistia, Salvinia, Hydrilla, Nelumbo, Zizania* etc. The slightly elevated tracts of the alluvial plain have tree vegetation of different types. Bamboo is the common species occurring throughout the region.

Forests in Loktak Watershed

Assessment of current pressures on Loktak catchment has been carried out for identification of specific problems and developing strategies for regulating flow regimes and control of soil erosion. A detailed land use study was undertaken to assess the current status of the watershed (Map 16). The study indicated that western catchment area directly draining into the lake has 342 sq km under agriculture, 133 sq km under habitation, 262 sq km under forests, 22 sq. km under waterlogged and 287 sq. km being the lake area itself (Map 15).

Land capability studies of catchment area of Loktak Lake undertaken to assess the status of the catchment area using slope gradient and soil and vegetation characteristics highlight its erosion status and land capability. The Loktak watershed can be broadly divided into four physiographic units viz. high hills (elevation ranging from 900 to 1940 MSL), medium hills (elevation ranging between 760 to 900 MSL), plains (very gentle slope) and marshy lands (shallow water with presence of thick growth of floating and submerged plants). The study highlights that the soils developed on the higher slopes of both high and medium hills are deep to very deep, well drained, fine loamy to fine in texture with coarse fragments in place, and are moderately to excessively eroded. The soils in the higher slopes of both high and medium hills are prone to excessive erosion. About 5.9 % of the Loktak watershed falls under the very severe erosion class, 14.6% under severe and 7.2 % under moderately severe. The land capability classification of the Loktak watershed is given in Map 17.

Catchment degradation and its impacts

Loktak Lake catchments are under pressure mainly due to practice of *jhum* cultivation by local tribal population, deforestation, landslides and land slips (Cairns, 1998). These factors have mainly contributed to rapid siltation of the lake consequently reducing its water holding and overall carrying capacity. Developmental activities and increasing human population have led to changes in hydrological regimes and loss of vegetal cover thereby enhancing lake siltation and reducing overall benefits accrued from the wetlands through their natural processes and

functions.

The major causes for degradation of the lake are increasing human population and unsustainable developmental activities within the catchment area. The following are the impacts of various developmental activities on Loktak catchment and ultimately on lake ecosystem :

Siltation

Enhanced unsustainable agriculture activities, particularly shifting cultivation, has led to overall land degradation in hill areas leading to increased soil erosion and lake sedimentation. Area under paddy cultivation in the hill villages has increased at 2.3% per annum, thereby creating pressure on the forest resources. The shifting cultivation cycle, which until a few decades was more than 20 years has currently been reduced to five years or less due to increasing population and declining land productivity. The silt is deposited in the lake, which is responsible for declining water holding capacity and loss of wetland processes and functions.

Deterioration of water quality

Rapid urbanization in the Loktak catchment has led to severe stresses on the civic amenities especially safe drinking water and sanitation. The urban population in the catchment has grown at an annual rate of 3.5% during 1981-1991 as compared to the total watershed population growth of 2.4%. Imphal city alone accounts for 71% of the urban population of the watershed; Mayang Imphal, Bishnupur, Moirang, and Ningthoukhong are the other important urban centers of the basin.

Lack of adequate sewerage and solid waste management systems in the urban areas has led to high amount of wastes being leached to the wetland.Rivers Nambul and Nambol flowing through highly urban stretches consequently have very high level of pollutants and nutrient, which are directly discharged into the Loktak Lake.

There has been a tremendous increase in intensity of fertilizer usage in the valley region due to enhanced agricultural activities. During 1999-2000, the region accounted for more than 78% of the total fertilizer consumption of the state. The eroded silt and nutrient rich runoff from the surrounding agricultural fields besides human wastes gets deposited within the lake leading to deterioration of water quality. The situation is further compounded by construction of Ithai Barrage, which interferes with the lake dynamics and flushing out of pollutants.

Agriculture practice in hill areas

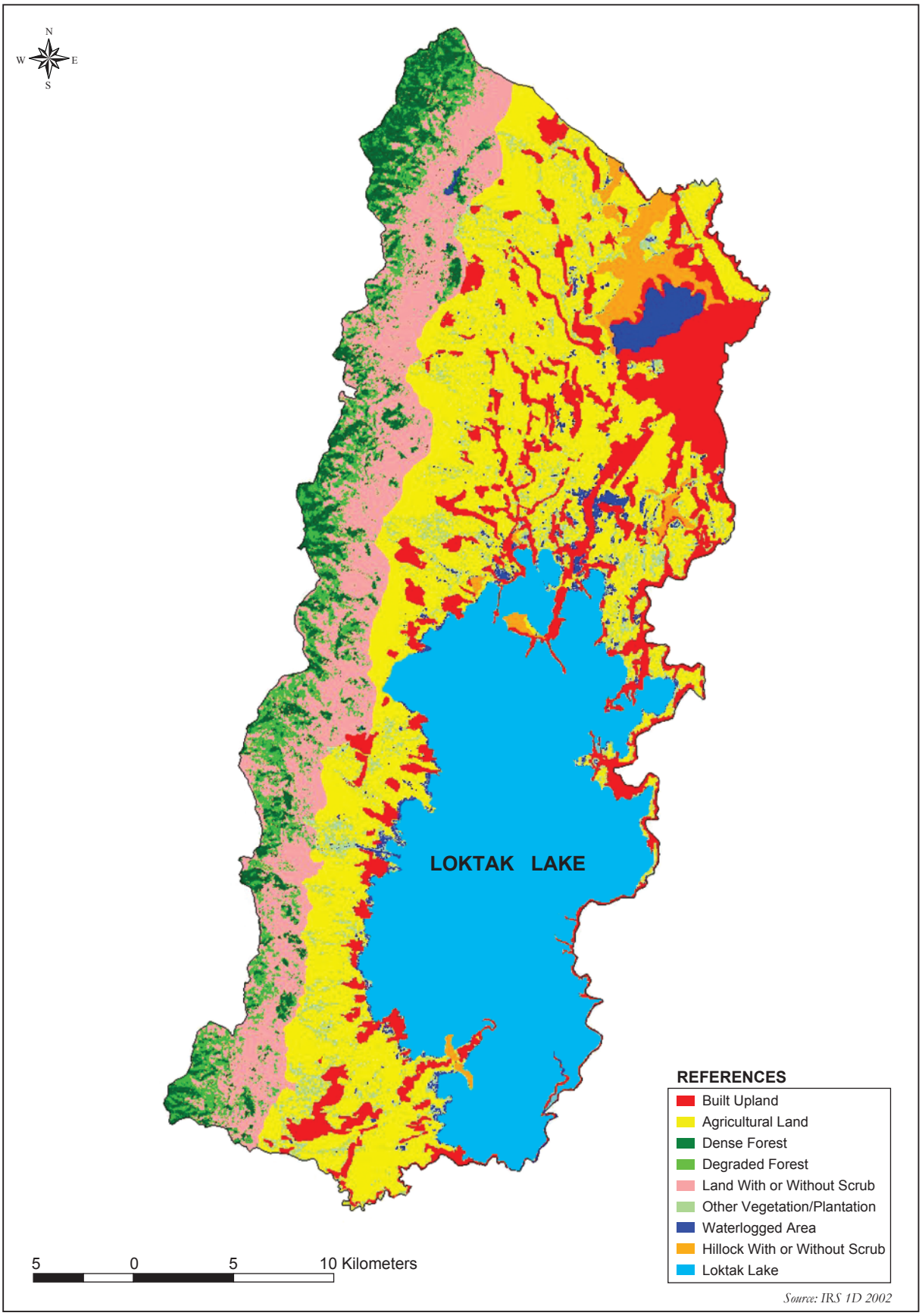
Flooding

The construction of hydraulic structures, particularly Ithai barrage has interfered with flushing pattern of lake ecosystem. Further, prolific growth of phumdis retards flow of water after receding of monsoon. Some areas particularly in the northern zone are under prolonged inundation due to clogging of channels by combined effects of siltation and phumdi proliferation. Prolonged flooding damages crops and property thereby threatening livelihoods of people.

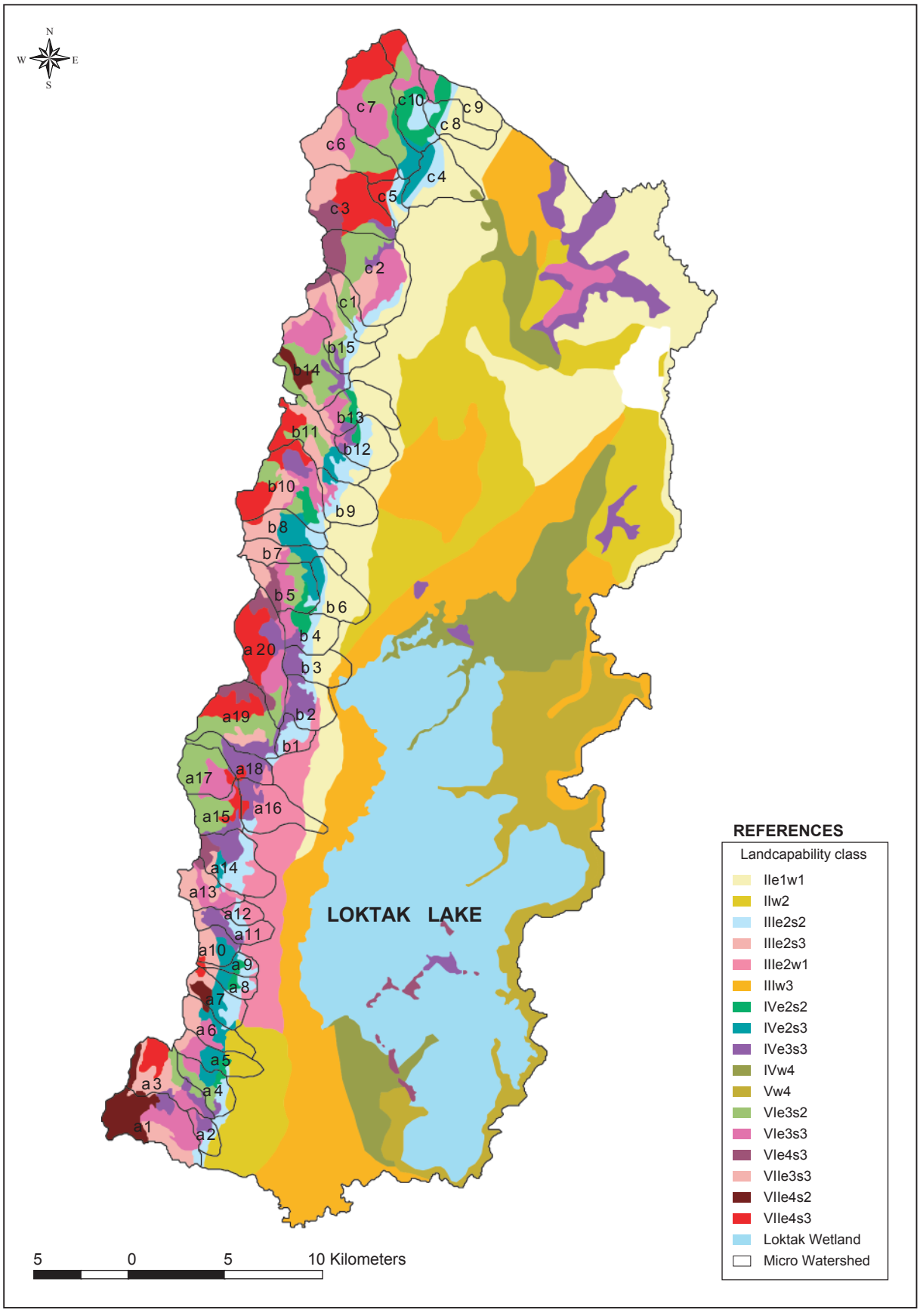
Poverty

Reduction in availability of forest and non timber forest products (NTFPs) in the hill catchments due to degradation of forests has led to poverty within hill communities. Limited opportunities for diversification of economic activities has promoted unsustainable activities leading to degradation of resources and impoverishment of communities.

Decrease in fish diversity and yield due to construction of Ithai barrage, which interferes with the migration of fish species from riverine to lacustrine environment for spawning and breeding purposes, has led to reduction in incomes and poverty of fishers. The inassessability of the area due to hilly terrain and limited transportation facilities for marketing of the catchment and wetland products has further led to impoverishment of communities.



Map 16: **LAND USE OF LOKTAK WATERSHED**



Map 17: **LAND CAPABILITY MAP OF LOKTAK WATERSHED**

Catchment Conservation

Realizing the importance of catchment area in lake conservation, MoEF has initiated several measures under the National Wetland Programme for catchment conservation. Under SDWRML project, identification of critical micro watersheds has been carried out based on land use and land capability surveys supported by remote sensing and GIS studies. Measures have been undertaken for treatment of critical micro watersheds through biological and small scale engineering measures.

The main approach adopted for catchment area treatment emphasizes on soil erosion control while providing economic benefits to the people through alternate income generation programmes. The measures undertaken for treatment of critical micro watersheds included afforestation, aided regeneration, limited small scale engineering interventions; and reducing pressure on forest resources by providing alternate livelihoods to the communities.

On priority basis western catchment area which contributes substantially has been undertaken for catchment area treatment with financial support from MoEF and Tenth Finance Commission (TFC Map 19). The western catchment area has been broadly divided into 5 sub watersheds (Maklang, Nambol, Thongjaorok, Ningthongkhong and Moirang) and further delineated into 45 micro watersheds covering an area of 293 sq km (Map 18). Sixteen micro watersheds have been selected on a priority basis for undertaking catchment treatment.The details of activities undertaken are :

Afforestation

Afforestation has been undertaken in 3700 ha in 16 micro watersheds (Map 19). The species used for afforestation include *Quercus serrata, Gaurelina arborea, Alnus nepalensis, Schima wallichii, Parkia roxburghii, Cedrilla toonna, Terminalia myriocarpa and Casotpsis sp*. All the species are native, vigorous coppicers, mix of fast and slow growing species, and yield firewood, fencing, small timber, vegetables, fibers and other non timber forest products. The selection of the species has been done in consultation with the communities. The nurseries are raised and maintained by women groups. The plantations after being maintained for two years, are handed over to the communities for ensuring protection against fire, grazing and illicit felling. Forty watershed committees have also been formed for designing and implementation of operational plans for maintenance of the plantations, scheduling of forestry operations and sharing of NTFPs.

Terrace cultivation at the foot hills

Aided regeneration

Aided regeneration in areas of low crown density of tree species has been undertaken with native species in 880 ha of 10 villages falling within 8 micro-watersheds.

Small scale engineering measures

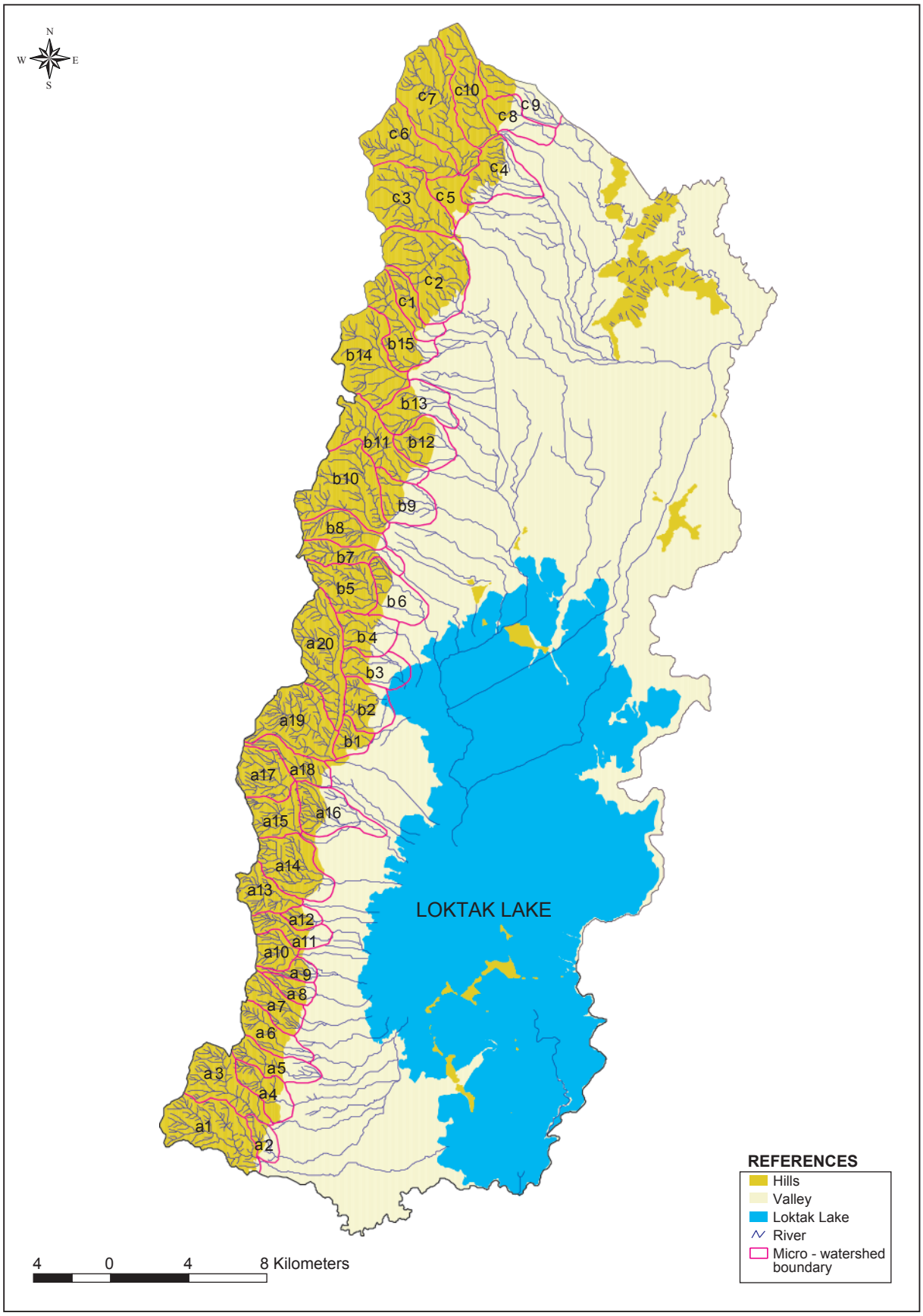
Small scale engineering measures have been undertaken in critical microwatesheds with the primary objective of controlling soil erosion. Contour trenching has been carried out in an area of 140 ha in 12 micro-watersheds. Construction of 2632 Rm vegetative check dams, 3750 boulder sausages and 400 Rm bamboo spurs has been undertaken in critical micro watersheds.

Horticulture

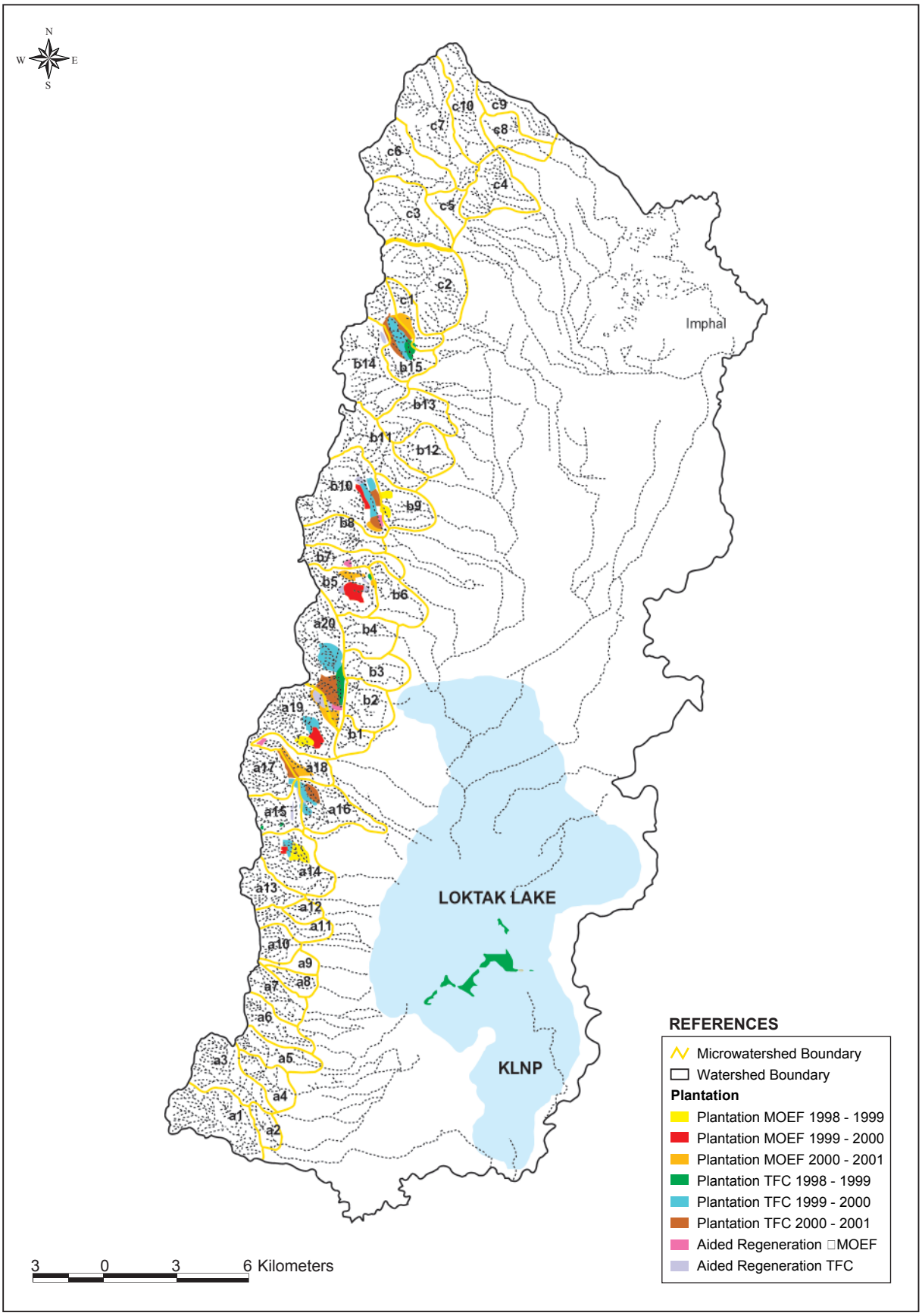
Horticulture, primarily of pineapple and banana intercropped with tree species as *Parkia* has been undertaken in 535 ha in 41 hill villages with a primary objective of reducing the pressures of shifting cultivation through provision of alternate source of income. The identification of individual plantation sites as well as the beneficiaries was undertaken by the village authorities of the respective villages. Field investigations have revealed that the plantations have yielded Rs. 6,000 - 8,000 per month for every ha of banana plantation and Rs. 1,00,000 - 1,30,000 per annum for every ha of Pineapple, therefore providing strong economic incentives to the communities to abandon low revenue options as jhumming.

Alternate source of energy

A demonstration project on reducing the dependence of communities on forest resources for fuel has been undertaken in 14 hill villages through provision of fuel efficient smokeless chullahs. The model of the chullah is as proposed by the Department of Science and Technology, named as 'Abhinap'. The beneficiary communities have been identified through participatory appraisal exercises with involvement of village authority and women groups.



Map 18: **LOKTAK WATERSHED**



Map 19: **AFFORESTATION IN LOKTAK WATERSHED**

Box 1: Shifting Cultivation

Shifting cultivation is the characteristic feature of agriculture in the hilly regions of the Manipur. This labour intensive and land extensive form of cultivation occupies a distinct position in the tribal economy, with 73.5% of the tribal population deriving its sustenance from this traditional mode of agriculture. It involves slashing the vegetation, burning the dried slash before the onset of monsoon, raising the mixture of crops on a temporarily enriched soil for a year or two, fallowing the plot for re-growth of natural vegetation, and eventual return to the same plot for another cropping phase after a few years. Plantation is usually done by dibbling method in an intimate mixture. Upland paddy is the main crop grown in mixture with maize, foxtail and finger millets, beans, cassava, yam, banana, sweet potato, chillies, sesame etc. A single crop of rice is usually preferred in the second year of jhumming. Productivity is usually low (50 - 60 bags / ha) leading to low surpluses and poor incomes. Average area of land holding per household of tribal family is 1.20 ha.

Rapid increase in population in the hill areas has led to tremendous pressure on forest resources for food, fuel wood, timber and other non timber forest products. The shifting cycle which until a few decades was more than 20 years has reduced to less than five years due to increasing population pressure and declining land availability. This reduction has led to land degradation and increased soil erosion leading to sedimentation of water bodies. Conversion of forests into agricultural, frequent perturbation as fires, introduction of crops, weeding and harvesting have led to reduction of forest biodiversity. The effect of shifting cultivation on retrogression is very striking, and has led to several changes in the vegetational composition. Many blanks have come up replacing the tree growth. These areas are prone to forest fires and are quite vulnerable to soil erosion. There is apparently no escape from the vicious circle of declining productivity of the soil brought about by increasingly short cycle of jhumming, which in turn is necessitated by the increasing demand for food.

Despite its detrimental impacts on the ecosystem, shifting cultivation is widely recognized as the only practical way out from the inherent difficulties confronted in preparation of proper seedbeds in steep slopes. In absence of sufficient land for terracing and proper communication, shifting cultivation is the only option for livelihood. Given the economic status of a hill household, jhumming presents a viable alternative in terms of no requirement for fertilizers and pesticides. The fields also yield a wide variety of crops which can be harvested for a longer period of time, and therefore, nearly meet all the households requirements.

Under the SDWRML project, several measures have been undertaken to reduce practice of *jhum* cultivation through improvising *jhum* cultivation and providing alternate sources of income. Horticulture, integrated farming and handloom and handicraft based alternatives have been promoted to provide people with sustainable livelihood options.

Jhum Cultivation in Loktak Watershed

HYDROLOGICAL REGIMES

Water regime of Loktak Lake is determined by the inflow from various streams and direct precipitation on the lake surface. Overall 34 streams from the western hills and the Manipur River via Ungamel and Khordak channels drain into the lake (Map 20). Direct precipitation also contributes significantly to overall water inflow into the lake. The outflow from the lake includes abstraction for hydropower generation, irrigation, domestic uses, link channels of Manipur River, Pumlen Lake, Ithai barrage discharge, evaporation and evapotranspiration. The flows to the lake through Ungamel and Khordak channels are bi-directional depending upon the relative water level in the lake and the Manipur River. All the rivers flowing directly from the western hills are non perennial, while the inflow through Ungamel and Khordak is more or less throughout the year.

Loktak Lake has been the subject of study since 1950s' with the primary objective of flood control and optimal use of water resources for accelerated economic development in the region. The first major attempt to harness Loktak water was undertaken by the state government by establishing a 105 MW hydro power project presently operated by the National Hydroelectric Power Corporation (NHPC). This project aimed at impounding water in the Loktak Lake, by constructing 10.7 m high barrage at Ithai, to maintain water level at 768.5 m at Ithai and to facilitate adequate flow in the intake channel for hydel power generation. The lake water is transferred to Leimatak Valley through a water conductor system after power generation.

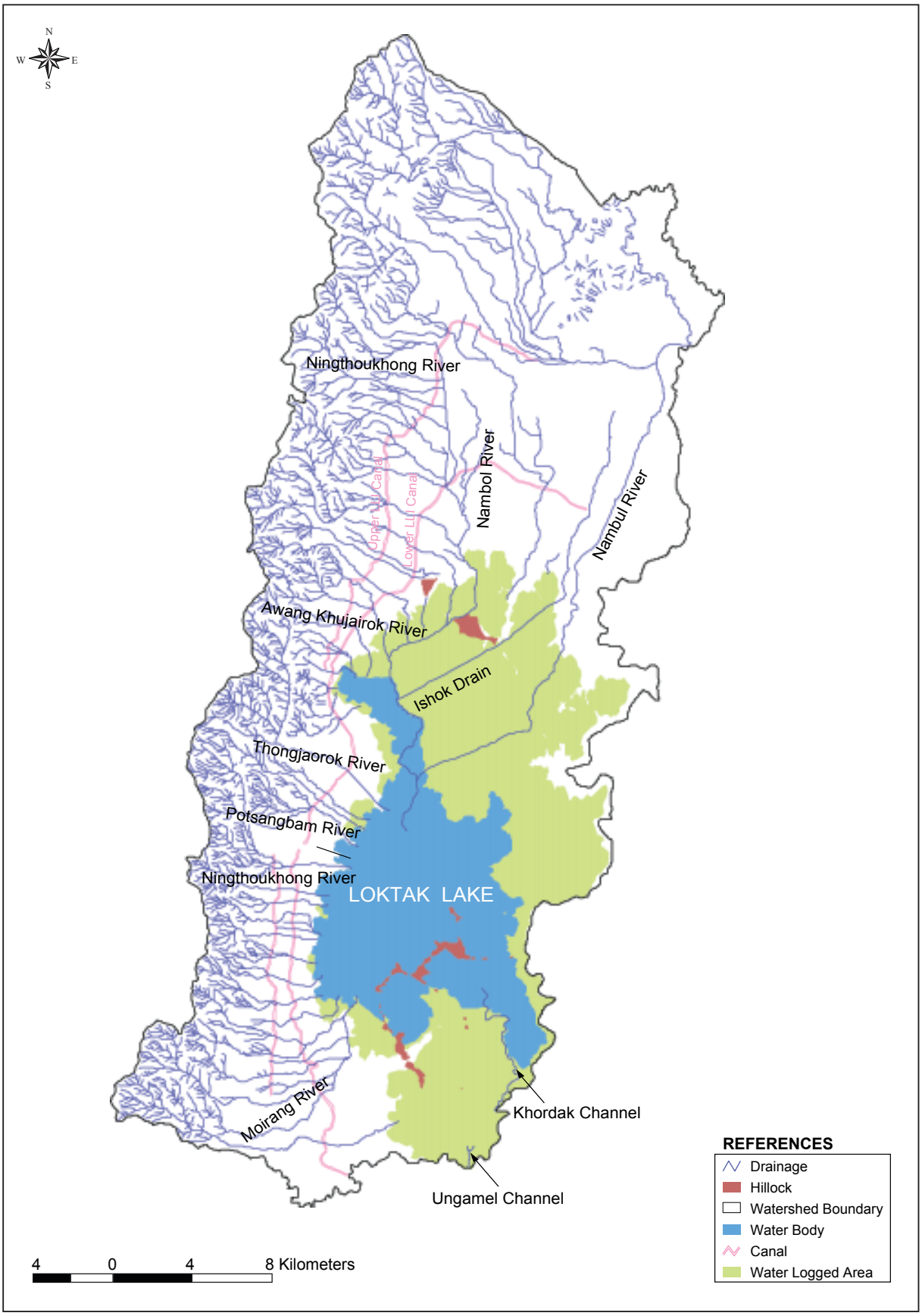
Stream Gauging Station in Iril River

River Nambol

The present operational regimes for water management is essentially characterized by:

- Vague and qualitative estimation of water availability and demand and consequent apprehensions about perceived damage due to construction of Ithai barrage.
- In the absence of a reliable monitoring network flood forecasting in terms of likely discharge, timing and consequences is at best on an adhoc basis.
- Lack of quantitative sectoral demands on Loktak water has left its regulation to be dictated only by hydel power generation requirement.
- Lack of coordination among the institutions dealing with different sectors of development.
- Lack of basic data for sectoral and also integrated development of the Manipur River Basin.

Realizing the need for water management on scientific basis, leading national and international hydrologists were engaged under SDWRML project to advise on the development of water management plan for the lake. Several reports have been published based on the analysis carried out by various experts. (Hay, 1998; James, 2000; Maudgal, 2000; and LDA - WISA, 2004).



Map 20: **DRAINAGE MAP OF LOKTAK WATERSHED**

Water Inflow-Outflow

A network of hydrometric stations was established under SDWRML project to assess water and sediment inflow and outflow (Map 21). Bathymetric survey was carried out to assess the depth profiles and overall volume of the lake. In addition, relevant data have also been collected from various concerned agencies. The water displacement by *phumdis* was determined to assess reduction in water holding capacity of the lake due to *phumdi* proliferation. The water balance, as estimated for the water year 2000 - 01 is given in the Box 2.

Box 2: Water balance of Loktak (2000 - 01)

Water inflow into Loktak Lake

Total Water Inflow - 1,687 Mcum

Percentage contribution by various sources
- *Stream/ rivers from the western hills - 52%*
- *Link channels viz Ungamel and Khordak - 23%*
- *Direct precipitation - 25%*

Nambul and Nambol rivers, which bring a heavy load of sewage, contribute 10% and 6% of the total inflows from the western hills.

Water Outflow from Loktak Lake

Total water outflow - 1,217 Mcum.

Percentage contribution by various sources
- *Hydropower generation - 70%*
- *Ungamel channel - 12%*
- *Evapotranspiration - 9.5%*
- *Evaporation - 6.5%*
- *Khordak channel - 2%*

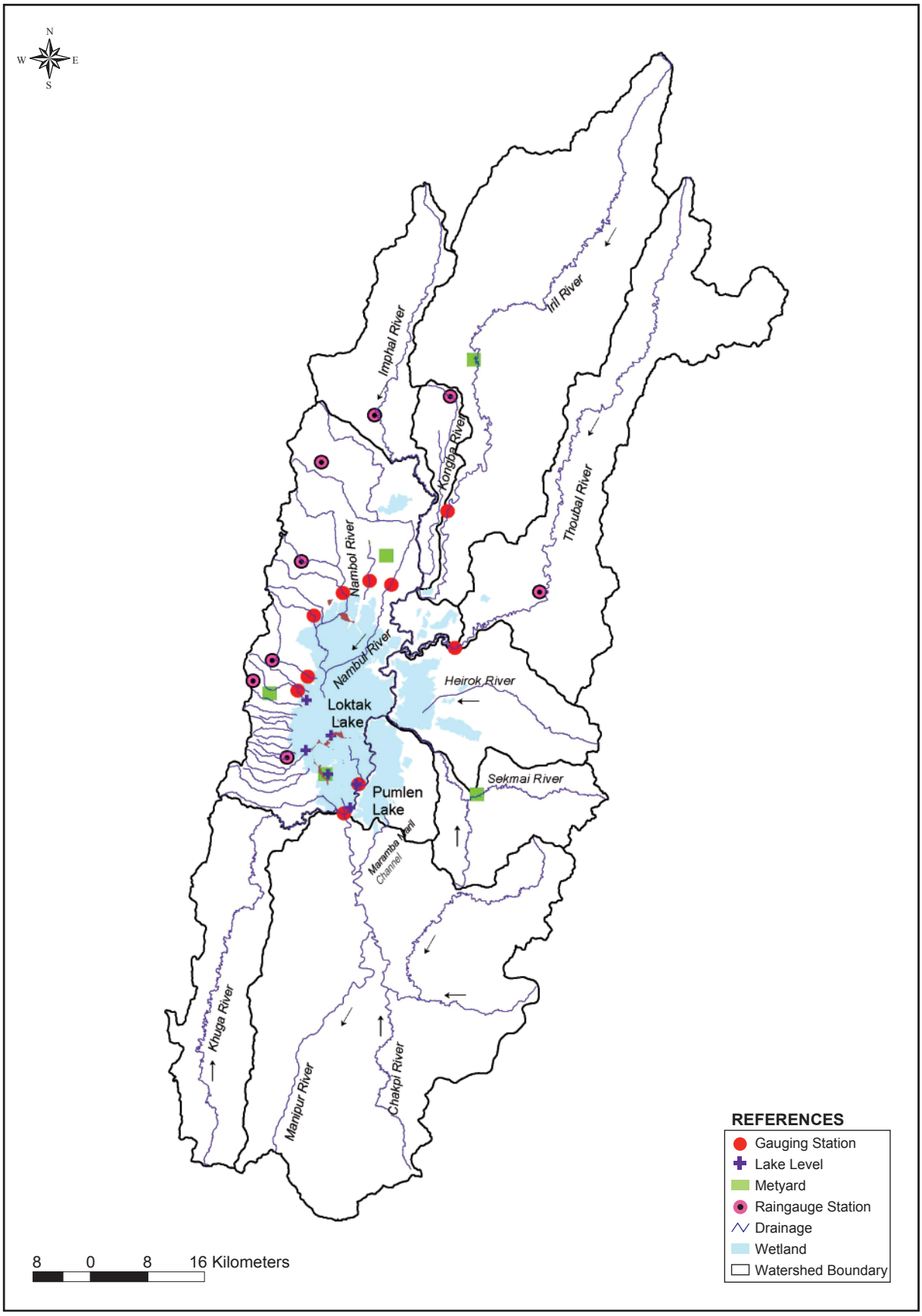
Water Holding Capacity

Based on the hydrographic survey carried out in 2000, the overall capacity of the lake is estimated to be 519 Mcum (Map 22). The volume displaced by *phumdis*, islands and the fish farms is 34 Mcum, 9 Mcum and 28 Mcum respectively. The effective capacity of the lake after accounting for these displacements is 448 Mcum. Water holding capacity of the lake has considerably decreased due to sedimentation and proliferation of *phumdis*. The lake water holding capacity has reduced by 175 Mcum over a period of more than 2 decades (ERM, 2003).

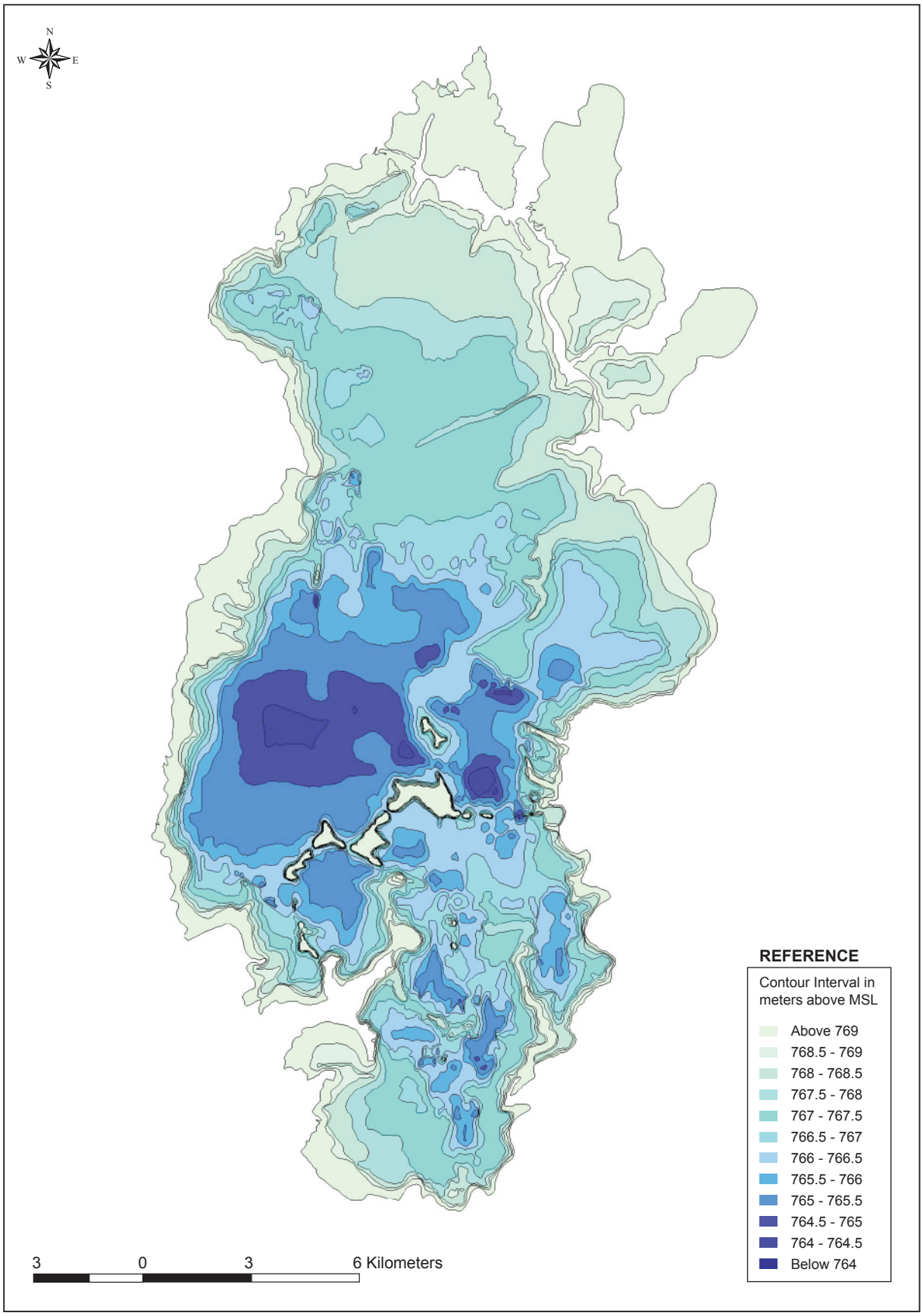
Sedimentation

The annual average sediment input into the lake has been estimated to be 650,000 MT. The rivers from the western hills account for 65% of the total sediment input into the lake and the rest 35% is from the link channels. Of the streams / rivers from western hills, Thongjaorok has the highest sediment yield (40 t/ha/year) and Potsangbam the lowest (10 t/ha/year).

Thongjaorok River from western catchment



Map 21: **LOCATION OF HYDROLOGICAL STATIONS**



Map 22: **BATHYMETRY MAP OF LOKTAK LAKE**

Water Allocation

Allocation of water in qualitative and quantitative terms for human uses and ecological purposes is critical to water management planning of the lake. Based on detailed studies of Keibul Lamjao National Park, which has been highly affected after construction of Ithai barrage, a draft plan has been prepared to regulate water level in different seasons of the year to ensure healthy growth of *phumdis* and enhancing the population of *Sangai*. A draft stakeholder endorsed water management plan is under preparation for allocation of water for various uses including hydro-power generation, irrigation, domestic use and ecological purposes.

Flooding

The natural flooding pattern with frequently fluctuating water level has been drastically modified to a less fluctuating condition with prolonged high water level regime. The causes of flood in the wetland system can be attributed to operation of Ithai barrage, silted drainage channels, changes in land use pattern, synchronisation of flood peaks, loss of forest cover in the watershed, presence of natural barriers like Sugnu hump and alignment of Chakpi River which interferes with the flow of Manipur River.

A total area of 63.5 sq km from different zones of the lake has been identified as highly flood prone (Map 23). The affected settlements in the four zones are :

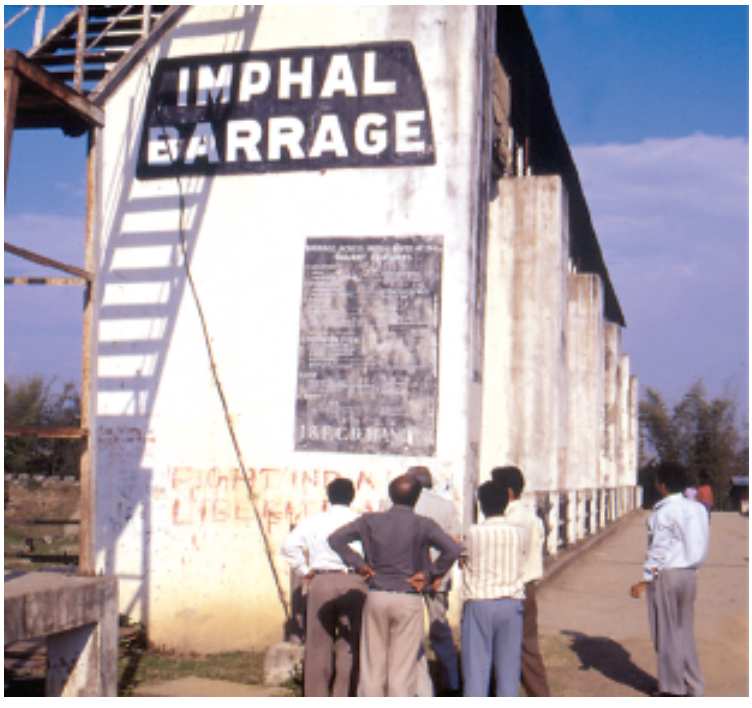
Northern Zone: Nambol, Ishok, Waheng Khuman, Top Upokpi, Irom Meijrao, Samushang, Shantipur, Wangoi, Mayang Imphal , Yumnam Khunou and Keinou with a total population of 62,637.

Western Zone: Toubul, Khoijuman, Kwasiphai, Potsangbam, Nachou,Toupokpi, Upokpi, Ningthoukhong, Thinungei, Phubala, Sunusiphai and Thamnapokpi with a total population of 37,750.

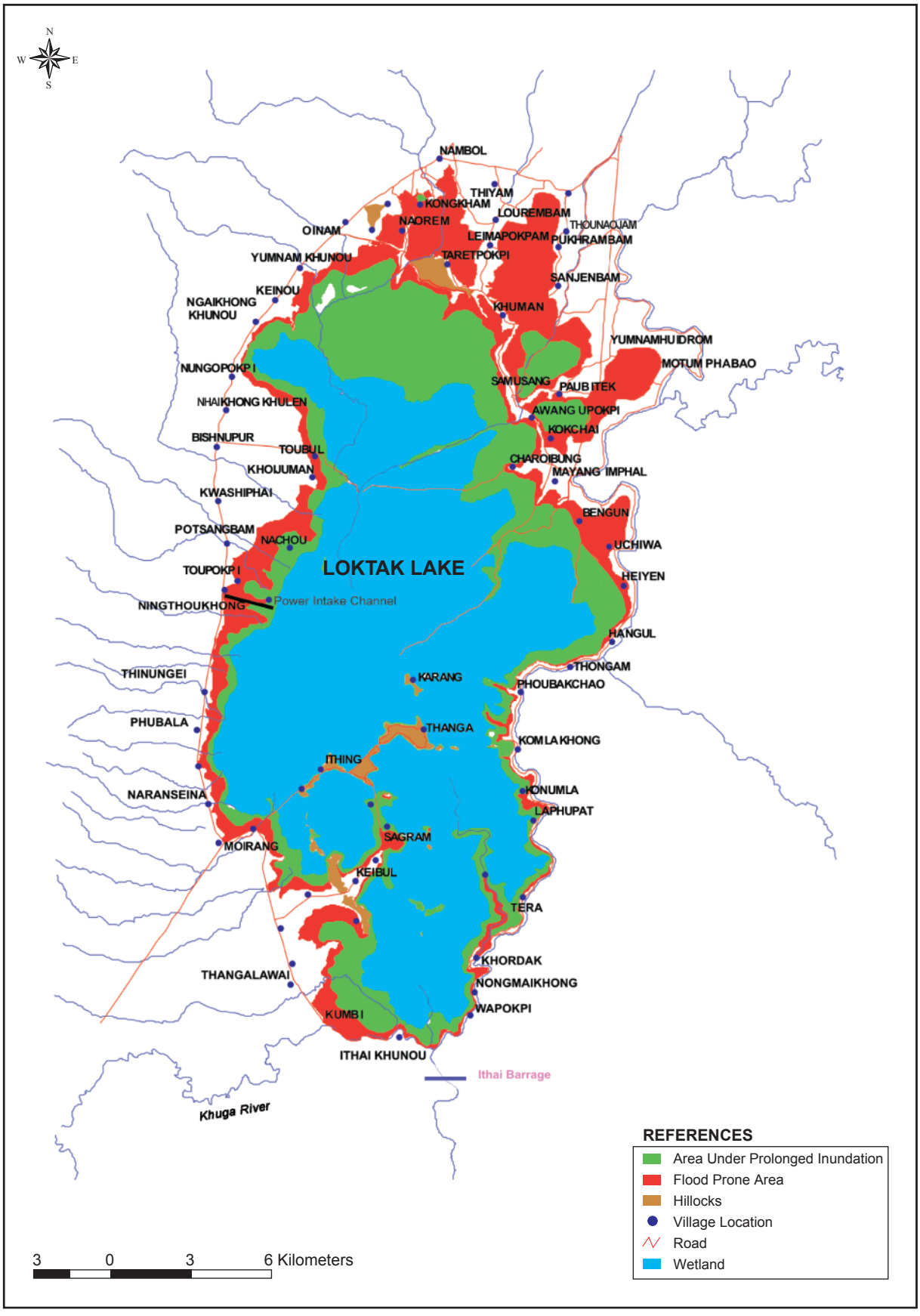
Southern Zone: Moirang, Moirang Khunou, Keibul, Keirenphabi, Thangalawai, Kumbi, Wapokpi, Ithaikhunou, Nongmaikhong, Laphupat Tera and Khordak with a total population of 22,252.

Eastern Zone: Uchiwa, Hayel, Hangul, Thongam, Phoubakchao and Komlakhong with a total population of 7,750.

Characteristics of flooding in the northern zone is different from those of the southern zone. Many of the drains in the northern zone are heavily silted up and are choked with thick *phumdis* resulting in reduction of their flushing capacity. This causes flooding of their upstream courses. Water level in the southern zone, in general, remains higher compared to rest of the lake and is prone to more flooding due to its proximity to the Ithai barrage. The backflow in the Ungamel and Khordak retards the outflow thereby leading to sedimentation and interference with the natural flushing.



Imphal Barrage in Imphal River



Map 23: **FLOOD PRONE AREAS**

WATER QUALITY

Water quality of Loktak Lake has not been comprehensively studied except a few research studies carried out mainly by Manipur University (Banerjee et al, 1983; Bhatia et al, 1985; Shyamananda, 1991; Singh, 1992). Under SDWRML project, a well equipped laboratory was set up at Ningthoukhong for assessment of physical, chemical and microbiological characteristics of lake ecosystem. Monitoring stations covering strategic locations within the lake (15 stations) and rivers (15 stations) were established (Map 24). The various parameters assessed included pH, dissolved oxygen, biological oxygen demand, free carbon dioxide, nitrate nitrogen, dissolved inorganic phosphate phosphorous, organic phosphate phosphorous and total and faecal coliforms. The details of seasonal variations of these parameters at different stations are indicated in the Maps 25 to 32.

Garbage accumulated on the banks of Nambul River

Physical and Chemical Characteristics

Physical and chemical features of water of Loktak and various streams flowing into the lake showed the following characteristics :

Lake Water

The mean pH value of water fluctuated between 6.4 and 8.0. In general, lower pH values were found in the northern and southern zones and higher pH values during monsoon.

The highest concentration of dissolved oxygen was found in open water area of Takmu (8.9 mg/l) and the lowest at Keibul (2.8 mg/l). BOD varied between 2.9 mg/l at Takmu and 13.8 mg/l near Toubul where high pollution loads are brought in by the rivers Nambul and Nambol from the urbanized areas of Imphal and Bishnupur.

The free CO_2 values ranged between 2.7mg/l at Ungamel, the outflow channel of Loktak Lake and 20 mg/l at Keibul. In general, free CO_2 was lower in the western (5.4 - 10.9 mg/l) and central zone compared to the eastern zone (11 - 12.4 mg/l) covered with dense growth of *phumdis*.

Higher concentrations of inorganic phosphate phosphorous were found during premonsoon. Organic phosphate phosphorous values showed fluctuations within the range of 0.82-1.81mg/l.

Nitrate nitrogen concentration ranged between 0.13 mg/l and 2.14 mg/l, with higher values recorded at Karang followed by Patangkhong, Khordak, Ungamel, Ningthoukhong, Mayang Imphal, Phubala, Thanga, Loktak Proper, Phoubakchao, Komlakhong, Keibul and Hubidak in decreasing order.

Microbiological Analysis

The microbiological analysis of the water samples clearly indicated pollution of the lake water due to organic matter. The values of standard plate count for bacteria ranged between 12,000/ml at Takmu in September and 58,000/ml at Keibul Lamjao in December. Microbial analysis in terms of Most Probable Number (MPN) of total coliform bacteria/ml ranged between 8.8 at Takmu in postmonsoon to 25.6 at Thanga in monsoon. This indicates high concentration of micro organisms and contamination of water. According to IS 10500 : 1991, drinking water should not contain any coliform bacteria in 100 ml of sample. Thus, the present analysis indicates that the water in the Keibul Lamjao and Thanga areas is contaminated with coliforms and can be used only after treatment.

Naga Turel carrying down pollutants into Nambul River

Rivers

A large population of 0.28 million people living within Nambul catchment generates on daily basis72.23 million tonnes of solid waste and 31,207 cum of sewage. Nambol also contributes 4.9 million tonnes of solid waste and 2,121 cum of sewage annually. All the wastes directly or indirectly find their way into Loktak Lake.

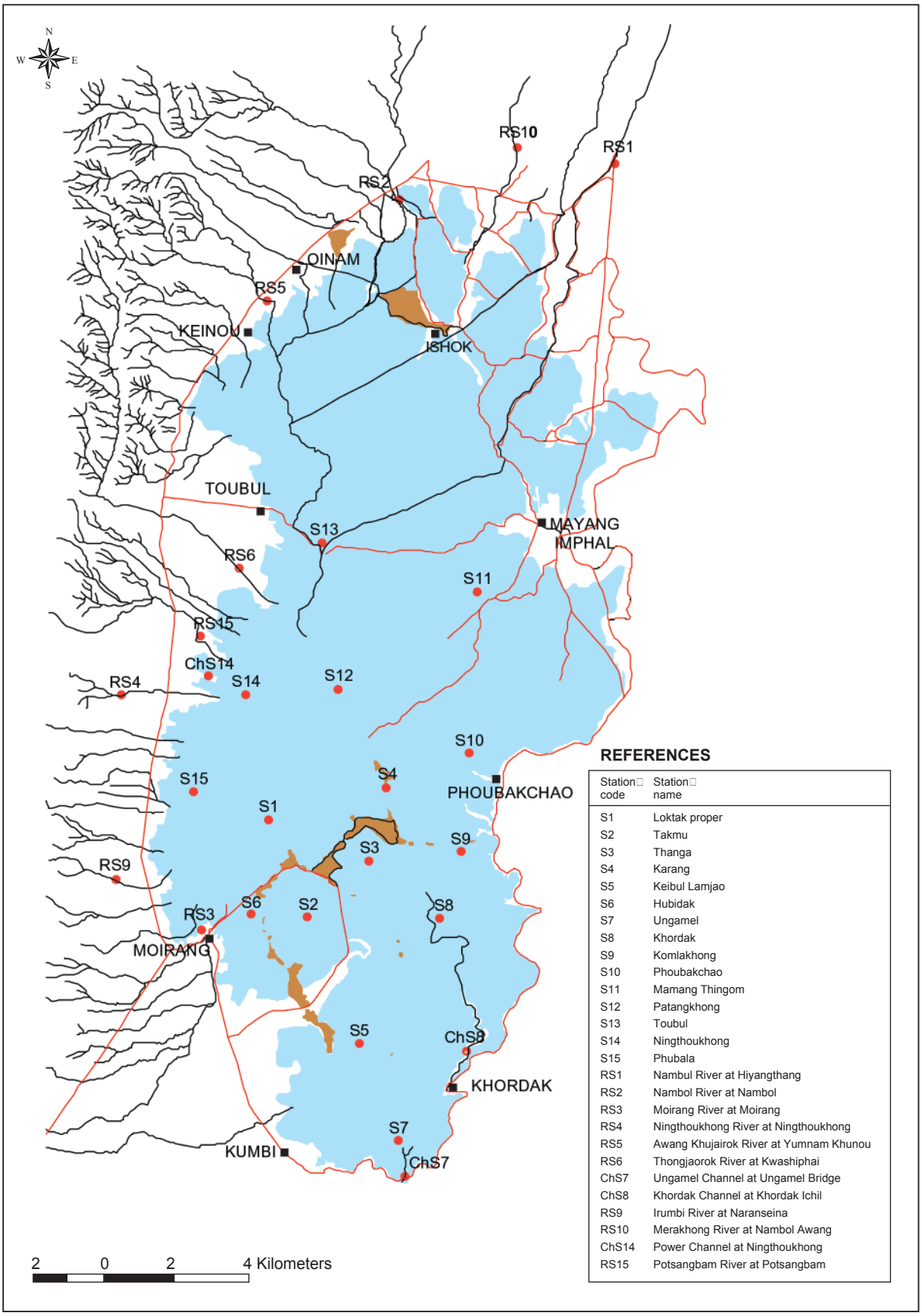
Nitrate nitrogen, dissolved inorganic phosphate phosphorous and organic phosphate phosphorus concentrations as indicated in the maps reveal that all the rivers carry high loads of mineral nutrients. Awang Khujairok, Ningthoukhong, Potsangbam, Merakhong and Irumbi draining the agricultural fields subjected to high amounts of fertilizers, in general, have higher concentration level of nitrogen and phosphorous. Nambul and Nambol rivers bring a heavy load of pollutants into the lake and contribute significantly to water quality deterioration of the Lake (Table 2).

Mineral Dynamics

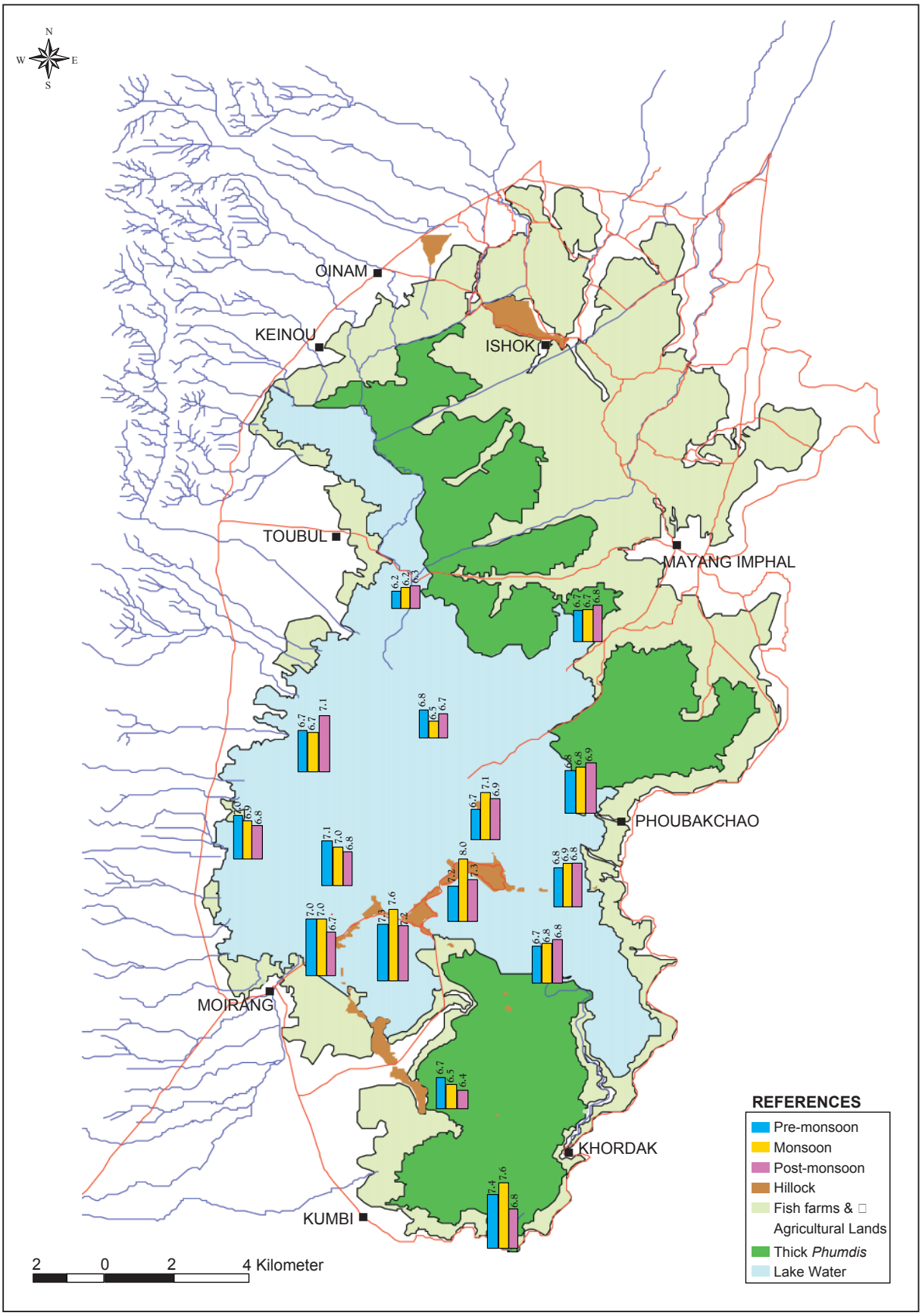
A comparative analysis of mineral nutrients within water, sediments and *phumdis*, as presented in the Table 3, indicates that *phumdis* provide biological sink to N, P and K which are mainly implicated for water quality deterioration. Sediments act both as a source and sink for these nutrients. *Phumdis* play an important role in filtering of mineral nutrients responsible for deterioration of water quality. A thick strip of *phumdis* in the northern sector is critical to maintenance of water quality of the lake by acting as a biological sink to the key nutrients. The assessment of mineral accumulation indicates that annually 478.6 tonnes of nitrogen, 39.6 tonnes of phosphorous and 157.2 tonnes of potassium are accumulated within the *phumdis* of Northern Zone (Table 4). The huge amount of the pollutants brought in by the rivers, particularly Nambul and Nambol, if not absorbed by these *phumdis*, would have been otherwise available in the water thereby leading to further degradation and making the lake unfit for fisheries and other aquatic biodiversity. It could also further trigger the growth of micro organisms thereby compounding the problems by interfering with the growth of macrophytes by shading effect.

Designated Best Use

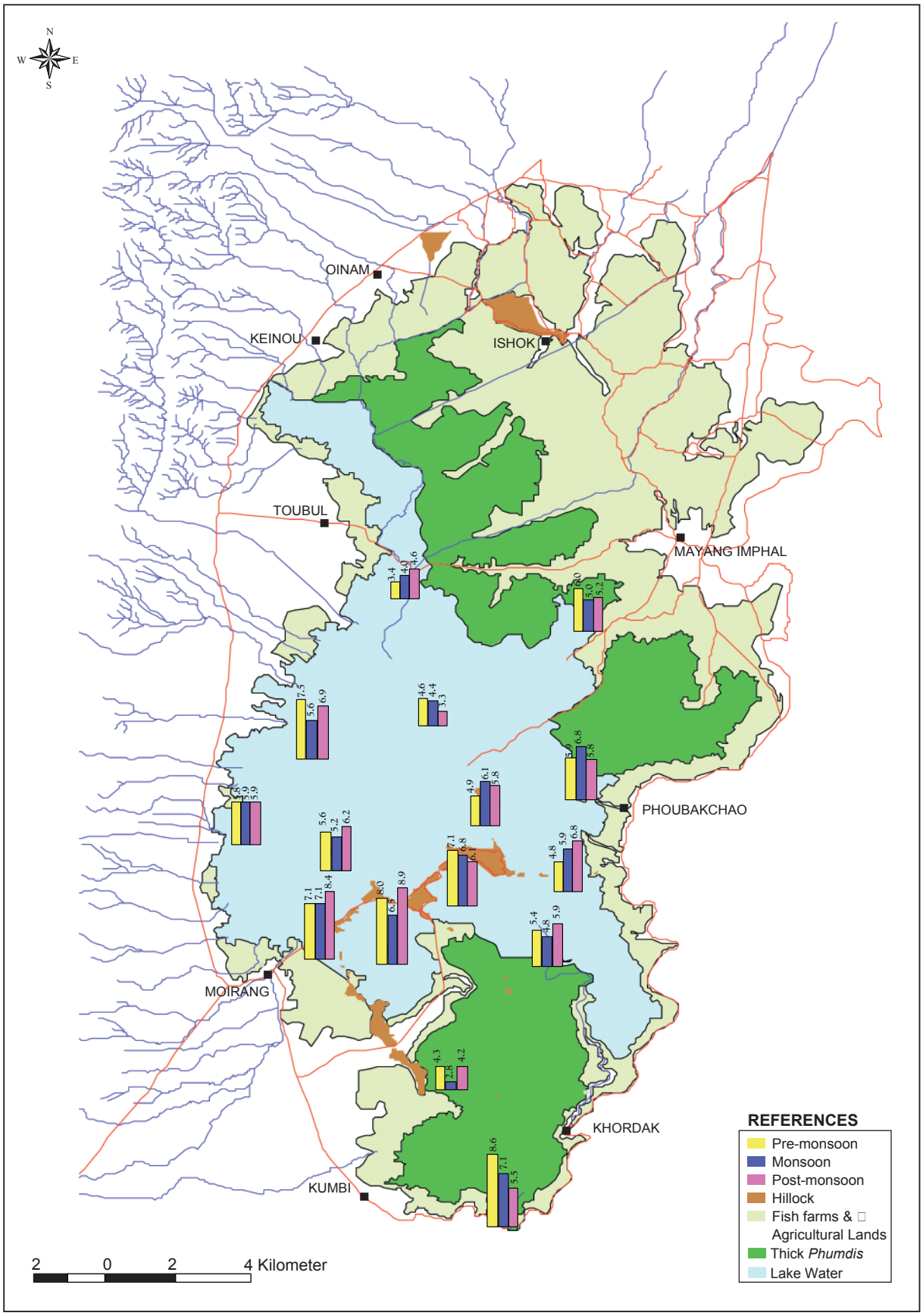
The water quality, in general, falls within class C to E as per the CPCB's designated best use criteria. The lake water is not fit for direct drinking without treatment but can be used for irrigation and ecological purposes. A comparative analysis of water quality of different zones indicates significant levels of pollution in the Northern Zone and Southern Zone. High intensity of fertilizer usage in the agricultural fields and practice of fish farming contribute significantly to water quality deterioration in the Northern Zone. The Nambul and Nambol rivers also finally discharge pollutants in this zone. Southern Zone is polluted due to flow of all the pollutants finally in this zone and their accumulation due to poor flushing.



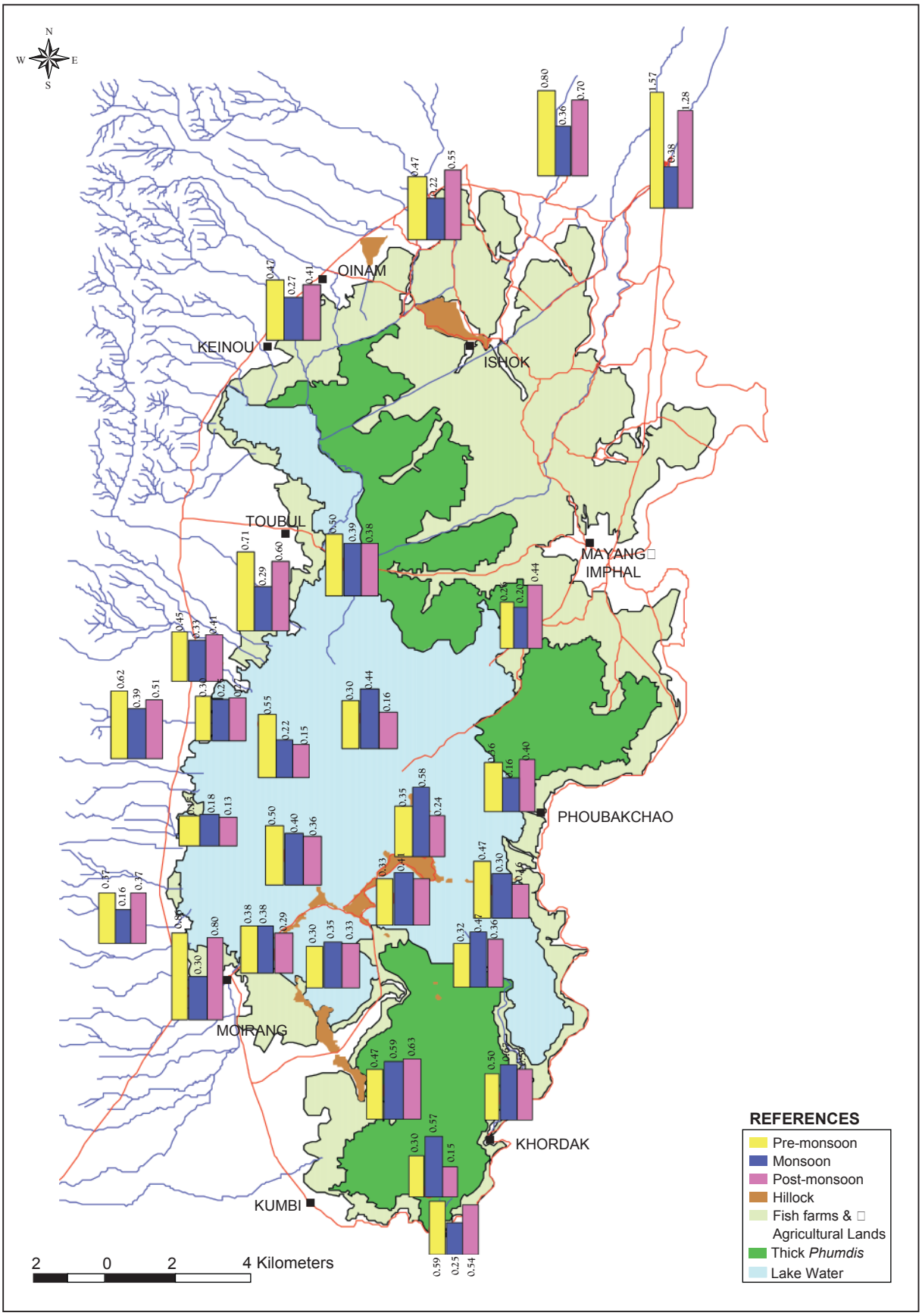
Map 24: **WATER QUALITY SAMPLING STATIONS**



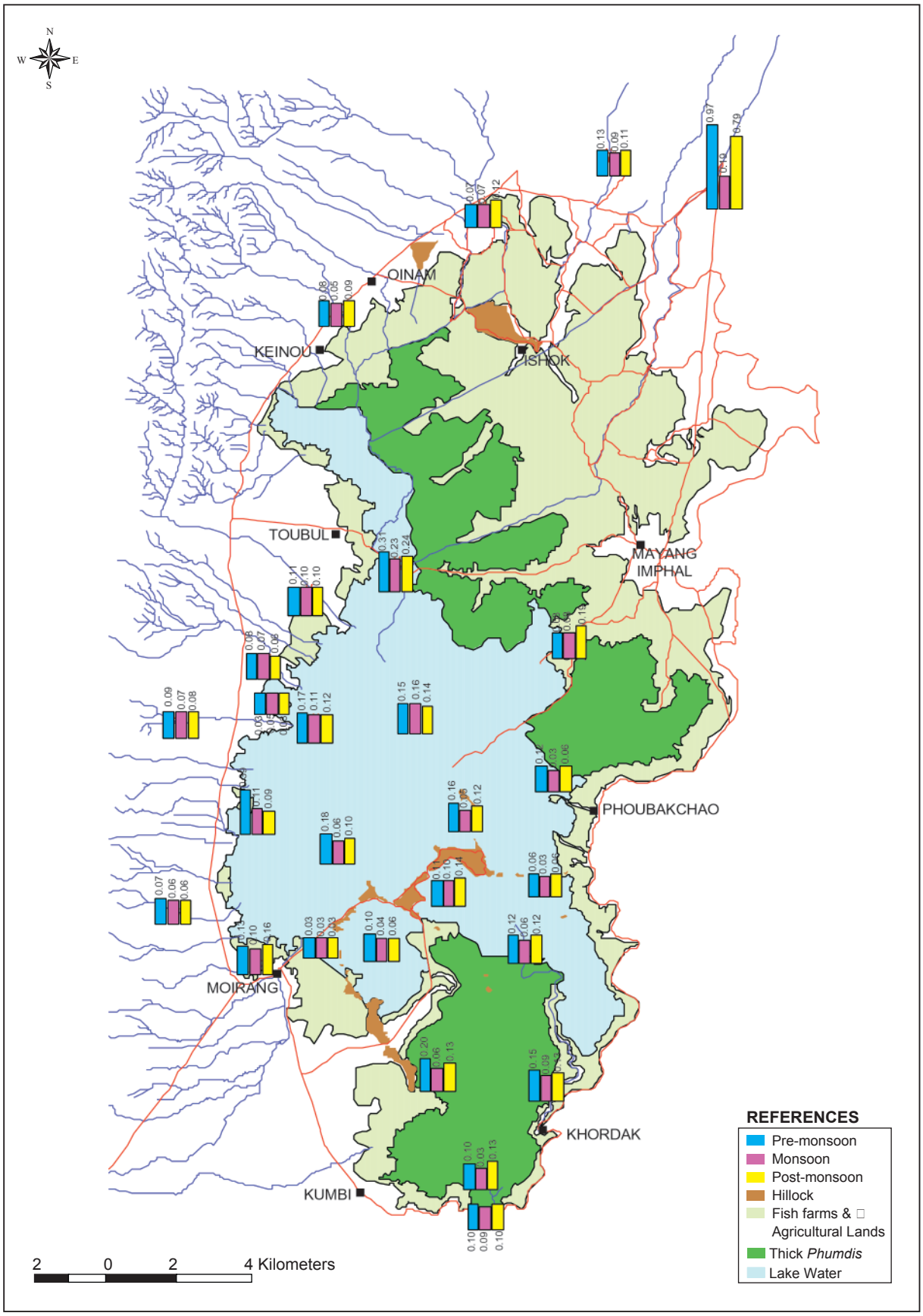
Map 25: **SEASONAL VARIATIONS OF pH IN LOKTAK LAKE**



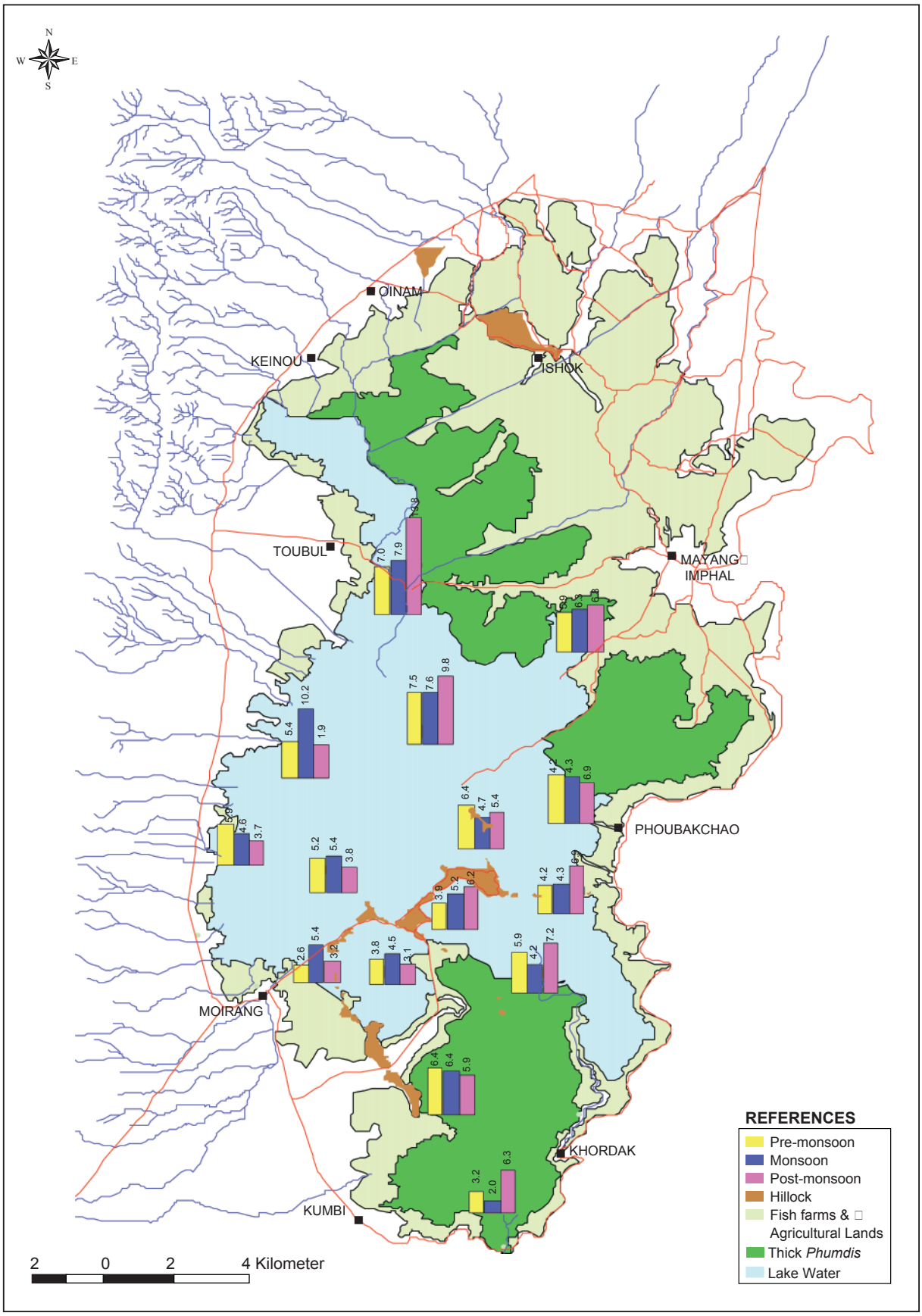
Map 26: **SEASONAL VARIATIONS OF DISSOLVED OXYGEN (mg/l) IN LOKTAK LAKE (2000-2001)**



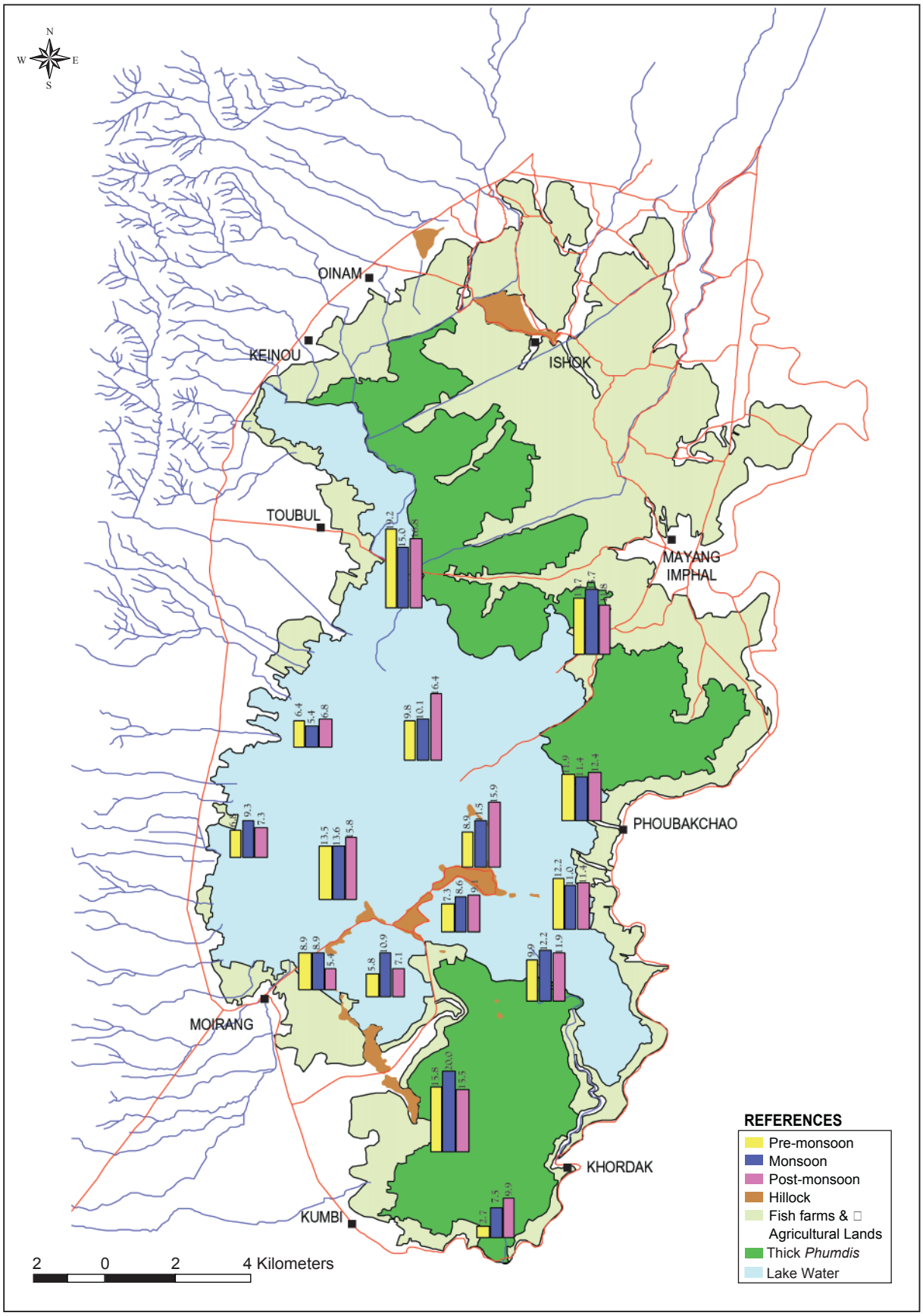
Map 27: **SEASONAL VARIATIONS OF NITRATE NITROGEN (mg/l) IN LOKTAK LAKE, RIVERS AND CHANNELS**



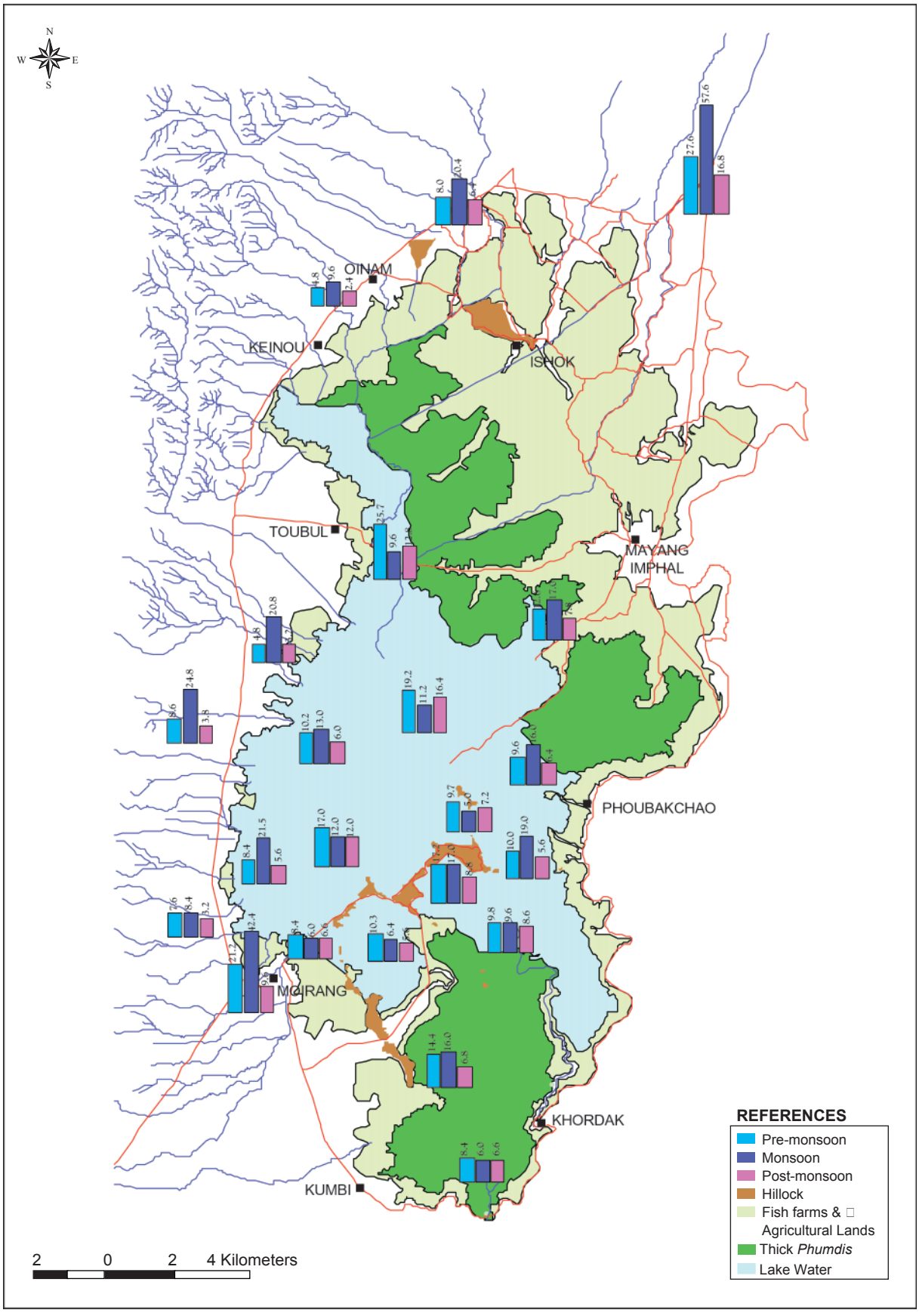
Map 28: **SEASONAL VARIATIONS OF DISSOLVED INORGANIC PHOSPHATE PHOSPHORUS (mg/l) IN LOKTAK LAKE, RIVERS AND CHANNELS**



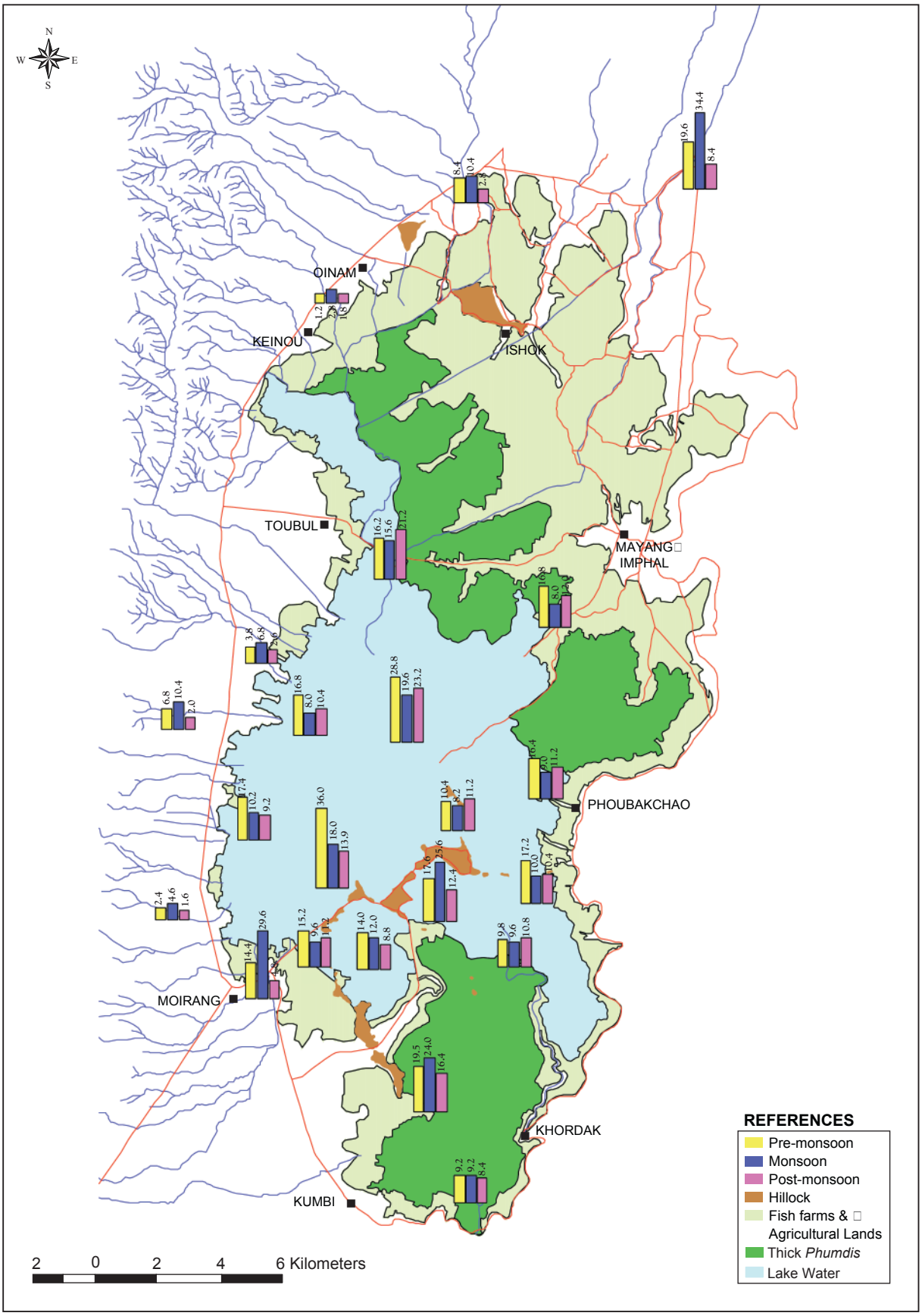
Map 29: **SEASONAL VARIATIONS OF BIOCHEMICAL OXYGEN DEMAND (mg/l) IN LOKTAK LAKE**



Map 30: **SEASONAL VARIATIONS OF CARBON DIOXIDE (mg/l) IN LOKTAK LAKE**



Map 31: **SEASONAL VARIATIONS OF FAECAL COLIFORM (MPN/ml) IN LOKTAK LAKE, RIVERS AND CHANNELS**



Map 32: **SEASONAL VARIATIONS OF TOTAL COLIFORM (MPN/ml) IN LOKTAK LAKE, RIVERS AND CHANNELS**

Table 2: Inflow of Nutrients (MT) from Major Rivers into Loktak in 2001

River	Discharge (MCM)	N	P	K
Nambul	161	2,338	270	2,081
Nambol	104	243	34	198
Awang Khujairok	9	54	8	41
Thongjaorok	30	57	9	45
Ungamel	210	642	118	462
Khordak	65	57	11	45
Potsangbam	22	27	6	20

Table 3: Mineral Nurient Accumulation (MT) in Water, *Phumdis* and Sediments in Loktak Lake in 2001

	N	P	K
Water	1411.2	717	1,658
Phumdis	1627	136	621
Sediments	8,060	559	4,524

Table 4: Mineral Nurient Accumulation (MT) in *Phumdis* of Different Zones of Loktak Lake in 2001

Zone	Area (Sq km)	N	P	K
Northern	41.6	478.6	39.6	157.2
Central	59.6	729.0	60.3	239.5
Southern	33.4	419.2	36.1	224.3

FISHERIES

Fishery is an important economic resource of Manipur contributing to approximately 3% of the state's gross domestic product. Loktak Lake is the largest fishery resource of the state accounting for more than 50% of its fish producing area. Prior to 1950s', the lake contributed 60% of the total fish production of the state of which migratory fishes from Chindwin - Irrawady River system contributed 40% of the total capture fisheries. Currently, it accounts for merely 11% of the total state fish production.

Fish is the main food of the majority of Manipuri population, particularly of the Meities and occupies a distinct place in their traditions and livelihoods. The annual requirement of table fish for the whole state is 26,000 MT as per standard nutritional requirement of 11 kg per capita per annum consumption of fish. The present production of the state is 11,600 MT (Fisheries Report 2001) per annum leaving a huge gap between demand and supply.

Dip Net Fishing in Loktak

The growth rate of inland fish production during the Ninth Five Year Plan was 6.5% throughout the country. The State Government of Manipur during ninth and tenth plans emphasised on aquaculture development in the valley. However, at the end of the ninth plan, the state government was successful in achieving a growth of only 6% per annum in fish production. The state fisheries department also provided training to the fish farmers who were

Fish catch from Loktak

successful in producing 80% of the total fish seed requirement of the state and exporting surplus to the neighboring states of Nagaland and Mizoram. However, potential of all water bodies has not been adequately realized. Capture fisheries development was almost ignored and Loktak Lake, the largest fishery resource of the state, was not given proper attention. Open access to the fisheries resources of Loktak has led to indiscriminate fishing without considering limited regenerative capacity of the fish stock. The water quality of the lake has deteriorated over a period of time due to heavy discharge of pollutants from the catchments. Prolific growth of *phumdis* has choked the entire lake leaving little open water area which is essential for fish growth.

High rates of population growth in the valley accompanied by insignificant growth in the secondary and tertiary sectors have led to stresses on the natural resource base of the state including fisheries. Over a period of time the availability of fishes and other products, such as vegetables, fuel and fodder from the lake has declined causing immense hardships to the communities. There has been a significant decline in fish landing which along with the increase in fisher population, has seriously impacted the livelihoods of these communities. Changes in fishing practices, use of exploitative fishing techniques and inadequate marketing infrastructure have further led to their poverty.

Fishing in fish farm around Loktak Lake

The implementation of SDWRML project over last several years has helped to develop baseline information for developing strategies for sustainable management of lake fisheries. Several interventions have been carried out for enhancement of fish yield and diversity and livelihood improvement of fishing community. The activities have been implemented through participation of local communities in resource appraisal and planning.

Fish Diversity

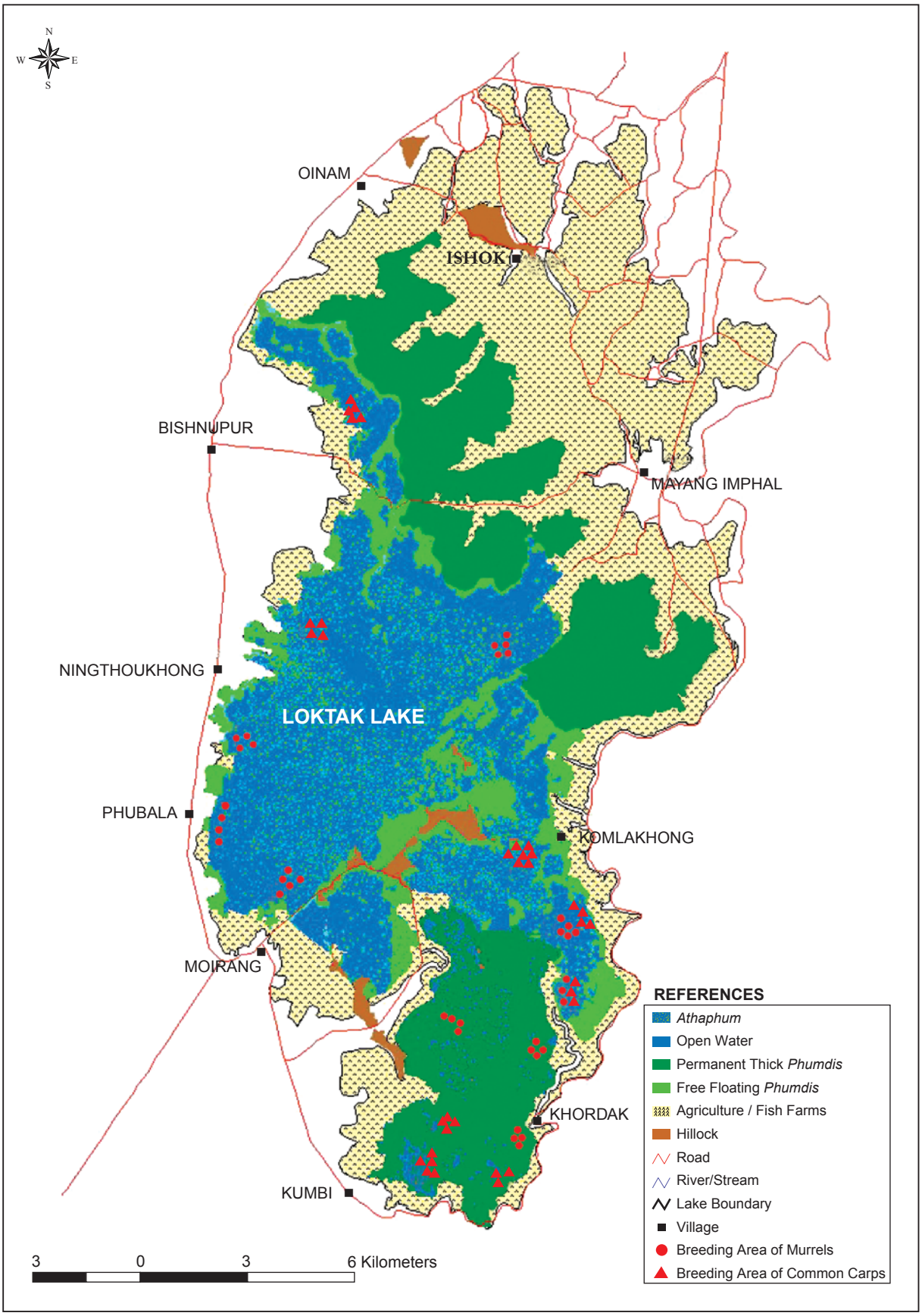
Loktak Lake harbours a wide range of fish fauna. A survey carried out under SDWRML project has identified occurrence of 54 fish species representing 17 families. Twelve fish species reported earlier by Fisheries Department (1981), Tombi Singh (1994), Pishak Singh (1996) were not observed in the present study. An exotic catfish *Clarias gueripinnus* and a riverine species *Aplocheilus punchax* were recorded in the lake for the first time.

Before construction of Ithai barrage, minor carps like *Labeo angara, L. bata, L. dero and Osteobrama belangiri* used to migrate from Chindwin Irrawady River system, Myanmar to the upstream of Manipur River for breeding and spawning purposes. Fingerlings of *Labeo sp* and *Osteobrama belangiri,* locally known as *ngaton* and *tharak* respectively returned downstream with the onset of monsoon. Construction of hydraulic structures, particularly Ithai barrage, blocked the migratory pathways of the riverine fish species. Currently occurrence of these species is restricted to rainy season when either flood or short opening of Ithai barrage allows them to enter the lake.

Intensive survey has been conducted in KLNP and other parts of the lake to identify breeding and spawning areas of fishes. Scattered type breeding areas of common carp and murrels were observed in KLNP and 5 other pockets of the lake (Map 33).

Food and feeding habits of 8 important fish species viz. *Channa punctatus, Clarias gueripinnus, Labeo rohita Cyprinus carpio, Clarias batrachus, Heteropneustes fossilis* and *Anabas testudinues* in Loktak Lake have been studied under SDWRML project. The study revealed that *Cyprinus carpio* and *Labeo rohita* are omnivorous species feeding on vegetative and animal matter. *Channa punctatus, Channa striatus, Clarius gueripinnus and Clarius batracus and Heteropneustes fossilis* mainly feed on insect and animal matter.

Smoked fish from Loktak



Map 33: **FISH BREEDING AREAS IN LOKTAK LAKE**

Fish Yield

Stock Assessment

Maximum Sustainable Yield (MSY) as estimated using surplus production model (logistic) for a standardized gear (gill nets of different mesh size) is 1,102 MT/annum. The present production estimated at 1,237 MT/ annum indicates over exploitation of the resource. Catch per Unit Effort of a fisherman is only about 0.45 kg indicating poor returns with high unit efforts.

Annual Fish Yield

Annual fish landing of Loktak Lake varied between 1,261 and 1,685 MT, during 1999-2003 (Fig. 1). Fish population of the lake is dominated by exotic major carps (44%) and Indian major carps (27%). Minnows contributed significantly (14%) to the total fish landing. Other contributing groups were murrels, catfishes and minor carps (Fig. 2).

Crafts and Gears

Several types of fishing gears viz. gill nets (mesh size ranging from 15 to 140 mm), multi-pronged spears, dip nets, lift nets, cast nets, scoop nets, hooks and gorges, traps, drive in nets etc are used for fishing in the lake. Among all the fishing gears, gill nets are the most efficient. Two primitive types of fishing crafts made from the trees such as *Artocarpus chaplasa*, *Cedrella tuna* and *Phoebe sp*. are used in Loktak lake. The canoes are either made from a single log or jointed planks. There are 2,800 canoes being used for fishing and navigation purposes in Loktak lake. The canoes lack stability during rough weather conditions. Very little modernization has taken place in the traditional fishing crafts.

Different fishing methods are being practised in Loktak Lake. Most of the fishing methods are more or less similar to the general techniques practised in other places of the country, although there are slight modifications to suit the local conditions. Groping or hand picking, stranding, wounding with gears, line fishing, traps, nets and stupefying devices are some of the methods for fishing in the lake.

Eel from Loktak

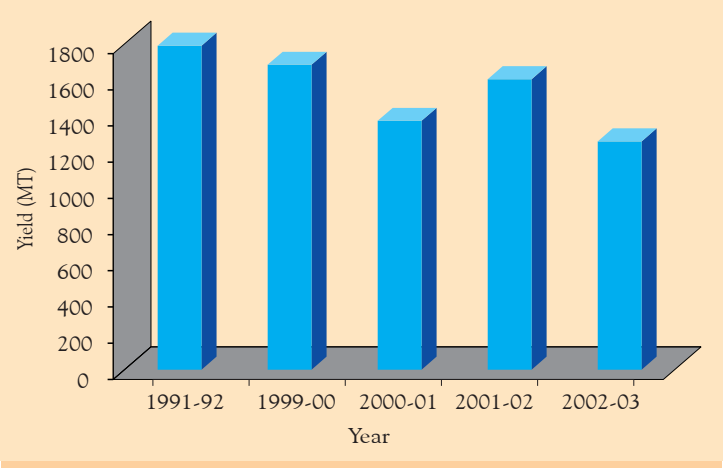


Fig. 1 Annual Fish Yield From Loktak Lake

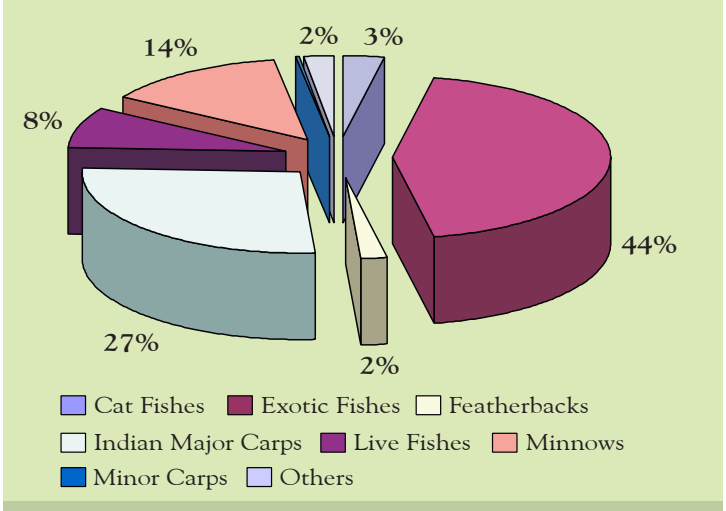


Fig. 2 Composition of different groups in fish yield of 2001-02

Athaphum Fishing

Use of *phumdis* for fishing is a traditional practice in Manipur. *Phum* fishing, practiced in Loktak prior to construction of Ithai barrage, involved preparation of a fishing enclosure made up of *phumdis*. Fishermen used to cut and drift pieces of *phumdis*, which were fixed to the lake bottom using bamboo poles. Subsequently, an enclosure of bamboo poles and grass was built around the *phumdi* enclosure at a level little higher than the lake water to prevent fishes to escape. At a later stage, the floating *phumdis* and grasses were cut in small pieces and cleared, and all the small fishes attached were carefully collected. After the surface was cleared of floating material, fishermen used buffaloes to move in the enclosure making the water muddy. Different kinds of nets were used for taking the fish out. This practice was limited to winter months only (Hora, 1921).

Changes in fishing techniques took place after construction of Ithai barrage due to rise in water level and inundation of large areas of agricultural land. *Athaphum* fishing, an improvised version of *phum* fishing, is now practised as an adaptation to changes in water level. This is no more a seasonal activity and is practised throughout the lake particularly in central zone.

Athaphum fishing essentially involves two phases. In the first phase called *phum thaba*, large circular *phums* (2.5 m wide and 1m thick) are prepared and kept afloat in the lake. Long strips of cut *phumdi* (2-3 m wide and 0.5- 1.0 m thick) are transported maintaining a circumference of 200-250 m. Thin cut pieces of *phumdis* / other aquatic plants such as water hyacinth and *Salvinia sp*. are put within the *phum* enclosures. Sometimes soaked rice bran, oil cakes, cow dung, rotten coconut, waste from local liquor breweries etc. are used as baits. The second phase called *phum namba* involves a team of about 20 fishermen and women on 6-7 canoes working for about 6-8 hours. First, the circular *phum* is surrounded with a kind of net called *hapa* which touches the lake bed leaving no room for the fishes to escape. The floating plants within the *athaphums* are gradually removed and the entire area is churned with bamboo poles. The high suspended silt and organic matter load soon deoxygenates the water. Fishes start coming to the surface of the water due to oxygen depletion and the fishermen catch them easily with dip nets. Nowadays, dragnets are also operated inside the encircled *athaphum* without muddling it.

As per remote sensing studies, number of *athaphums* in Loktak has increased from 217 in 1989 to 2,642 in 2002, covering 1,118 ha of open water area in the lake (Map 34 and 35). Moreover, isolated and abandoned pieces of

Athaphum in Loktak Lake

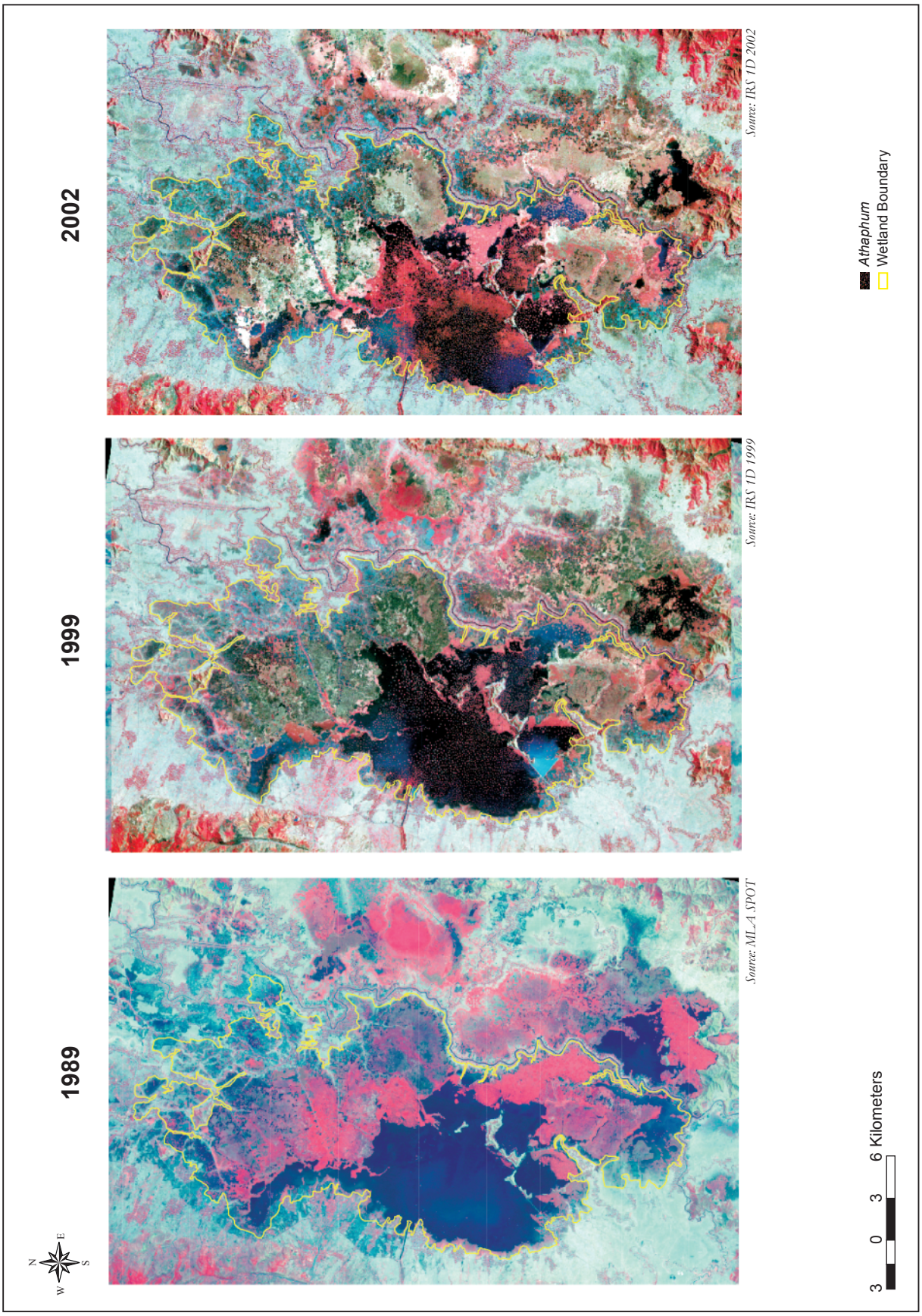
athaphums have profusely proliferated. Annual fish production from *athaphums* (558 MT) presently accounts for 39% of total fish yield of Loktak Lake.

Restocking

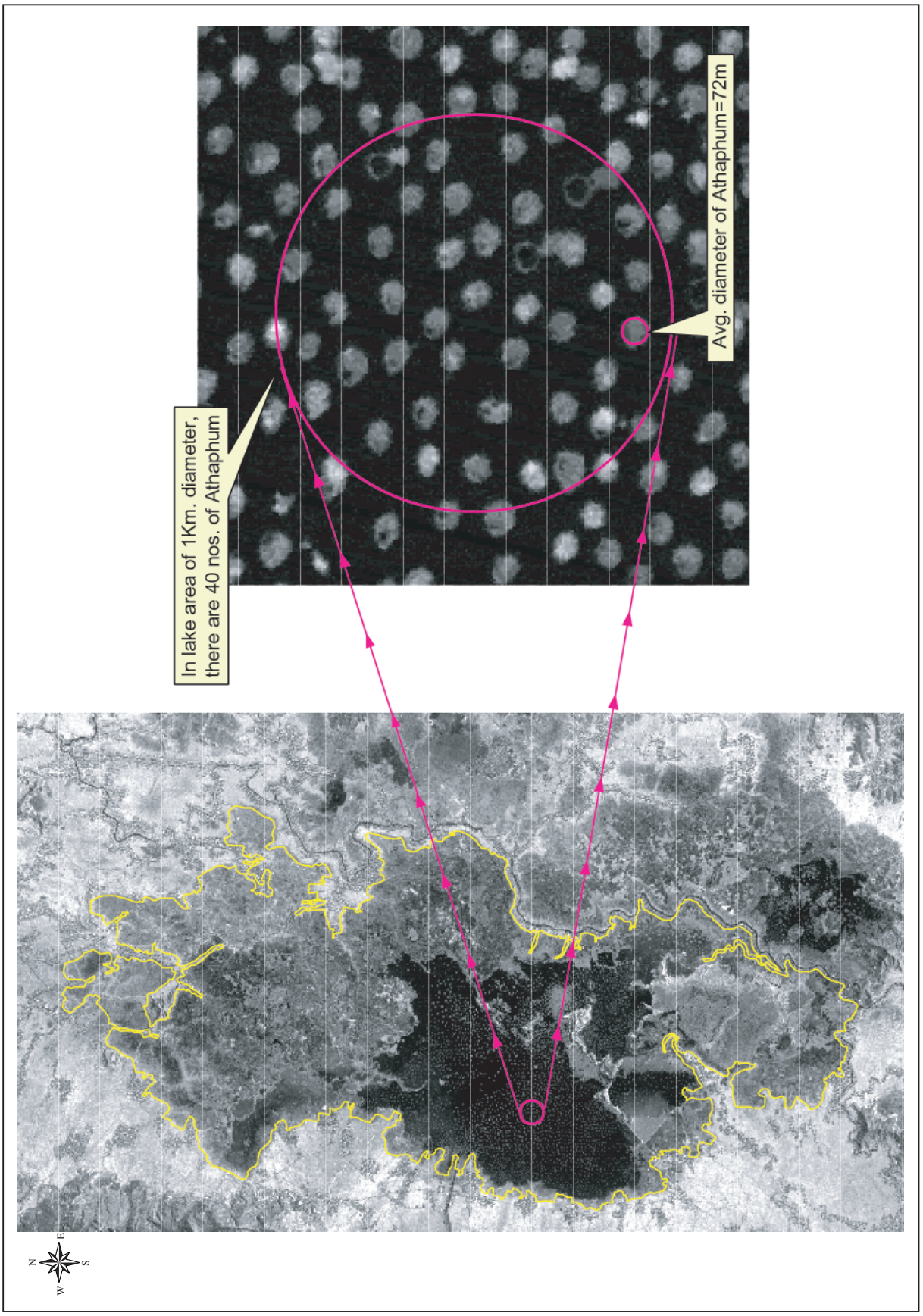
Indian Major Carps i.e. *Labeo rohita, Catla catla* and *Cirrhinus mrigala* have high commercial value and are most popular for culture fisheries (Saha, 2003). As these fishes breed only in running water, fish farmers have to depend solely on artificial breeding for procurement of fish seeds. Hypophysation or induced breeding of carps by administering hormones is a well known and common practice in the state.

Traditionally fish farmers produce fish seeds by induced breeding in small *hapas* in lake shore villages. There are about 100 traditional hatcheries currently existing in villages Malom, Kodompokpi, Ningombam, Shantipur, Mekola, Yurenbam, Hiyangthang, Laphupat Tera, Khordak, Sekmaijin, Mayang Imphal, Ningthoukhong, Thanga and Kumbi. The state Fisheries Department has also established a circular Chinese hatchery in lakeshore village at Ningthoukhong with production capacity of 3 million spawns per operation. Private entrepreneurs are also successfully running hatcheries in Thanga (capacity 3 million spawns per operation) and Kodompokpi (capacity 5 million spawns per operation).

Enhancement of fisheries production of Loktak Lake emphasizes on improvement of capture fisheries yield along with encouraging culture fisheries on sound ecological basis in the ponds owned by the communities in the lakeshore villages. As an immediate measure, under the SDWRML project two large circular hatcheries having production capacity of 2.5 million spawns per operation at Toubul village in western side and Mayang Imphal in eastern side of the lake have been constructed. Eight more mini hatcheries having capacity of 1.2 million spawns per operation have also been constructed at Phoubakchao, Laphupat Tera, Sagram, Thanga, Naranseina, Keinou, Shantipur and Thinungei under the project (Map 36).

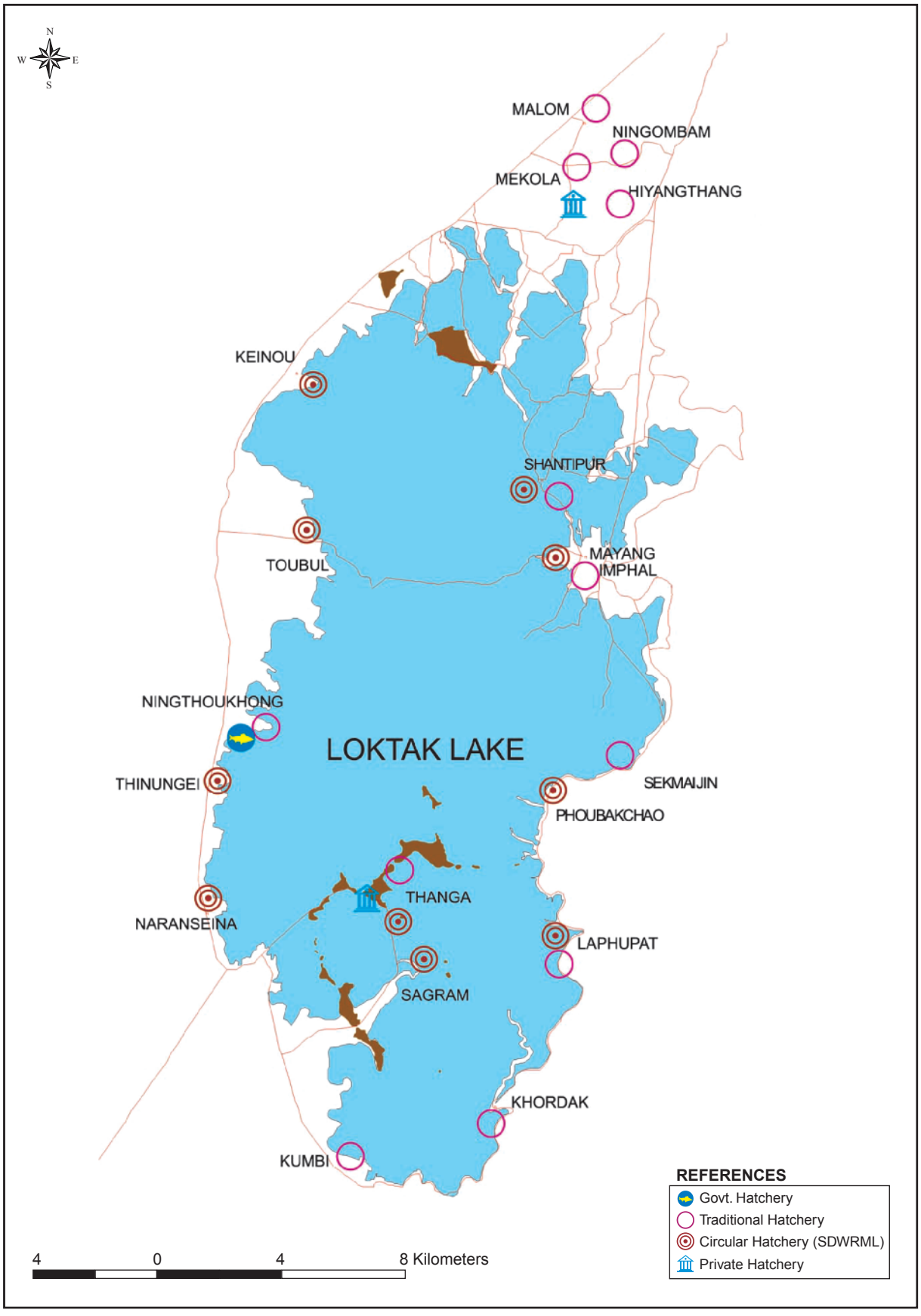


Map 34: **DISTRIBUTION OF ATHAPHUMS IN LOKTAK LAKE (1989, 1999 and 2002)**



Source: IRS 1D PAN 1999

Map 35: **DENSITY OF ATHAPHUMS**



Map 36: **LOCATION OF HATCHERIES IN AND AROUND LOKTAK LAKE**

VEGETATION

Loktak is a shallow basined floodplain lake covered with thick vegetation comprising emergents, submergeds and floating leaf type life forms. The plant species, in general, are inter-mixed forming large associations in different geographical locations. Vegetation plays an important role in the ecological processes and functions of lake ecosystem besides being of great cultural significance to the people. The rich plant diversity of the lake is of considerable importance to the local communities as food, fodder, fuel and gene pool.

Vegetation in the lake can be broadly categorized into *phumdi* and non *phumdi* types. The macrophytic species in *phumdi* and non *phumdi* areas are intermixed, although specific zonations are noticed in different

Formation of Phumdis

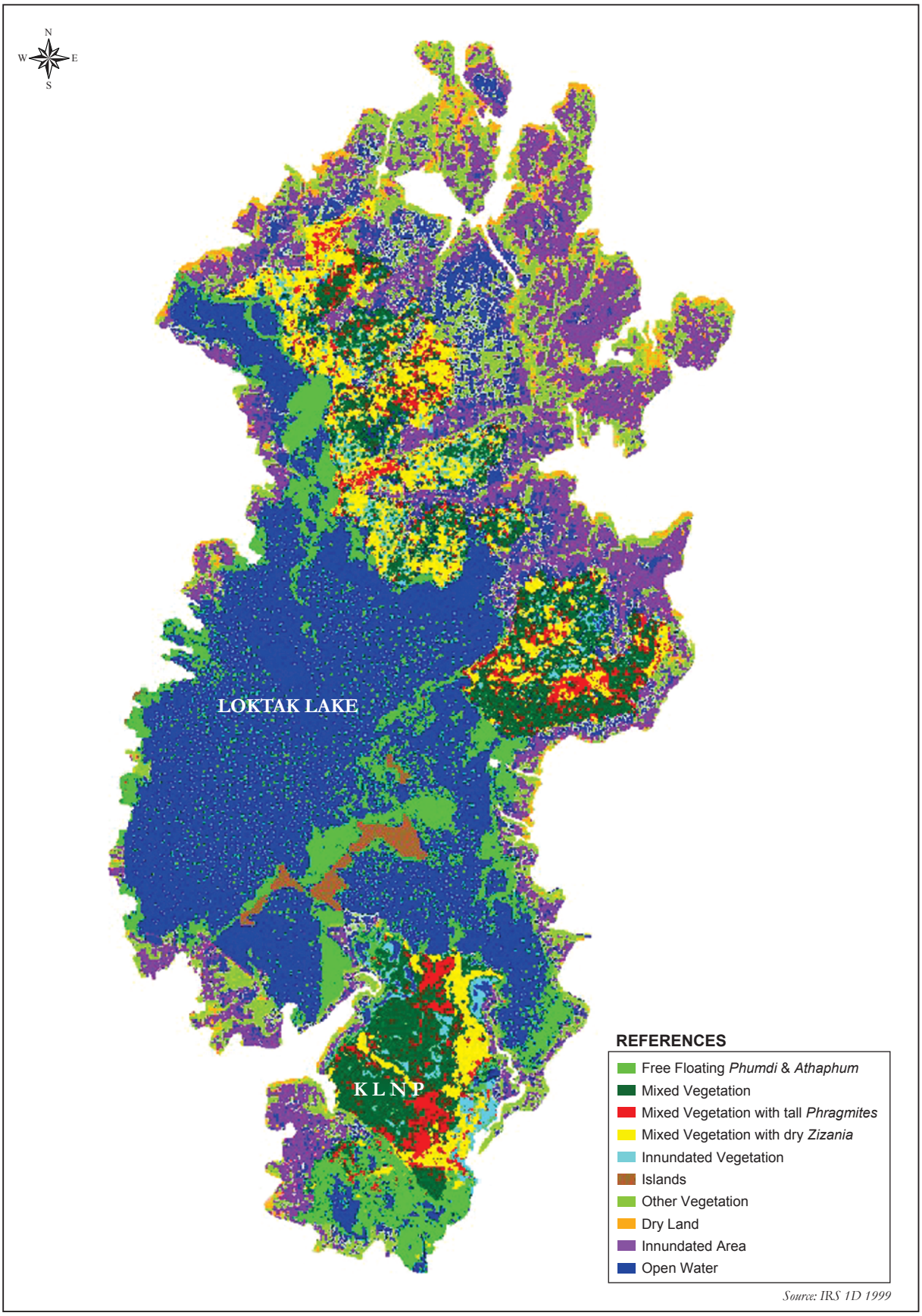
parts of the lake. The lake vegetation has profusely grown over last few decades due to proliferation of *phumdis*, which is threatening the carrying capacity of the ecosystem. Several studies have been carried out under SDWRML project to assess the current status of *phumdis* and factors governing their growth and proliferation.

Nelumbo in Loktak Lake

Vegetational Composition

Overall 132 plant species have been identified from different parts of the lake. The species widely distributed are *Echinocloa, Salvinia, Eichhornia, Phragmites, Zizania, Capillipedium, Hydrilla and Brachiaria*. The highest number of species has been observed in the Southern Zone (108) followed by the Northern Zone (92) and the Central Zone (78) in decreasing order. A list of plant species identified from the lake is given in Annexure I.

The main species found in the *phumdis* are *Zizania, Phragmites, Capillipedium, Echinochloa, Impatiens, Saccharum, Hedychium, and Alpinia*. Overall 60 species are common to *phumdis* in all the zones. The macrophytic species in non *phumdi* areas are represented by emergents, submergeds, floating and rooted floating leaf types depending upon the water depth. Overall 24 species have been observed in the non phumdi areas of which *Phragmites, Brachiaria, Salvinia, Eichhornia, Hydrilla, Trapa, Scirpus and Nympheae* are widely distributed in the lake. The Central Zone, which is relatively free of *phumdis*, excepting athaphums, is dominated by non *phumdi* vegetation. The distribution of dominant plant species in the non *phumdi* areas is given in the Map 37.



Map 37: **VEGETATION MAP OF LOKTAK LAKE**

Distribution and Extent of *Phumdis*

While *phumdis* of varying thickness are scattered throughout the lake, a general trend is observed in their distribution. In general, *phumdis* can be broadly categorized into four thickness classes (i) 0.2 to 0.3 m (ii) 0.3 to 0.5m (iii) 0.5 to 1m and (iv) above 1m. *Phumdis* in the core zone area of KLNP and northwestern portion are relatively thick with more than 1m thickness. These *phumdis* are not easily drifted by the wind and remain either fixed or touch the bottom during their annual growth cycle. The other classes of the *phumdis* ranging between 0.2 and 1m are interspersed with rooted and floating types.

The Central Zone is mainly covered by *phumdis* which are thick on the edges but almost hollow inside and are covered with various plant species. These *phumdis* are locally called *athaphums* and are specially designed for aquaculture purposes.

As per the remote sensing imagery of 2002, the total area covered by *phumdis* in Loktak Lake is 134 sq km. The Central Zone has the largest area under *phumdis* (59.6 sq km) followed by Northern Zone (41.6 sq km) and Southern Zone (33.4 sq km) in decreasing order.

Phumdi Proliferation

Phumdis, in general, have profusely proliferated in the lake. Overall area of *phumdis* in the lake has increased from 116.4 sq km to 134.6 sq km during 1989 - 2002. Map 12 and 14 indicate changes in *phumdi* cover in various zones of the lake. *Phumdis* in the Central Zone have increased at an annual rate of 5.7%. However, the most substantial increase by 18.96% has occurred during 1999 - 2002, which can be attributed to the enhancement of aquaculture activities using *phumdis*. In the Northern and the Southern Zones, area under

Phum huts

phumdis has decreased mainly due to their extraction for *athaphum* purposes. This is more pronounced in Northern Zone as compared to Southern Zone.

Experimental plots were established in the open water area to assess the rate and pattern of *phumdi* proliferation. The studies carried out indicate annual growth in *phumdi* coverage by more than 80% under experimental conditions. It has been further observed that proliferation takes place laterally in the open water area, while in the closed areas, the annual growth and accumulation of debris result in increasing vertical thickness. *Phumdis* grow vertically adding up layers of decomposed and semi decomposed mass of plant material along with silt and other debris.

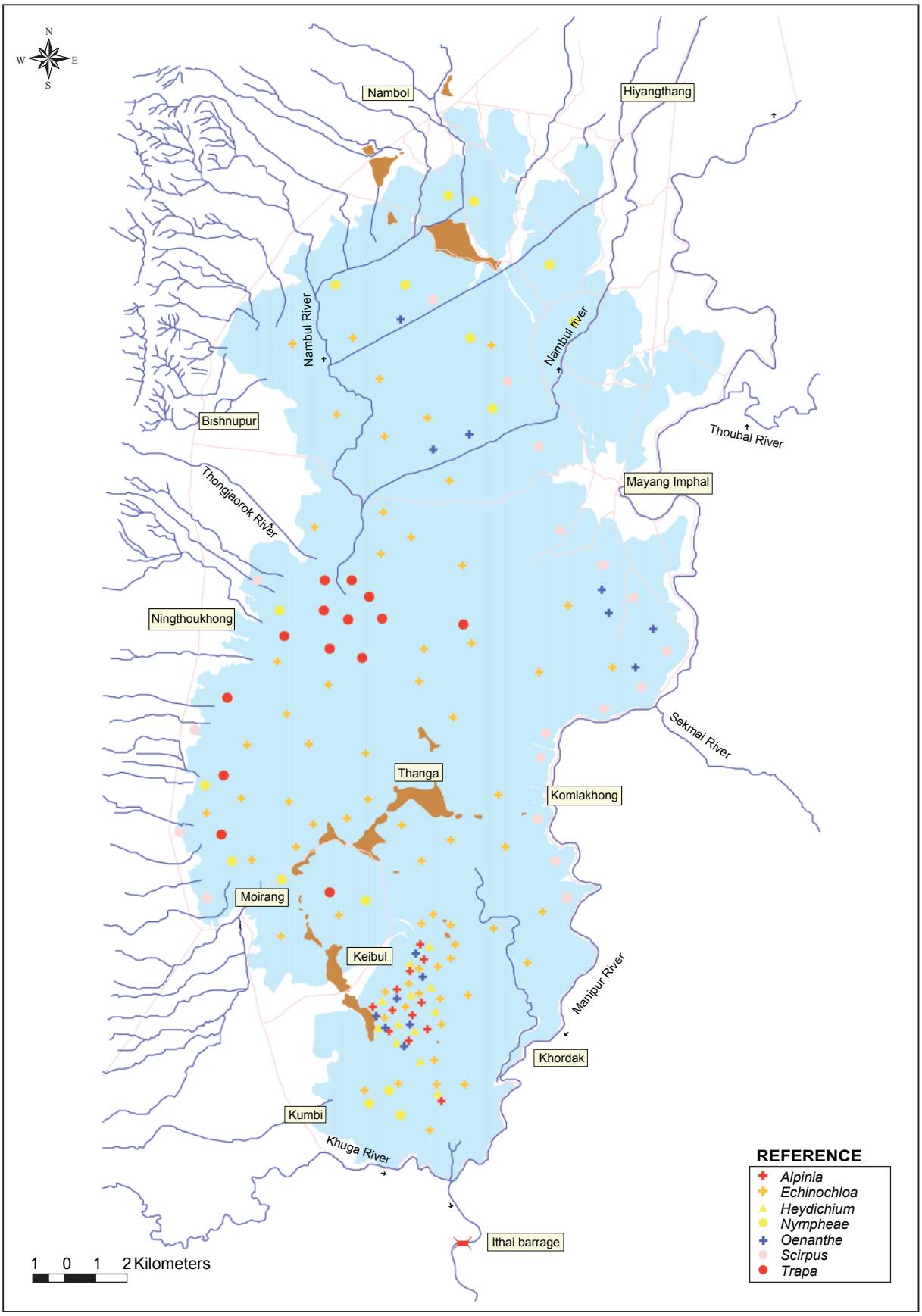
Economically Important Species

Almost all plant species have some economic utility in terms of providing benefits to the people. Overall 132 plant species associated with *phumdis* have been identified which are utilized by the people as vegetables, food, fodder, fuel, thatching, fencing material, medicines, raw material for handicrafts, and for religious and cultural purposes. Distribution of the economically important plants in Loktak is given in Map 38. The main plants species used for such purposes are:

Box 3: *Phumdi* Proliferation in Loktak

(All figures in sq km)

	1989	2002	Net Change (+/-)
Northern Zone	55.0	41.6	(-) 13.4
Central Zone	29.0	59.6	(+) 30.6
Southern Zone	32.4	33.4	(+) 1.0
Total	**116.4**	**134.6**	**(+) 18.2**



Map 38: **DISTRIBUTION OF ECONOMICALLY IMPORTANT PLANT SPECIES IN LOKTAK LAKE**

Food - Twenty three plant species are used for food by the communities of which *Zizania* and *Polygonum, Nelumbo, Euryle, Nympheae, Alpinia, Hedychium, Ipomea* are widely found in the lake and harvested for local consumption as well as income generation.

Fodder - Eighteen plant species are used as fodder. *Echinocloa, Capillipedium, Zizania, Alternanthera* and *Brachiaria* widely distributed in the lake are harvested by the communities as feed for cattle.

Fuel - *Coix, Phragmites* and *Saccharum* species are used as fuel by the communities living in and around the lake especially for fish drying, smoking and cooking.

Construction of hutments - Eight plant species particularly *Arundo, Phragmites, Zizania* and *Saccharum* found in abundance are used for thatching, fencing and hutment construction.

Medicinal - Seventeen species are identified to have medicinal properties of which 4 species viz. *Fuirena, Polygonum, Impatiens*, and *Malaxis,* are found in abundance in Loktak. Rhizomes of *Fuirena umbellata* are used for treatment of fever and jaundice. *Polygonum sp* is used by communities as a health tonic. Rhizomes of *Arundo donax* are used as emollient and diuretic. Flowers of *Eichhornia crassipes* are used traditionally for treatment of skin diseases, particularly those of horses. *Enhydra fluctuans* is used in skin and nervous afflictions. Rhizome of *Hedychium coronarium* are used for stomach and liver disorders as well as for treatment of inflammations. Shoots of *Hedychium coronarium* as well as *Mikania cordata* are used as antidote for snakebites as well as fish poisoning.

Alpinia galanga (Pullei) *used as vegetable*

Vegetable products from Loktak Lake

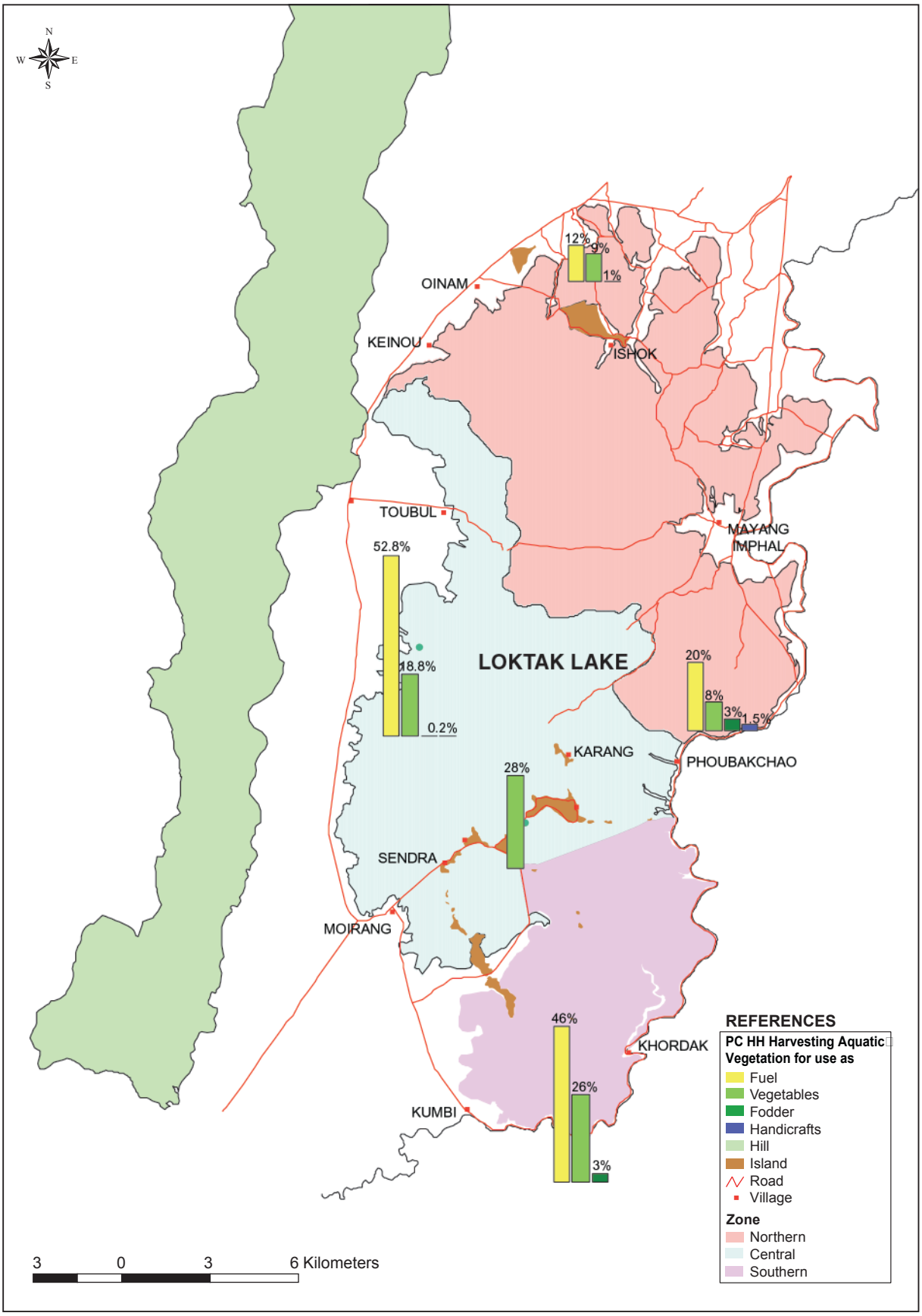
Handicraft - *Cyperus* and *Scirpus* species are used for making mats, cushions, baskets, hats and handicrafts. These products being ethnic are in high demand in other parts of the country.

Cultural - Eleven species are used by communities for several religious and other cultural purposes. Meitei community uses twigs of *Echinochloa stagnina* for worship of their Gods and Goddesses. *Nympheae* and *Nelumbo* species are used in several religious ceremonies.

There is a significant population which harvests aquatic plants from Loktak Lake for different purposes. It has been estimated that 33% of the lakeshore households harvest aquatic vegetation for use as fuel; 18% for use as vegetables; 2% for use as fodder and 1% for manufacturing handicrafts. Annually 15,400 MT of plant biomass is harvested for use as fuel, 1,900 MT for use as vegetables, 230 MT for use as fodder and 40 MT for making handicrafts. Profile of utilization of aquatic vegetation by the communities living in and around Loktak is presented in Map 39.

Threatened Species

Species composition, in general, has slightly changed due to modifications of hydrological regimes and human pressures. *Phragmites karka* that earlier formed



Map 39: **DEPENDANCE OF LAKESHORE COMMUNITIES ON AQUATIC VEGETATION**

thick and tall stands and provided shelter to *Sangai*, is now found stunted in growth. Similarly, several other species including *Cymbopogon nadus, Erianthus arundinaceus, Erianthus procerus, Imperata cylindrica*, which were earlier distributed widely are now confined to some pockets of the lake. *Carex cruciata*, the preferred food plant of *Sangai*, which was earlier a dominant species in KLNP has now become rare. However, some patches of this species are still found in Maibam Phumlak area.

Invasive Species

Eichhornia, Salvinia, and *Brachiaria* are the main invasive species identified from the lake. Biological control measures using two weevil species, *Neochetina eichhorniae* and *Neochetina bruchi* for controlling the growth of water hyacinth was successfully undertaken in Loktak by LDA in 1988 - 89. However, another invasive species, *Salvinia*, taking the advantage of absence of competition and availability of free space has profusely grown in the lake and is a major threat to the natural vegetation.

Brachiaria mutica is another invasive species introduced by the State Veterinary and Animal Husbandry Department in consultation with National Seed Corporation of India, Guwahati during 1972-1973 without undertaking introductory trials. The plant species despite its high fodder value has presently assumed nuisance proportions and is seriously interfering with natural biodiversity of the lake. Its presence in some pockets of KLNP poses a great threat to the plant species preferred by *Sangai* and other wildlife. Distribution pattern of the invasive plants is given in Map 40.

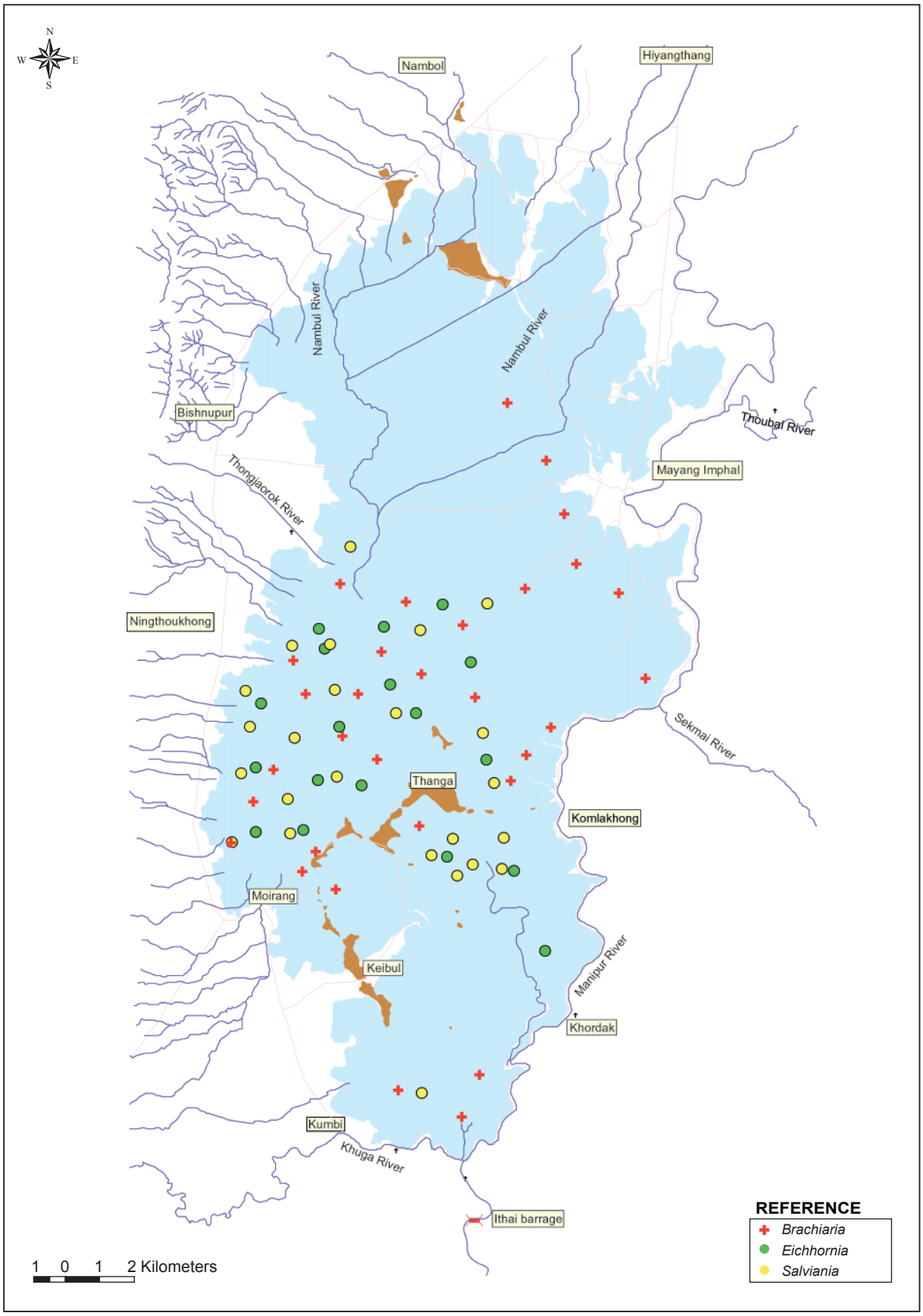
Role of *Phumdis*

Phumdis play an important role in governing ecological processes and functions of the lake ecosystem (Trisal and Manihar, 2002). They influence hydrological regimes, harbour rich biodiversity, support productive fisheries and provide several economically important plant species to the communities.

Phumdis, if not properly managed, pose a great threat to the survival of lake ecosystem. Rapid proliferation of *phumdis* can choke the entire lake area, retard flow of water and natural aeration, accelerate process of eutrophication, make water unfit for various uses, promote water logging and reduce water holding capacity by accelerating sedimentation.

An integrated approach, therefore, needs to be adopted for management of *phumdis* to control its proliferation and utilize it as a resource for economic development. Conservation of *phumdis* in the Northern Zone, which plays a critical role in providing a biological sink to the pollutants brought in by Nambol and Nambul rivers, is extremely important for maintenance of water quality of the lake. Similarly maintenance of thickness and overall health of *phumdis* in KLNP is crucial to the survival of *Sangai* and other wildlife fauna. *Phumdis* can also be utilized as compost, bio fertilizers and several other products, which can provide economic benefits to the people as well as regenerate the health of lake ecosystem. Management of economically important plant species used as food, fodder and fuel by the local communities in different pockets as indicated in Map 37 would help to sustain livelihoods of the people as well as enhance their overall well being.

Nymphaea locally called as Tharo



Map 40: **DISTRIBUTION OF INVASIVE PLANT SPECIES IN LOKTAK LAKE**

KEIBUL LAMJAO NATIONAL PARK

View of Keibul Lamjao National Park

Keibul Lamjao is located in the southeastern part of Loktak Lake between longititude 24°27' to 24°31' N and latitude 93°53' to 93°55' E. It is a unique natural habitat of *Cervus eldi eldi* locally called *Sangai*. The habitat consists of floating *phumdis*, hillocks and elevated strips of land. In its natural habitat *Sangai* lives with other animals such as hog deer, wild boar, large Indian civet etc. The park is rich in fauna and accounts for 81 species of birds, 25 species of reptiles and 22 species of mammals (Singh, 1992). A list of these species is given in Annexures III and IV.

Sangai is a highly endangered species and has been declared by the Government of Manipur as the State Animal. The Wildlife wing of Department of Forest, Government of Manipur has undertaken several measures for conservation and management of wildlife with main focus on protection and enhancing population of *Sangai*.

Protection of *Sangai*

Sangai being the flagship species has a special focus in overall wildlife management. This species has adapted to floating *phumdis* conditions of the Keibul Lamjao. The morphological features of *Sangai* as well as its feeding and breeding habits are briefly described in the Box 4.

Herds of *Sangai* ranging from 200 to 300 were reported widely distributed in the marshes of Manipur in the past (c.f. Dey, 2003). Prior to 1891 this species was preserved by the order of the royal family and any man proved to have killed a *Sangai* had his hands chopped off. However, it was mercilessly poached and in 1951, the Government of Manipur declared that this species had become extinct. But a survey conducted by IUCN in 1953 discovered a few survivors in small pocket of floating park. In response to this, Government of Manipur designated the entire area of Loktak Lake as a sanctuary and closed it for shooting of wildlife.

Subsequently it was realized unnecessary to close the whole area of the lake for shooting as this deprived many sportsmen from geese and duck shooting and consequently in July 1954, the northern portion of the lake was opened to shooting. The southern portion, where the deer existed, was declared as a sanctuary covering 52 sq km. The notification declaring the area as a national park was issued in 1975 followed by final notification in the year 1977 covering an area of 40 sq km. The satellite image of Keibul Lamjao National Park is shown in Map 41.

The declaration of Keibul Lamjao as a National Park has helped to enhance the population of *Sangai* from 14 as recorded in 1975 to 162 in 2000 (Fig.3). The population of other wildlife species, such as hog dear and wild boar, as estimated in 2000 by the Forest and Wildlife Department indicates a population of 144 and 26 respectively.

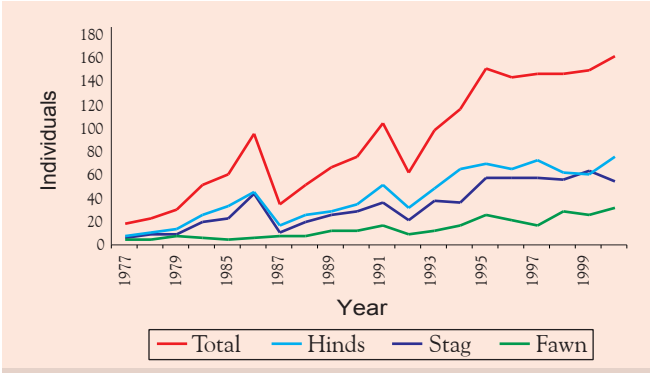
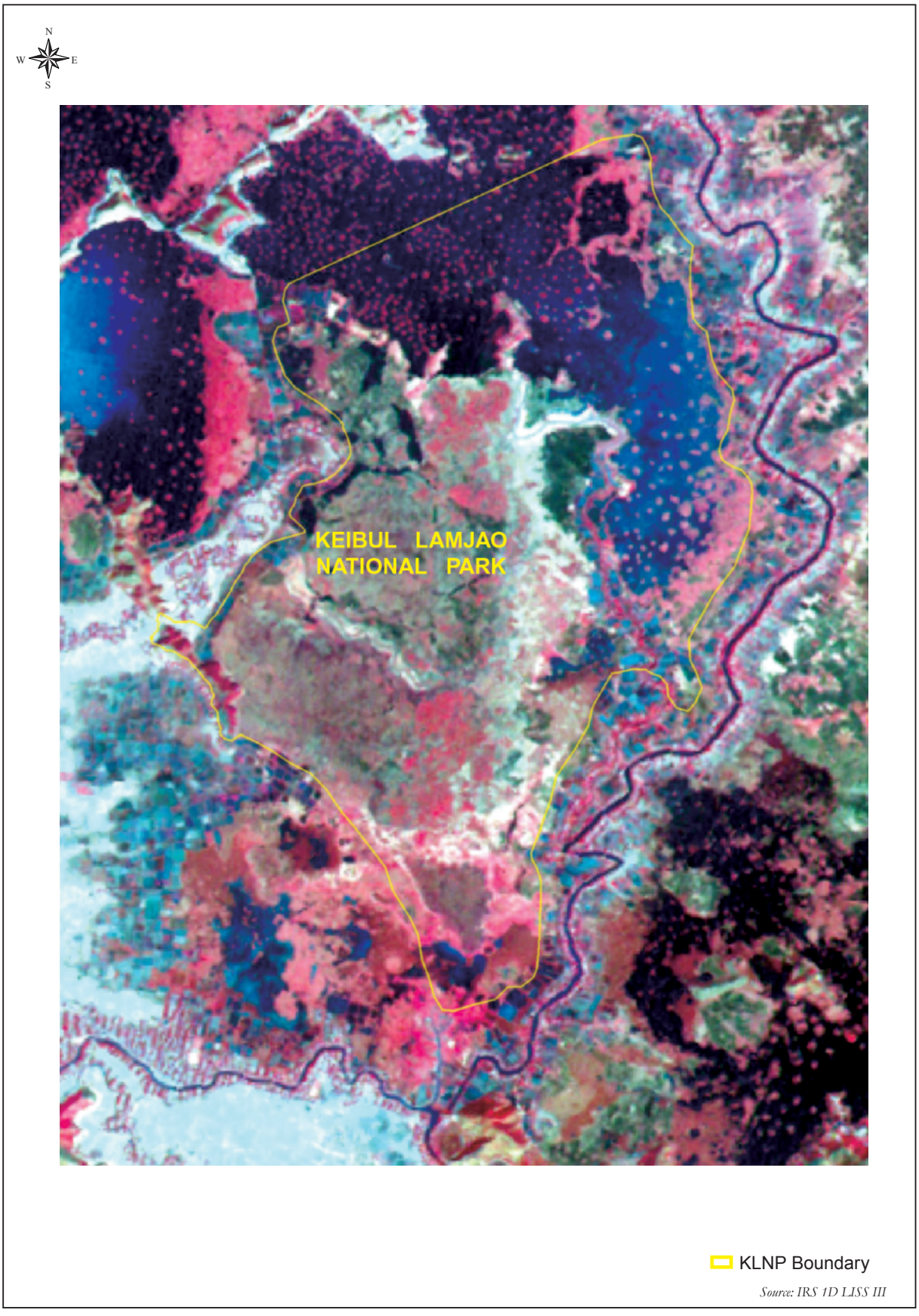


Fig 3: Census of *Sangai* During 1977 - 2000



Map 41: **SATELLITE IMAGERY OF KEIBUL LAMJAO NATIONAL PARK**

Habitat Features

Degradation of the Loktak Lake, particularly after construction of Ithai barrage has seriously affected the park habitat. Maintenance of high water level throughout the year without allowing *phumdis* to settle down at the bottom during part of the growth period has been mainly implicated for decrease in its thickness. Decrease in thickness of *phumdis* has been linked to changes in hydrological regimes by several investigators (Singh, 1994; Prasad and Chhabra, 2001). However, no substantial data was available to authenticate this hypothesis.

Under SDWRML project, a detailed survey of KLNP was undertaken in collaboration with the State Wildlife Department, NGOs, local school students and experts from hydrology, remote sensing and GIS, botany, limnology, wildlife, fishery and community development. The main objective of the survey was to assess habitat characteristics of the park and develop strategies for management planning. The study resulted in establishment of an extensive database on various hydrological, ecological and socioeconomic aspects. Based on the data collected, assessment of habitat characteristics, strategies for management of KLNP have been developed.

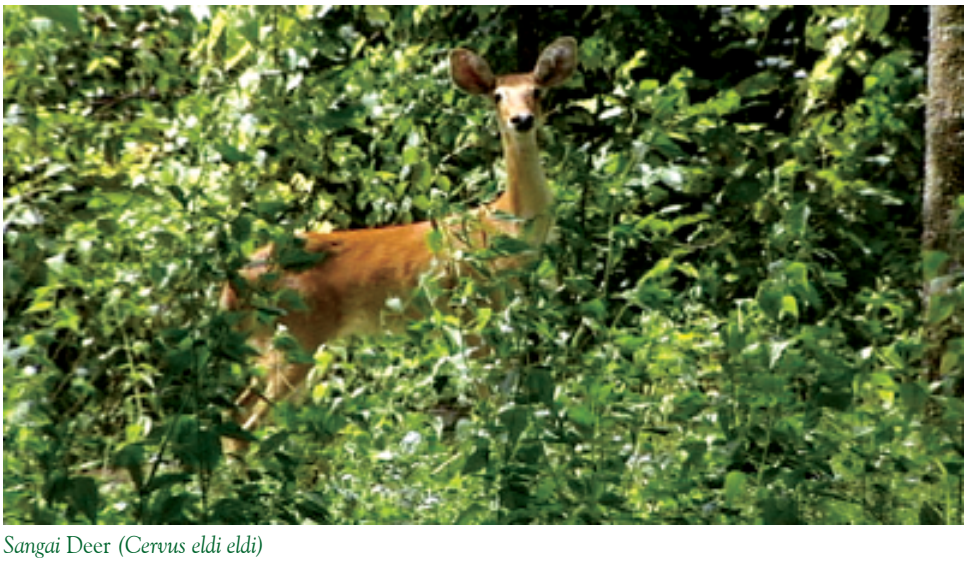
Zonation

The elevation of KLNP as per bathymetric survey ranges from 764 to 769 m above MSL. The average water depth is approximately 3m. Overall the water level in KLNP during the lean season is higher by 0.5m as compared to that of the main lake. The thickness of *phumdis* in the park varies drastically in various sectors (Map 42). The park, therefore, can be divided into following three zones based on the *phumdi* thickness and other features:

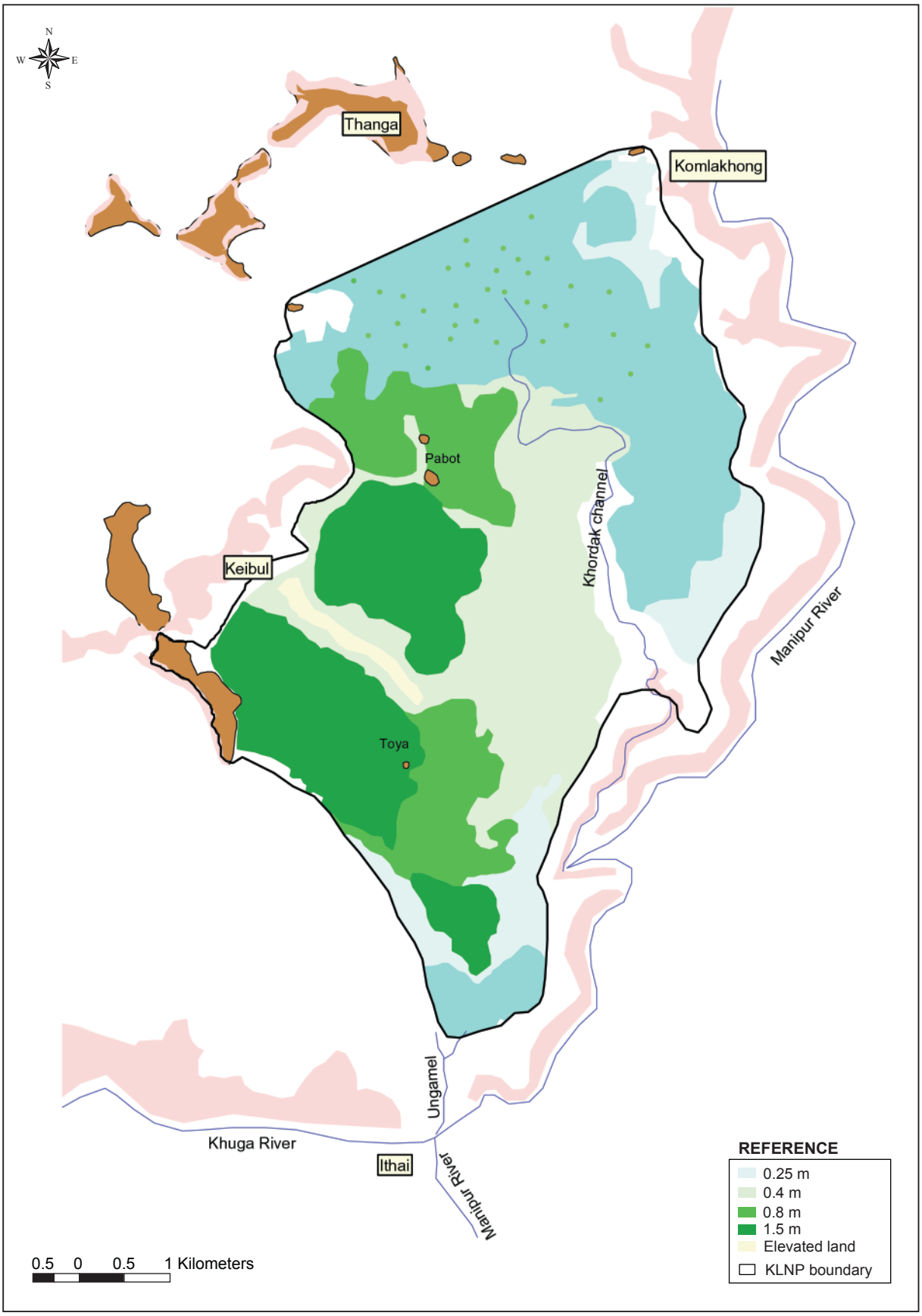
(i) Western Zone: This zone is covered with two thick chunks of *phumdis*, and forms the main habitat of *Sangai*. In between two chunks of *phumdis* there is an elevated portion called Thangbrel yangbi. During lean season it gets exposed and is an important place for breeding of *Sangai*. This area is occupied by thick vegetation mainly comprising emergent species such as *Oryza rufipogon* (wild paddy species), *Capillipedium sp.* and *Dactyloctenium aegypticum*. Pabot and Toya hills which are located in the northern and southern parts of this zone are extremely important as shelter and resting places for *Sangai*. Sagram, Keibul, and Chingmei are main villages bordering this zone.

(ii) Eastern Zone: This zone extends from Nongmaikhong village to end of Khordak channel in the east and Pabot and Toya hills in the west. It is mainly covered by thin *phumdis* intermixed with thick growth of plant species such as *Sachharum, Zizania* and *Phragmites*.

(iii) Northern Zone: It extends from Keibul hill to Chingthi hill in the northern side and from Komlakhong village to Laphupat Tera in the eastern side. This zone is an open water area, relatively deeper and covered with thin *phumdis*. Nearby villagers practise *athaphum* fishing in this zone.



Sangai Deer *(Cervus eldi eldi)*



Map 42: **THICKNESS OF PHUMDI IN KEIBUL LAMJAO NATIONAL PARK**

Zizania latifolia (Kambong) in KLNP

Vegetation

The highest number of 132 plant species recorded in Loktak are found in KLNP comprising aquatic, semi-aquatic and terrestrial species. The composition of *phumdis* in the park varies due to varying ecological factors. *Zizania latifolia, Phragmitis karka, Echinochloa stagnina, Saccharum munja, Cyperus sp., Salvinia sp., Brachiaria mutica, S. bengalensis, Eiranthus procerus, Dioschoria bulbifera, Cynodon dactylon, Alpinia galanga, Eichhornia crassipes, Hedychium coronarium, Nelumbo nucifera,* and *Capillipedium sp*. are dominant species in the park (Map 43).

Overall composition of plant species in KLNP has slightly changed. Gee (1960) reported maximum relative density of *Phargmitis karka* (45%) in species composition of *phumdis* followed by *Narenga porplhyrochroma* (25%), *Saccharum munja* (15%) and other species viz. *Z. latifolia, Alpinia allughas* and *E. procerus* in the range of 2 to 5 %. Shamungou (1999) has suggested that the proportion of fodder and shelter grasses in the park should be maintained in the ratio of 58 and 42. He observed that shelter plants during their studies in 1996 had reduced to 35%. The study carried out by SDWRML has also indicated considerable decrease in the shelter plants. There is significant change in the composition of the *phumdis,* which is very prominent with respect to *Phragmites karka, Zizania latifolia* and *Saccharum munja* which constitute favourite food of *Sangai* and also provide shelter to the species.

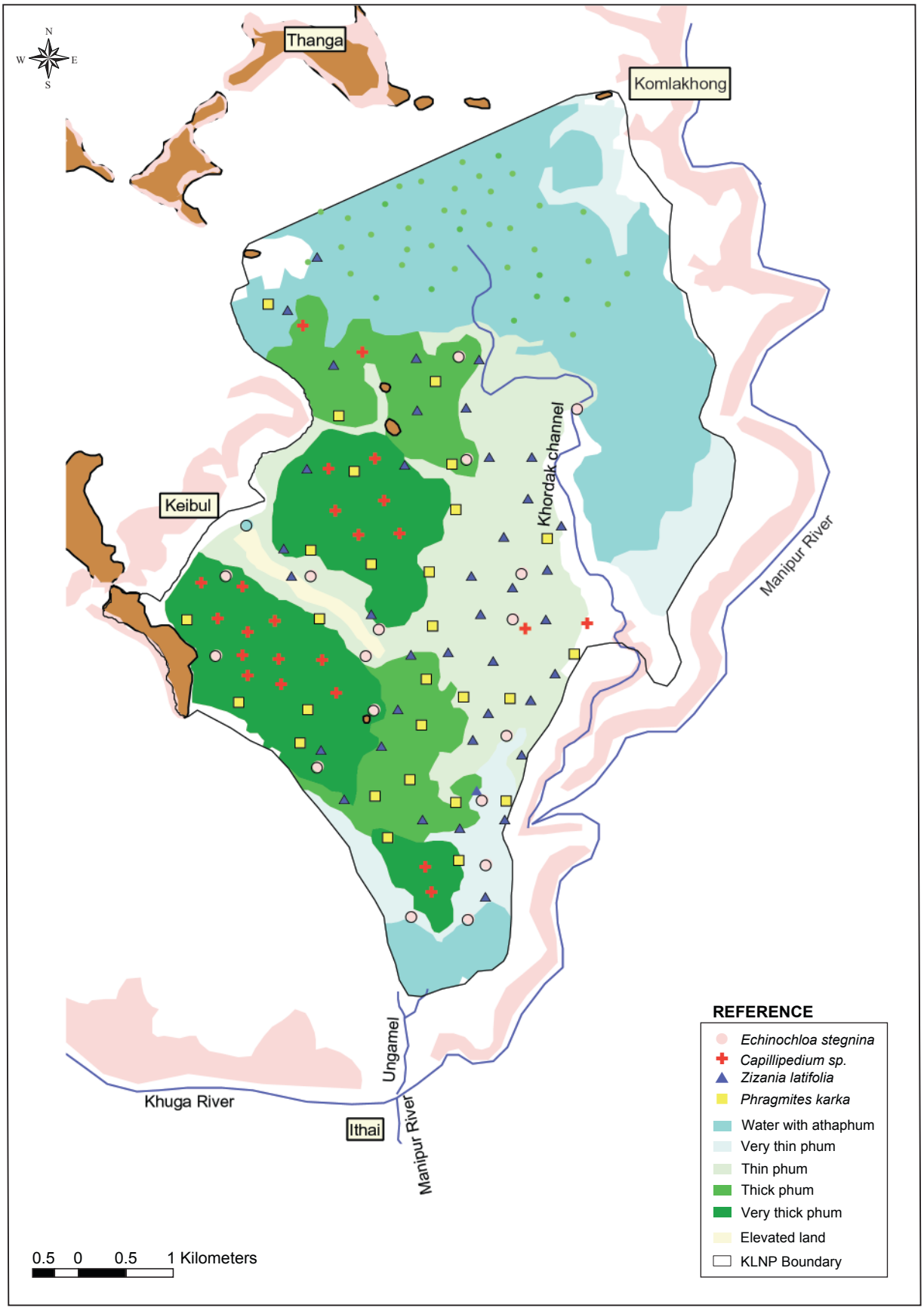
In general, *Phragmites* dominated areas having very thick *phumdis* (average thickness 1.5m) and *Saccharum* dominated areas have thin *phumdis*. Paragrass of all types were found generally associated with thin *phumdi* areas. The stunted growth of cover plants such as *Phragmitis* providing protection to wildlife is a matter of serious concern. Paragrass, unless controlled in the peripheral and central zone can pose a great threat to the biodiversity of the park due to its gregarious growth.

Fish Diversity

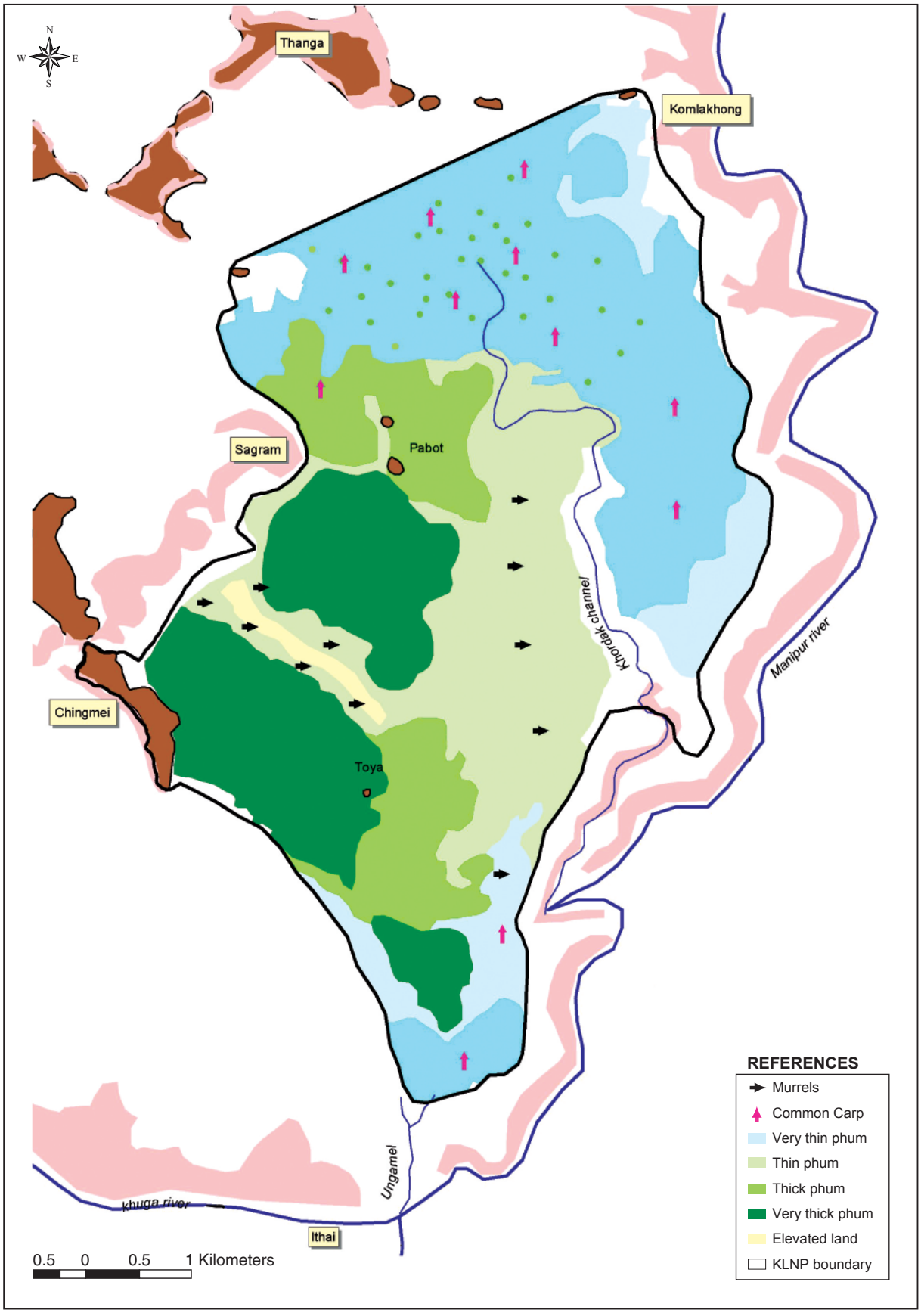
Overall 21 fish species representing 8 families have been identified from different location of KLNP of which *Channa sp.* (Murrels), *Cyprinus carpio* and *Ctenopharyngdon idella* are dominant.

Some probable fish breeding grounds have been identified in KLNP area (Map 44). Shoals of fries and fingerlings of air breathing fishes *(Channa orientalis, Channa striatus, Channa punctatus)* and common carps *(Cyprinus carpio)* have been observed in the park.

A view of Keibul Lamjao National Park



Map 43: **DISTRIBUTION OF DOMINANT PLANT SPECIES IN KEIBUL LAMJAO NATIONAL PARK**



Map 44: **FISH BREEDING AREAS IN KEIBUL LAMJAO NATIONAL PARK**

Water Quality

Microbiological analysis of the water indicates severe pollution in most parts of the park. High values of standard plate count for bacteria (74,000 - 97,000) have been observed in the park. Microbial analysis of MPN of coliform bacteria vary between 105 and 311 / 100ml and faecal coliform 92 and 180/ 100ml.

The pH values, in general, vary between 3.8 and 8.5 (Map 45). Low pH values have been found in and around core zone area with poor flushing pattern. Lower pH in core zone is a matter of concern due to its effect on uptake of nutrients. The acidic conditions may lead to changes in microbial population generally implicated for degeneration of *phumdis*. This needs further investigation under controlled conditions.

Free CO_2 concentrations vary between 2 and 54 mg/l at the surface and 7 and 64 mg/l at the bottom (Map 46). Higher concentration of CO_2 and lower concentration of DO (Map 47) indicate higher rates of respiration and decomposition over primary productivity. This may be due to the fact that most of the areas are covered by *phumdis* thereby blocking light penetration required for photosynthesis as well as exchange of gases.

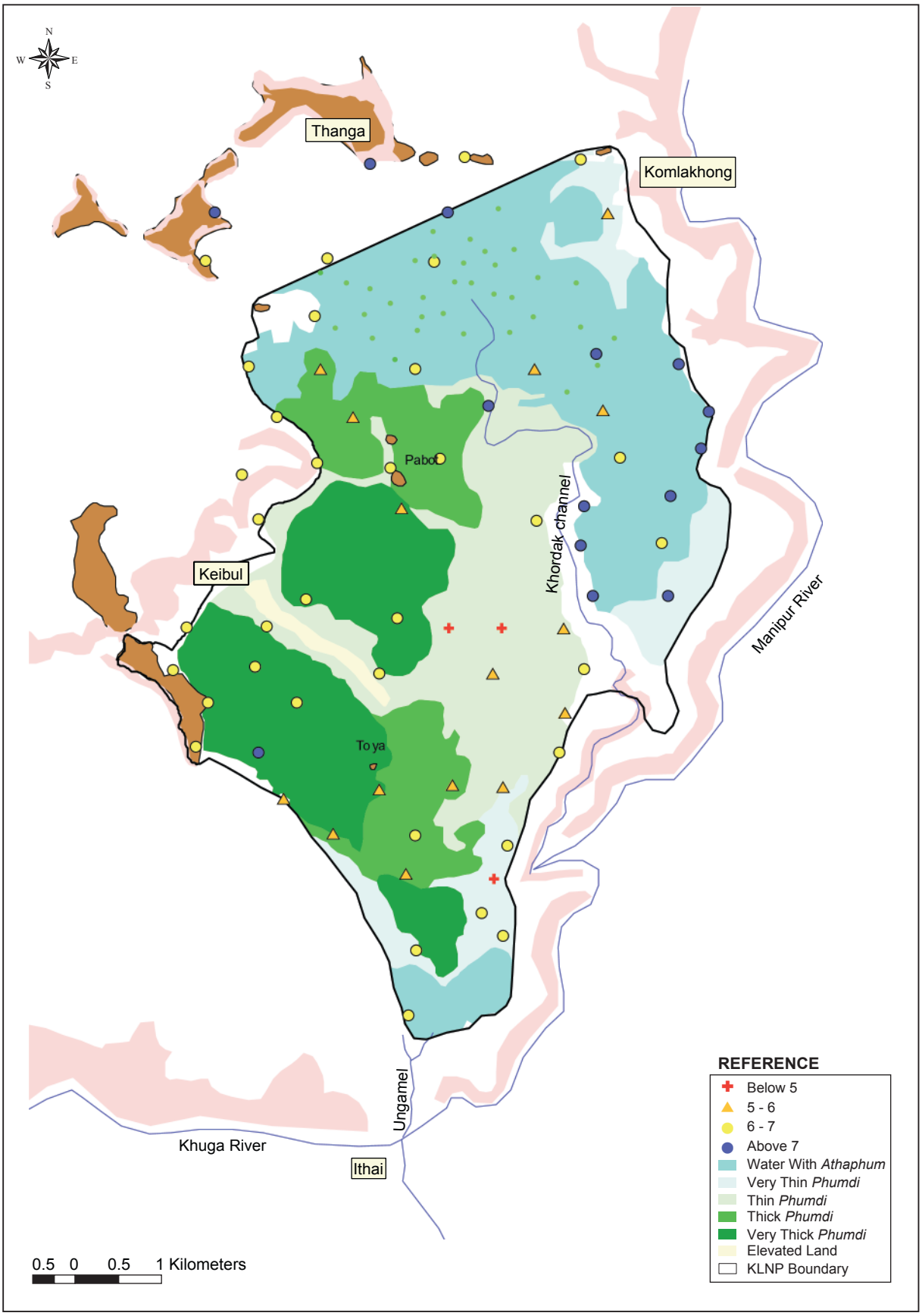
Habitat Improvement

Studies carried out under SDWRML project has indicated that the changes in hydrological regimes by construction of Ithai barrage have led to degradation of KLNP. The population of *Sangai* is threatened due to changes in habitat characteristics. The protection measures undertaken by the Wildlife wing of Department of Forest, Government of Manipur have led to increase in population of the species. However, for long term management of the park, the problems of habitat degradation have to be addressed by integrating hydrological, ecological and soico-economic aspects. The measures recommended for habitat improvement are :

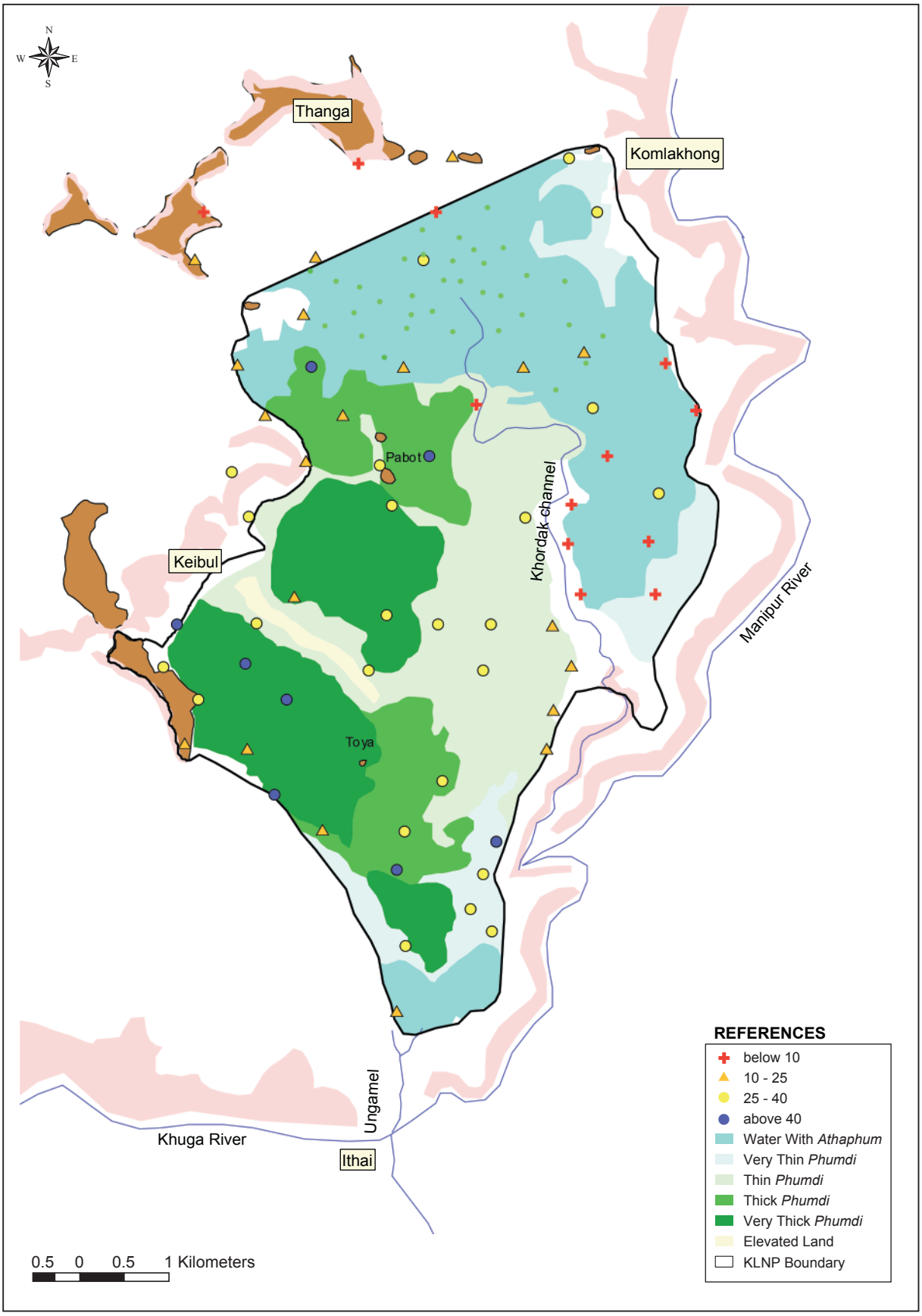
Delineation of Management Zones

Based on habitat features, KLNP may be broadly delineated into three zones: (i) core zone, (ii) core extension zone, and (iii) eco-development zone. Core zone with *phumdi* thickness of more than 1m is an ideal habitat for *Sangai*. However, this zone is presently confined to western part of the park, needs to be further extended to the eastern zone to allow free movement of *Sangai* and other wildlife. In the core extension zone, activities like raised earthen platform, plantation of food and shelter species, providing bridges over regular streams for crossing of animals from one zone to another and placement of salt licks may be undertaken. The ecodevelopment activities in this zone already identified by the Forest Department may be intensified. Ecotourism may be promoted as part of the ecodevelopment activities to generate awareness about the values of the park and providing additional revenue through community involvement.

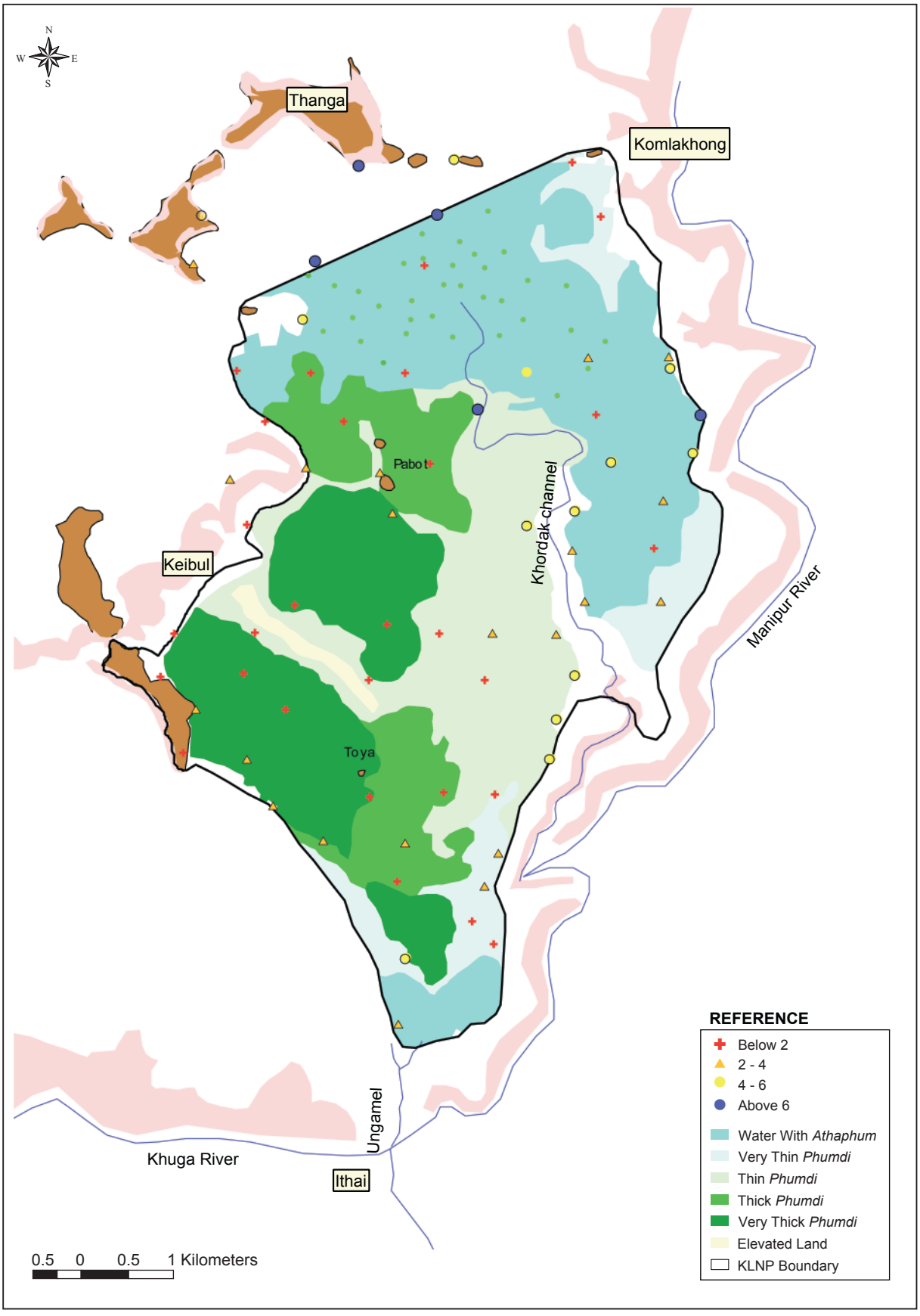
Water Quality Monitoring in KLNP



Map 45: **pH IN KEIBUL LAMJAO NATIONAL PARK**



Map 46: **FREE CARBON DIOXIDE (mg/l) IN KEIBUL LAMJAO NATIONAL PARK**



Map 47: **DISSOLVED OXYGEN (mg/l) IN KEIBUL LAMJAO NATIONAL PARK**

Water level monitoring station in KLNP

Optimizing Water Regime

One of the major issues of the park is thinning of *phumdis* due to reduced nutrient supply by remaining afloat throughout the growth period. This interferes with uptake of nutrients particularly under prevailing acidic conditions. Fluctuation of water level is an important factor which allows *phumdis* to settle at the bottom and derive nutrients from the nutrient rich bottom sediments during the growth period. The level of water in the park during December - January should be maintained at 767.5m to allow *phumdis* to strike roots in the soil for proper nourishment and growth, as well as drying and compaction of upper exposed portion. Luxuriant uptake of nutrients is an adaptive advantage of macrophytes during early growth period and oxygenation of sediments through transport of oxygen from aerial parts to the root zone. This will also help enhancing pH values to alkaline range through reoxygenation of bottom sediments. *Phumdis* settling at bottom will help providing appropriate habitat to *Sangai* during December to February which is the rutting period of this species. Construction of a regulator at Ungamel channel will help in restoration of fluctuating water levels for the nourishment of *phumdis* and movement of *Sangai* during breeding period.

Water Quality Improvement

Flushing during monsoon and manipulating water level fluctuations will considerably help water quality improvement by flushing out of pollutants and process of reaeration. Minimizing waste disposal at source through community participation and promoting low cost sanitation programme, particularly in and around the southern zone, will help control discharge of solid wastes and sewage into the park.

Regeneration of Food and Shelter Plants

Regeneration of food and fodder plant species to restore habitat for *Sangai* needs to be undertaken during low water level phase by using appropriate techniques. This could be done by aerial seeding and transplantation of food and fodder species using standard techniques of plantation.

Provisions of Alternate Habitat

Since a single population of *Sangai* is fraught with the danger of getting wiped out by epidemic, natural calamity, political instability and arson, a second home of the species is required to be located, preferably in and around the Loktak Lake. Maibam Phumlak has been identified as an additional habitat of *Sangai* deer (Dey, 2003).

Awareness Generation

KLNP is of great tourist interest due to its unique biodiversity. Several NGOs and local clubs are involved in conservation of *Sangai* and KLNP. *Sangai* Protection Forum with the network of other NGOs has been working on conservation of *Sangai* for last several years and has successfully controlled poaching of *Sangai* in the park. The Wildlife wing of Department of Forest, Government of Manipur should aim at synergizing these activities to promote conservation of the park. The feasibility of application of communication, education and public awareness programmes as highlighted by Ramsar Convention should be assessed for its application to generate awareness about the values and functions of the ecosystem and providing alternate incomes to the communities in an organized manner. Mainstreaming sustainable development within awareness generation programmes needs to be undertaken.

Capacity Building

Conservation and management of KLNP essentially involves protection of wildlife, habitat improvement of the park and reducing pressures by providing alternate income generation opportunities to the people around the park. The solutions for long term management have to be based on scientific management involving local communities at all levels. Currently the park managers are trained in traditional wildlife management with the focus on protection of flagship species without taking into consideration habitat characteristics that are governed by complex hydrological processes. The capacity of the park managers has to be built up to meet these challenges.

For capacity building specific training programmes on integration of hydrological aspects into wildlife management, techniques of maintaining the vegetation for threatened wildlife and improving habitat by interventions based on ecological principles. The infrastructure for analysis of habitat features and wildlife management needs to be built up on priority basis.

Ecodevelopment of peripheral areas

The core zone should be insulated against all commercial and destructive activities and accorded priority for protection of endangered species. Participation of local communities for conservation and protection of wildlife is critical to the management of KLNP. Livelihoods improvement of the local communities will ensure their continued participation. Realizing this, the state government of Manipur has already undertaken several measures for ecodevelopment of the area to provide alternate income generation activities. The broad strategy for ecodevelopment should include following activities :

- Generation of biomass resources outside the protected area, which the local communities used to collect from the area before declaration as a national park.

- Providing alternatives for energy requirement by substituting use of fuelwood by non-conventional energy sources such as biogas, solar cooker and solar lanterns.

- Efficient utilization of biomass through installation of smokeless *chullah*, fuel efficient stoves etc.

- Development of indigenous skills and practices like apiculture, pisciculture, horticulture, mushroom cultivation, weaving of handicrafts and other cottage industry products which are eco friendly.

- Development of social infrastructure including drinking water supply, mobile medical camp, veterinary care, nature camps, education and recreational facilities.

Monitoring

Participatory approaches involving local communities and forest staff should be adopted to control poaching in the park and protection of wildlife. Controlled burning of grasses in early winter, making of inspection channels, maintenance of watch towers are some of specific measures to be undertaken as per requirement.

Monitoring of habitat features using key indicators and periodic assessment of the impacts of strategies adopted should form the base for future management of the park.

Sangai in Keibul Lamjao National Park

Box 4 : *Sangai* in Keibul Lamjao National Park

Sangai, the Brow antlered Deer of Manipur, *Cervus eldi eldi* is one of the three sub species of Elds deer in the world confined to Southeast Asia. Myanmar's brow antlered deer or Thamin *(Cervus eldi thamin)* in upper and lower Myanmar as well as Western Thailand and Siamese Brow antlered Deer (*Cervus eldi siamensis*) found in Eastern Thailand and on the Hainan islands are the other two sub species (Khan, Parasad and Mathur, 1992). All the sub species of Elds deer are highly endangered. It is believed that these three sub species originated from a single species, *Cervus eldi siamensis,* which was initially confined to Thailand and then migrated to Myanmar. Over a period of time some of its physical characteristics were modified after which it came to be known as *Cervus eldi eldi*. This species is especially adapted to their characteristic *phumdi* habitat. The deer has divided hooves and its pasterns are greatly elongated unlike those of other related deer species. Therefore, the animal can walk conveniently over the quaking surface.

Cervus eldi eldi is a medium sized deer with uniquely distinctive antlers, measuring 100 to 110 cm in length with an extremely long brow line which forms the main beam such that the two form a continuous curve at right angles to the closely set pedicles. The forward protruding beam appears to come out from the eyebrow signifying its name, Brow antlered Deer. The antlers of the opposite sides are unsymmetrical with respect to each other. The beams are unbranched initially whereas curvature increases as length increases and they get forked also. The sexes are moderately dimorphic in body size and weight. The height of a fully grown stag may be approximately 115 to 125 cm at shoulder level weighing approximately 95 to 110 kg. The female is shorter with lesser weight as compared to its male counterpart. The length of the body from base of the ear upto its tail is about 145 to 155 cm for both the sexes. The tail is short and rump patch is not pronounced.

Sangai gets sexual maturity in the fourth year and survives for approximately 16 years. The rutting period is from late January to April. Normal gestation period is 245 to 273 days. It breeds only once in a year with breeding lasting from September to December. A female delivers only one fawn at a time. The young fawn takes 2 to 3 weeks to start walking. Usually it uses an old destroyed nest of wild boar for hiding young ones till it starts walking. Before commissioning of hydro-electric project during rutting period *phumdi* used to settle down on the ground and higher and dry areas of Thangbrel Yangbi provided an ideal breeding site.

COMMUNITIES AND LIVELIHOODS

Fisherman of Loktak

Communities living in and around Loktak Lake are directly or indirectly dependent upon the lake resources for sustenance. The lake serves as an important source of various resources including fisheries, vegetation and water. Lake degradation leading to decline in these resources has directly impacted the livelihoods of the local communities. Therefore, proper understanding of the relationship between lake resources and community livelihoods is critical to management of the lake.

Human activities in the catchments are linked with the changes in the lake ecosystem. Sustainable management of Loktak Lake emphasizes on regulating human activities within catchments to maintain the ecological processes, functions and attributes of the wetland ecosystem while ensuring economic security of the communities. Sustenance of lakeshore communities is linked to the activities taking place in the catchments.

SDWRML project has a focus on community based management of Loktak Lake through their participation at all levels and in all sectors of management. A brief profile of the communities living in and around Loktak Lake and their resource linkages and overall planning is highlighted in this section for management of the lake ecosystem.

Community Profile

Demographic features

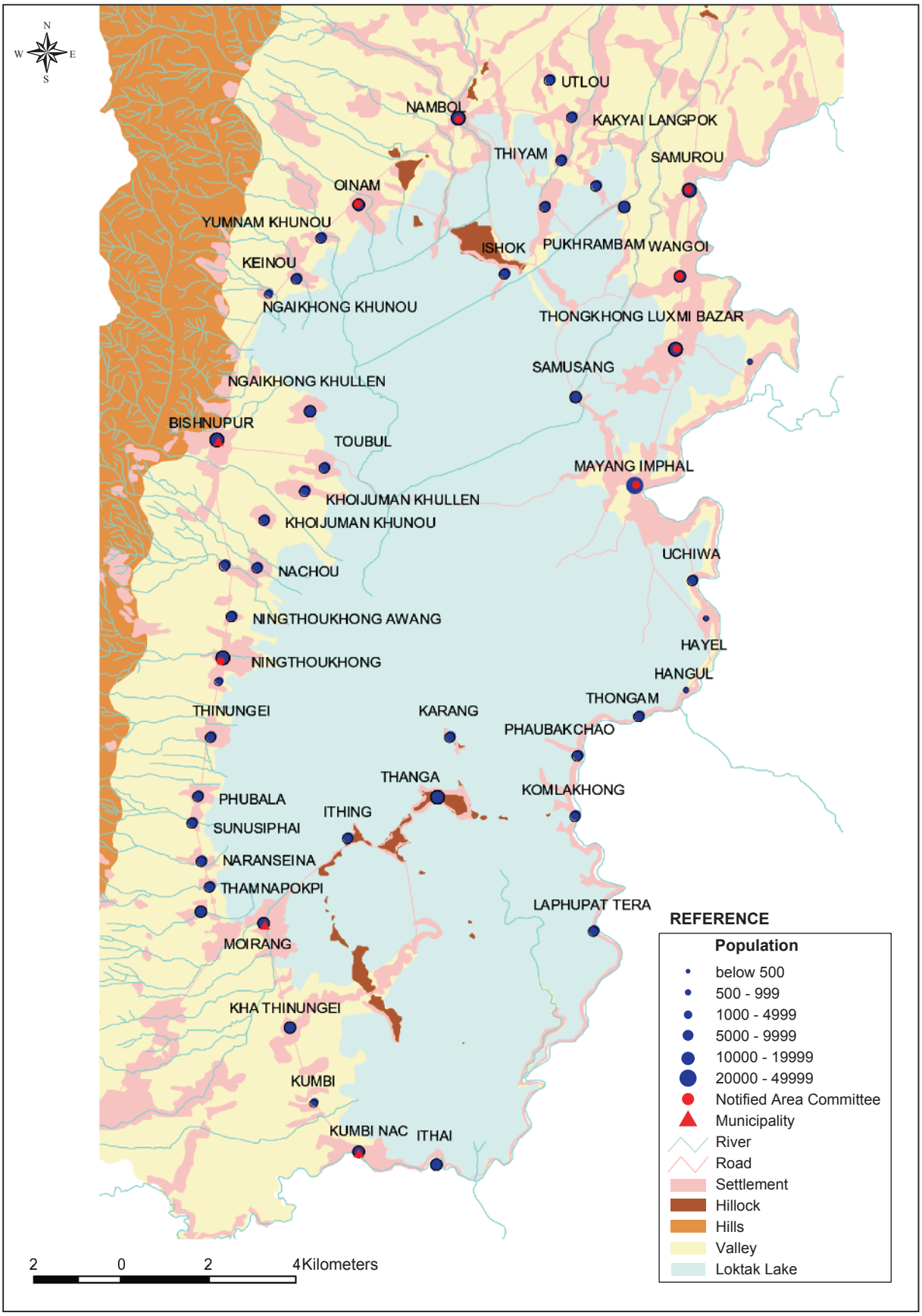
Overall 53 settlements in and around Loktak located in the valley districts of Bishnupur, Imphal East and Thoubal are directly or indirectly linked to the lake. The total population of these communities in 2001 was 279,935 which accounted for 12% of total population of Manipur. Map 48 describes the locations and population distribution of settlements in and around Loktak.

About half of the lakeshore population (47%) resides in 10 towns, the rest being sparsely distributed in 43 villages in and around the lake. The western zone accounts for 33% of the total population followed by 29% in the eastern, 21% in northern and 10% in the southern lakeshore villages in decreasing order. Seven percent of the valley population lives in the three islands located inside Loktak. As per a survey carried out under SDWRML project in 2001, there are 1977 *phum* dwellers inhabiting 733 *phum* huts located inside the lake.

There are 96 villages in Loktak catchment located in the two hill districts of Churchandpur and Senapati, with total population of 50,263 as per census survey of 2001, which forms 14% of the total hill population of the state. These communities comprise 29 tribes, which can be broadly divided into Naga and Kuki.

Social Amenities

Access to basic social amenities as primary education, medical facilities, markets and roads vary in the region. The hill communities have very limited access to these amenities and are mostly dependant on the nearest valley village for these facilities. The primary education facilities are fairly high in the valley region, with 83% of the valley villages having primary schools. However, higher education facilities are available only in the 4 towns situated in the northern, western and southern lakeshore villages. Access to medical facilities is very limited in the entire region. As per the 1991 census, there were only 2 primary health centers and 13 sub centers in the lakeshore villages with only 30% of the population having immediate access these facilities. The *phum* dwellers due to their floating settlements also depend on the nearby lakeshore village for basic social facilities.



Map 48: **POPULATION DISTRIBUTION OF LAKESHORE VILLAGES IN AND AROUND LOKTAK**

Adequate sanitation facilities, in general, are lacking in the entire region. Only 26% of the population living in and around Loktak have proper facilities of sanitation. The situation is more critical in the southern lakeshore and island villages, where 93% and 89% of the population respectively has no access to proper sanitation facilities. This leads to high amount of human wastes being discharged to the water bodies. Similarly access to safe drinking water facilities is critical in the southern and eastern lakeshore villages, where less than 20% of the population are provided with safe drinking water facilities. Map 49 presents the status of sanitation and drinking water facilities in the lakeshore region.

Although communication networks exist in almost all areas in and around Loktak, the western and the southern regions have better road network as compared to other regions. Most of the larger markets are also located in these regions.

Gender Relationships

Women in the villages around Loktak, as in the rest of Manipur, dominate in social and economic activities as compared to women in the rest of the country. Unless limited by economic opportunities, the girl child is given equal opportunity to study atleast till a certain age. However, women, in general, have a very hard life as they also take responsibility of key economic activities like fishing, gathering and selling vegetables and agriculture. They are also actively engaged in agriculture plantation, field preparation, fish farming and other activities. Being skilled in handicrafts, women undertake preparation of traditional fishing gears, an activity which has been severely affected by increased usage of *athaphums* and nylon nets from Myanmar. The responsibility of marketing of all products, including fish and vegetables, rests largely with the womenfolk. In the eastern lakeshore villages, women also work as labourers. A difference in status of women, especially their participation in decision making is observed within the hill communities. The ethnic groups are mostly patrilineal and have extreme patriarchial practices. Traditionally women in the hills do not have any property rights and cannot inherit property or assets. They do not participate in village meetings and are not eligible as Village Authority members.

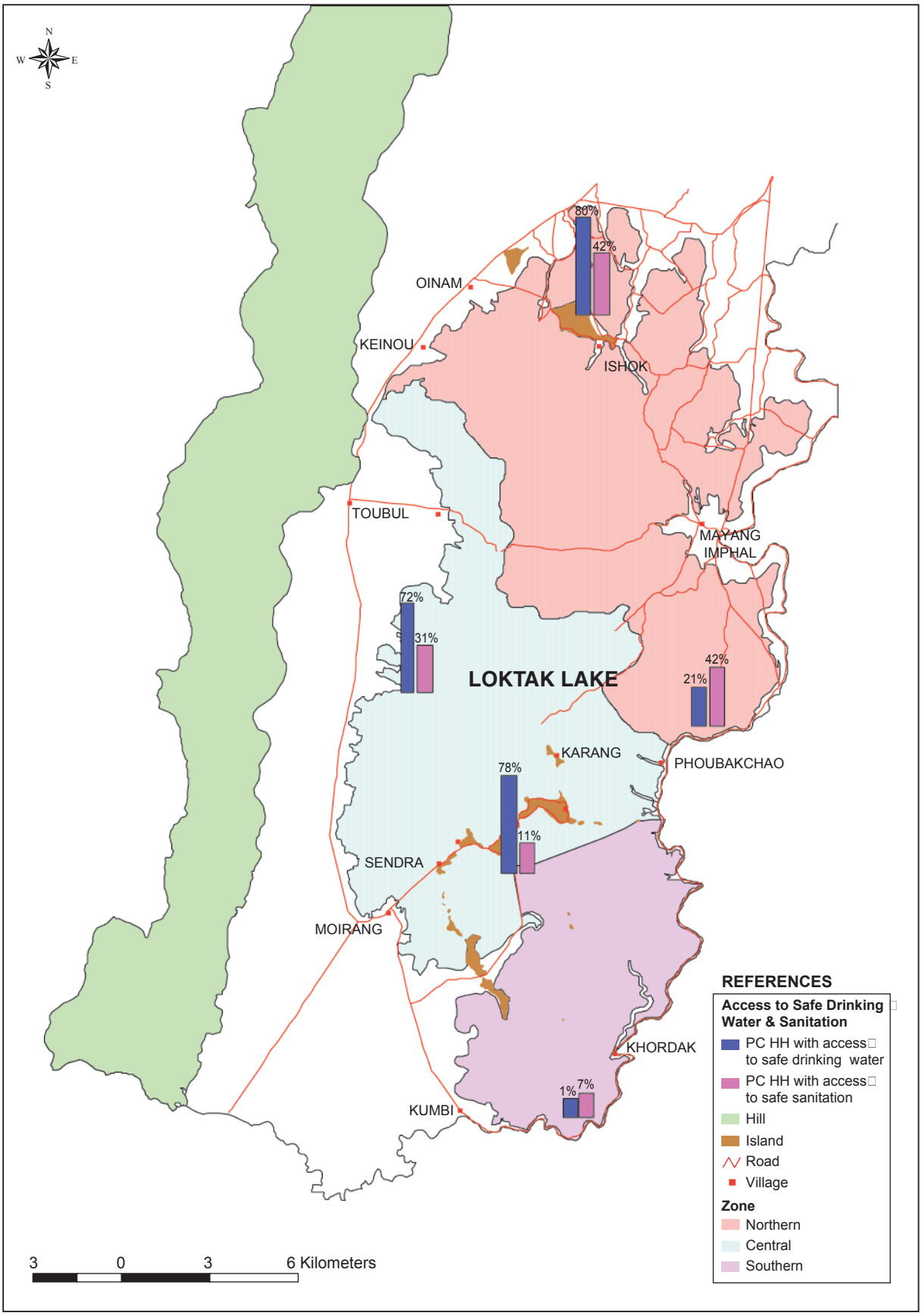
Economic Activities

Economic activities of the communities living in and around the lake and its catchment are dependent on their livelihood options from the lake resources. Primary occupation of the hill communities is agriculture which is predominantly shifting cultivation. Low returns from agriculture coupled with limited livelihood options lead to high occurrence of poverty, with 65% of the households falling below poverty line.

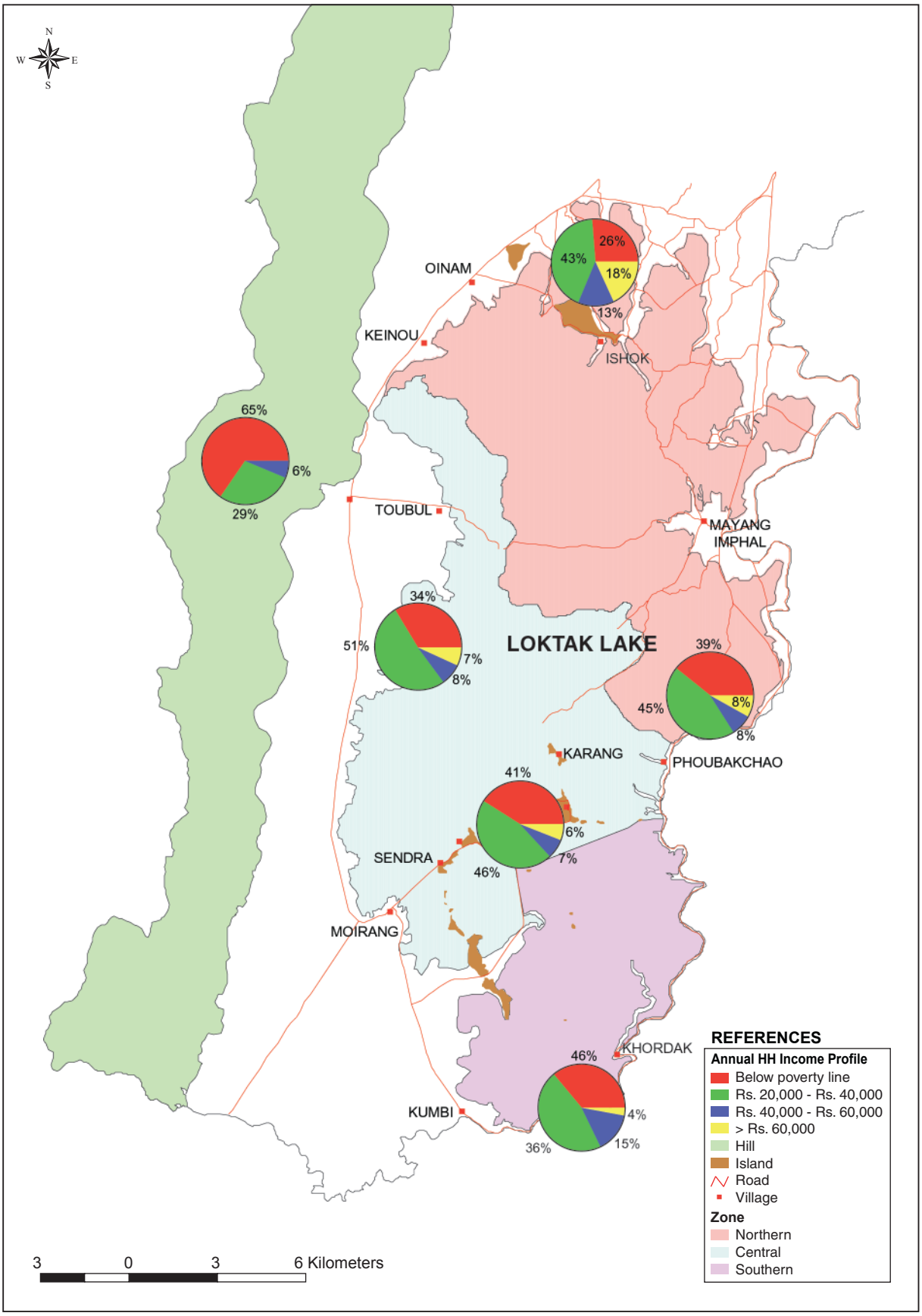
Sustenance of the communities living around the Northern Zone is mainly derived from agriculture with 45% of the households engaged in this activity. This zone also has the highest number of fish farms. A combination of highly productive agriculture coupled with good revenue from fish farming accounts for the highest annual household income, Rs. 45,212, and lowest proportion of population under poverty line (26%) in this region. Similarly, agriculture is the primary occupation of 61% of the households living in the western zone. The region also has high agricultural productivity. However, high population pressure has led to lower annual household income (Rs.30,790) as compared to Northern Zone.

A fisherwoman smoking fish

Communities living in the eastern and southern lakeshore villages practise a mix of fisheries and agriculture. Agricultural productivity, in general, is low due to high occurrence of floods in these regions. Income from fisheries is also not very significant due to declining fish yield and increasing population pressure. About 39% of the households living in these zones are Below Poverty Line (Department of Economics & Statistics, 2000). Communities living in the islands have very limited options of livelihood, and largely depend on lake fisheries and vegetation for sustenance.



Map 49: **SAFE DRINKING WATER AND SANITATION FACIILITIES IN LAKESHORE AREA**



Map 50: **INCOME DISTRIBUTION**

Rapid population growth and declining fish yield are primary causes for poverty within these communities. Athaphum fishing is practised by 54% of the households to augment incomes. Maps 50 and 51 provide the occupational and income profile of the communities. A profile of agricultural activities in the region is presented in Map 52.

Community Institutions

Village panchayats are the primary units of administration in the lakeshore villages. Liekei, informal village bodies play an important role in taking decisions in village affairs. In several areas fishermen groups have been formed which lease specific areas of lake for fishing and later on collect charges for fishing or construction of *athaphums*. There are several NGOs, CBOs and youth clubs, which undertake developmental activities at village level. Marups or informal savings credit groups are important part of all societies, providing credit in times of need. Meira Paibis are prominent women organizations of the society, which play an important role in ensuring women's participation in economic, social and political spheres of daily life and in safeguarding their rights. In the hills, the village authority or village chief is the main administrative unit responsible for development, administration, arbitration in conflicts, and apportioning of common resources amongst some tribes. Besides, youth clubs, agriculture clubs, churches, and marups are important institutions in the hill regions.

Impact of Wetland Degradation

The degradation of lake ecosystem has led to several impacts on the livelihoods of a large population depending on the various lake resources for sustenance. Some of the key impacts of lake degradation on the communities are:

Phumdi removal by local communities

Poverty

Decline in availability of lake resources, primarily fisheries has led to reduced income of the lakeshore communities. Presently, about one third of the lakeshore population falls below poverty line, with the highest incidence in the islands and eastern lakeshore villages, which have the maximum concentration of fishermen and limited opportunities for alternate sources of income.

Health Hazards

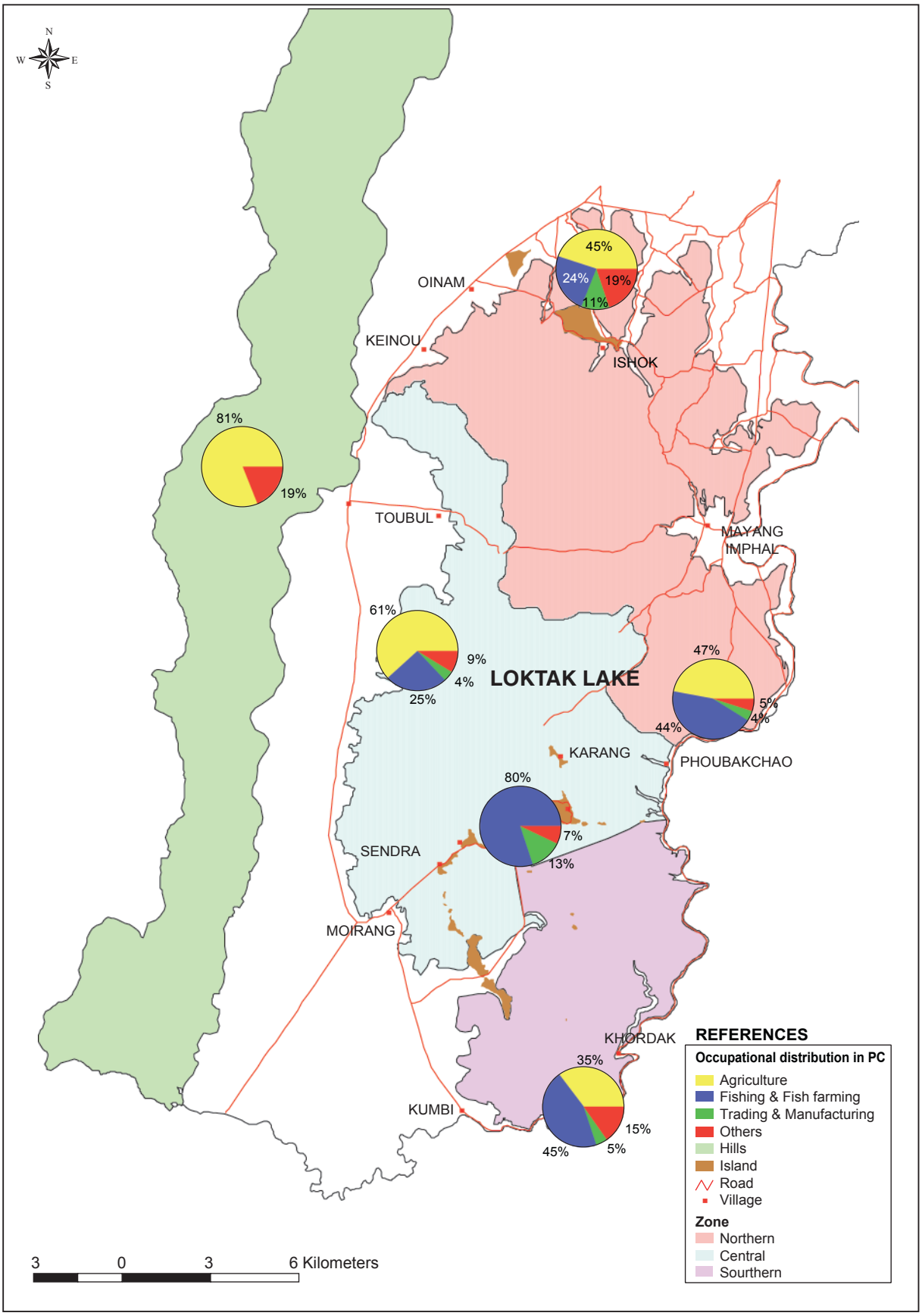
Deterioration in lake water quality due to direct discharge of untreated sewage in the lake and absence of adequate sanitation facilities in the peripheral settlements has led to severe health hazards. At present approximately 5,000 households withdraw lake water for domestic use as safe drinking water facilities are accessible to only 51% of the lakeshore communities. This leads to frequent incidence of waterborne diseases as diarrhoea, jaundice, stomach infections etc. within these communities. Fishers, especially women folk, who spend considerable amount of time in lake waters are affected by skin infections due to poor water quality.

Changes in Occupational Structure

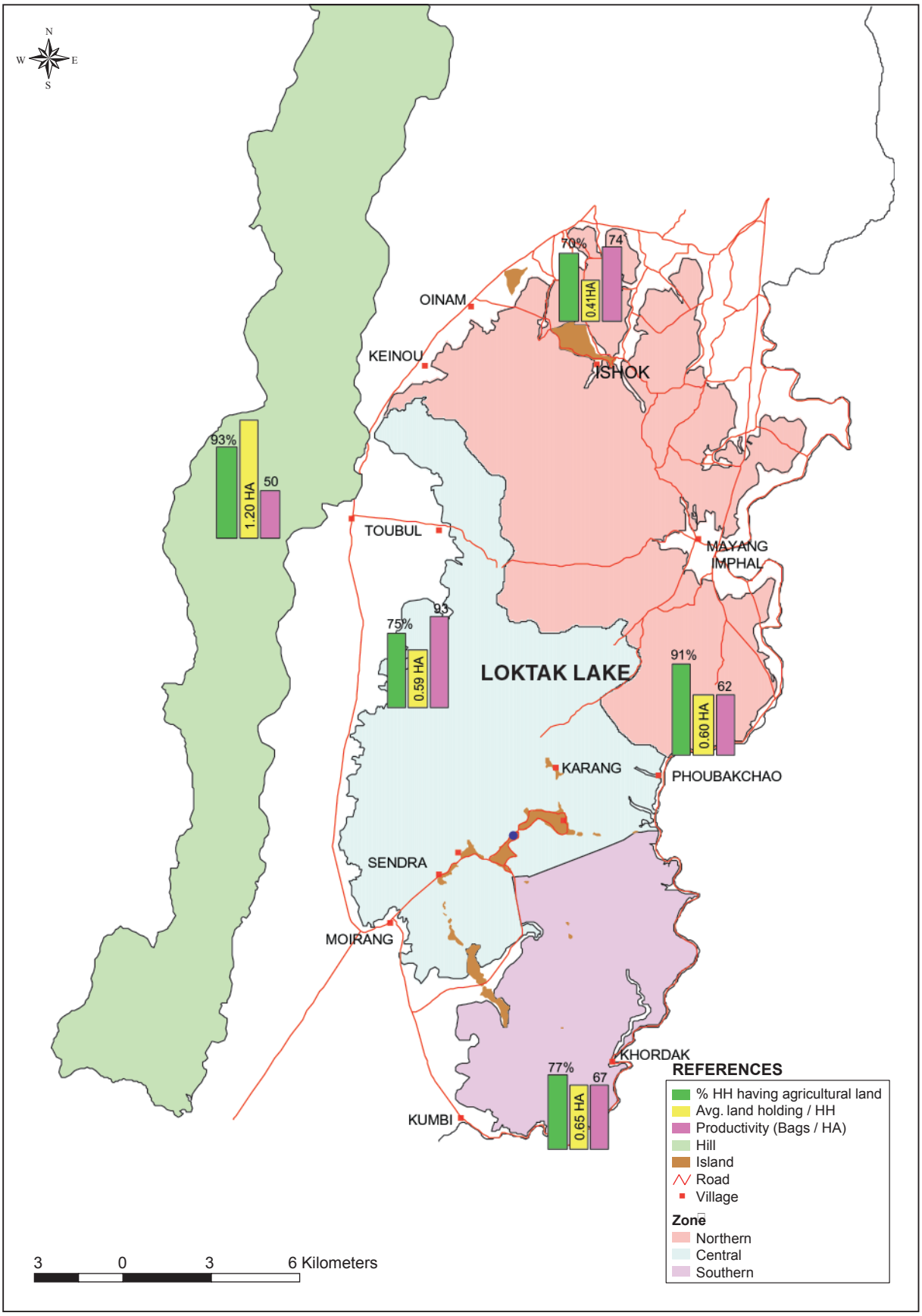
Inundation of large areas of agricultural land after construction of Ithai barrage has led to shifting of a large population of agricultural farmers to fisheries as the primary source of income. However, rapid increase in population of fishermen and reduced migration of fishes has led to adoption of several exploitative modes of fishing including *athaphums* and increased use of nylon nets. Increased usage of nylon nets has impacted the livelihoods of a sizeable population, largely womenfolk, specialized in manufacturing of traditional fishing crafts and gears.

Decline in agricultural yield

Prolonged floods, especially in the eastern and southern periphery of the lake, leads to damage to the agricultural crops and decline on overall yield. Agriculture farmers of these zones have the lower agricultural yield as compared to other regions of the state. Lower agricultural production and declining fisheries yield is reflected in poor economic status of these communities.



Map 51: **OCCUPATIONAL TRENDS IN AND AROUND LOKTAK**



Map 52: **LAND HOLDING AND AGRICULTURAL PRODUCTIVITY IN AND AROUND LOKTAK**

Problems in Lake Transportation

Rapid proliferation of *phumdis* in the lake has severely impacted the lake transportation, which is the primary mode of communication of the island villages and several peripheral villages, especially in the monsoon when access by land is limited.

Vulnerability Contexts

The key factors contributing to livelihood vulnerability in the hills and the lakeshore regions have been assessed through participatory rural appraisals, focal group discussions and household surveys. Factors contributing to livelihood vulnerability in the hills include

- Low returns from the primary occupation, i.e., shifting cultivation
- Limited technology for benefiting from the wide range of forest products
- Limited product organization and market integration, especially in the handlooms and handicrafts
- Lack of access to proper credit mechanisms
- Lack of adequate communication leading to distress sales and low value realizations, especially horticultural produce

Factors contributing to livelihood vulnerability in the lakeshore regions include:

- Health hazards due to poor lake water quality resulting from absence of adequate sanitation facilities and direct discharge of wastes into the lake
- Frequent occurrence of floods, especially in the lakeshore areas of Loktak Lake leading to low agricultural yield especially in the eastern and southern zones
- Decline in fisheries due to rapid increase in population, changes in hydrological regimes, abundant use of destructive fishing techniques and absence of both community and government regulatory mechanisms
- Heavy dependence on agriculture and fisheries, with limited micro enterprises based on other resources
- Limited technical know how and absence of market linkages to benefit from micro enterprise based on wise use of resources
- Lack of access to proper credit mechanisms

Participatory Planning for Lake Conservation and Livelihood Improvement

Local communities are an integral part of Loktak ecosystem and a participatory approach has been adopted to ensure their involvement at all levels and within all sectors of conservation and sustainable development of Loktak Lake. A co - management approach with emphasis on empowerment of impoverished community, promoting equity in access to and control of resources, sustainability and system orientation needs has been adopted through identification of needs and priorities of local communities and sharing of authority and responsibility for resource management according to institutional arrangements understood and agreed by all parties.

Participatory rural appraisals were conducted in 44 representative villages with the objective of involving communities in planning and implementation of activities for conservation of lake ecosystem and livelihood improvement. The exercises involved activities as social and resource mapping to understand community organization and linkages with natural resources. Geographical and historical transects, trend analysis and seasonality analysis were carried out with the communities for understanding the resources use patterns and potential for livelihood improvement. Problem tree analysis was also undertaken to understand the livelihood vulnerability context and root cause problems.

Consultation meetings and stakeholder workshops were organized with various stakeholder groups on various issues of lake conservation. Nine consultation

representing various sectors of the lake on causes of *phum* proliferation, impacts on livelihoods and suggested control measures. Similarly, twelve consultation meetings were organized in lakeshore and island villages to highlight the various issues related to lake fisheries bystake holders and suggest measures for sustainable development of fisheries of Loktak. The consultation meetings were followed by stakeholder workshops wherein specific recommendations on the issues were given by the communities, which were subsequently adopted into action plans of Loktak Development Authority.

Measures were also undertaken to ensure community participation into implementation of various project activities, specific instances include:

- Data collection and monitoring of hydrological stations by women groups
- Participatory rural appraisals and socio economic surveys through village volunteers
- Raising of nurseries and maintenance of plantation by women in the hill villages
- Comprehensive survey of Keibul Lamjao National Park by local youth club members, school children and community leaders
- Environmental awareness campaigns on issues of Loktak conservation by youth clubs and Meira Paibis
- Removal of *phumdis* from link channels by youth clubs and community groups

Microplanning

Microplanning for specific interventions for reducing pressures on lake resources and improvement of livelihoods of communities was carried out involving local communities and stakeholders. The microplans developed focused on included identification of specific intervention, identification of beneficiaries and roles and responsibilities of partners, implementation mechanisms, and modes of monitoring and evaluation. Specific issues for which microplanning was carried out are:

- Reducing/improvising *phum* cultivation in the hill areas through horticulture and alternate income generation programmes
- Promoting fuel efficient hearths (chullahs) to reduce pressure on forests
- Reducing pressure on lake fisheries through strengthening of traditional hatcheries and integrated farming techniques
- Enhancement of lake fisheries through construction of community owned hatcheries in lakeshore villages
- Provision of adequate sanitation facilities through construction of low cost community toilets in island villages
- Providing safe drinking water in lakeshore villages through construction of pond based safe drinking water units
- Management of *phumdis* through their removal and economic utilization

Formation and Strengthening of Community Institutions

Thirty six Self Help Groups have been formed and provided seed assistance under various alternate income generation programmes. Ten Hatchery Management Committees were formed for construction and management of community owned fish hatcheries. Village welfare committees were formed for construction and management of community toilets and pond based drinking water systems. Forty watershed committees have been formed in the hill villages with the primary objective to facilitate community in taking a lead role in watershed management. The committee looks after planning, implementation and evaluation of watershed development activities to ensure effectiveness, usufruct sharing of benefits from interventions, and sustainability. It also assists in building a revolving fund to meet the micro credit needs of the communities, maintain the afforested areas and strengthen the income generation programmes. A multi stakeholder working group has also been established primarily for conflict resolution.

Specific MoUs have been developed between the implementing community organizations and the project indicating implementation mechanisms, roles and responsibilities of partners and monitoring mechanisms. Emphasis has been laid on creating community stakes through their investment in creation of common assets, replication and capacity building through need based training programmes.

Special emphasis has been laid under the project for involvement of marginal communities, particularly women into planning and implementation of activities. Of the 36 SHGs, 22 are women groups, which have been provided seed assistance to support small scale cottage industries such as yarn for weaving under the project. There is a significant representation of women folk in all the community institutions

formed under the project. Interventions like provision of safe drinking water , community toilets and smokeless chullahs are aimed at improving the household environment through reducing health hazards.

Joint Community Based Demonstration Projects

The microplans developed by the communities were implemented through demonstration projects. These projects have been developed and implemented through participatory processes. The following demonstration projects have been established.

Reduction of jhum cultivation in hill villages

Strategies adopted for reduction of jhum include sources of income alternate to jhumming including horticulture, integrated farming and handlooms in identified villages.

Horticulture

Horticulture, primarily of banana and pineapple, intercropped with Parkia Roxburghii has been undertaken in 535 ha in 41 hill villages.

Integrated Farming

Integrated farming has been promoted in eight hill villages with high pressure of *jhumming*. Under this programme, the ponds in these villages are managed as an alternate source of income through an integrated fisheries cum piggery development.

Handlooms and Handicrafts

Twenty two women Self Help Groups have been formed in eight hill villages, and have been provided seed assistance of yarn under the handlooms and handicrafts initiative of the project.

Reducing pressure on lake fisheries

Integrated farming and strengthening of traditional hatcheries has been undertaken in representative lakeshore villages for reducing pressure on lake fisheries

Integrated Farming in Lakeshore Villages

Integrated farming has also been taken up with the primary objective of increasing incomes of marginal fishermen with partly or wholly submerged lands. Fisheries cum duckery has been taken up in 16 lakeshore villages and paddy cum pisciculture in 5 lakeshore villages.

Strengthening traditional hatcheries

A demonstration project on strengthening of traditional hatcheries has been taken up in Laphupat Tera. Community group having know how of traditional hatchery management was provided support in terms of brooders and hormones, under the condition that 50% of the first produce is released into the lake for restocking.

Enhancing lake fisheries through community owned hatcheries

Two Chinese circular hatcheries with production capacity of 2.5 million spawns per operation and 8 mini hatcheries with capacity of 1.2 million spawns per operations have been constructed in 10 lakeshore villages. These hatcheries are maintained and operated by Hatchery Management Committees,under a specific MoU signed between the committee and the project, with the restocking 50% of the fingerlings in the lake.

Control of Phumdis

A demonstration project on economic utilization of *phumdis* for composting has been undertaken in 10 lakeshore villages. *Phumdi* removed from Loktak has been converted to high quality compost using microorganisms multiplied in Biotechnology Laboratory established under the project at Ningthoukhong.

Reducing dependence on forests for fuelwood

A demonstration project aimed at reducing the dependence of community on forest resources for fuel has been undertaken in 25 lakeshore villages and 14 hill villages. Under this project, fuel efficient smokeless chullahs are distributed to sections of communities which face hardships in collection of firewood and find the conventional chullah, which emits a lot of smoke, hazardous to health.

Low cost sanitation in island villages

Three hundred and forty six community toilet units have been constructed in the three island villages of Karang, Thanga and Ithing providing proper sanitation facilities to 982 households.

Pond Based Safe Drinking Water Systems in Lakeshore Villages

Water is diverted from community ponds to a filtration unit comprising horizontal roughing filter and slow roughing filter. The filtration units are maintained by community groups and the user groups.

◆ ◆ ◆

REFERENCES

Banerjee, D.K., Bhatia, B and Haq, Inamul. 1983. Comparison of seasonal and diurnal patterns of some physico chemical parameters of the open and closed part of the Loktak lake, Manipur. Intern. J. Environ. Stud. 21: 243-250

Bhatia, B. 1979. Ecology of Loktak lake. Final Technical Report, Department of Science, Technology, Government of India, New Delhi.

Bhatia, B., Sarkar, H.L., Banerjee, D.K. and Haq, Inamul. 1985. Association between some planktonic species and physico chemical charecteristics of the water of Loktak lake, Manipur, India. Intern. J. Environ. Stud. 26: 111-123

Biswas, Shyamaprasad. 1978. Fishes of Manipur, Dissertation, Division of Life Sciences, Centre of Post Graduate studies, Jawaharlal Nehru University, Imphal: 1- 93

Cairns, M. 1998. Consultant's Recommendations to Sustainable Development and Water Resources Management of Loktak Lake. Consultancy Report. Sustainable Development and Water Resource Management of Loktak lake.

Dey, S.C. 2002. Conservation of biodiversity in the Keibul Lamjao National Park. Consultancy Report. Sustainable Development and Water Resource Management of Loktak lake.

Directorate of Economics and Statistics, 2000. Economic Survey, Manipur 1999 - 2000

Environmental Resource Management, India. 2003. A report on Environmental Impact Assessment of Loktak lake.

Fisheries Department, Govt. of Manipur. 2001. Annual Report.

Forest Survey of India, 2003. The State of Forest Report.

Hay, Duncan. 1998. Framework for Water management and Hydrology. Consultancy Report. Sustainable Development and Water Resource Management of Loktak lake.

Hora, S.L. 1921. Fish and fisheries of Manipur with some observations on those of the Naga hills. Records of the Indian Museum. vol. XXII. 165-215.

James, E.J. 2000. Work plan for water Resource management of Loktak wetland. Consultancy Report. Sustainable Development and Water Resource Management of Loktak lake

Khan, I. A.; Prasad, S.N. and Mathur, P.K. 1992. Management of an endangered cervid: A case study of Manipur Brow Antlered Deer (Cervus eldi eldi) in Keibul Lamjao National Park (KLNP), Manipur, Population and Habitat Viability Assessment Workshop, Briefing Book, brow Antlered deer of Manipur, 11 -14 October 1992, Mysore, India.

Laishram, J.M. 2004. Project report on Extension of Agro techniques for utilization of phumdi compost to farmers of Manipur. Consultancy Report. Sustainable Development and Water Resource Management of Loktak lake.

Loktak Development Authority and Wetlands International - South Asia, 1997. Project proposal Sustainable Development and Water Resource Management of Loktak lake.

Loktak Development Authority and Wetlands International - South Asia, 1998. Project Management Plan. Sustainable Development and Water Resource Management of Loktak lake.

Loktak Development Authority and Wetlands International - South Asia, 1999. Annual report. Sustainable Development and Water Resource Management of Loktak lake.

Loktak Development Authority and Wetlands International - South Asia, 2000. Annual report. Sustainable Development and Water Resource Management of Loktak lake.

Loktak Development Authority and Wetlands International - South Asia, 2001. Annual report. Sustainable Development and Water Resource Management of Loktak lake.

Loktak Development Authority and Wetlands International - South Asia, 2002. Annual report. Sustainable Development and Water Resource Management of Loktak lake.

Loktak Development Authority and Wetlands International - South Asia, 2003. Annual report. Sustainable Development and Water Resource Management of Loktak lake.

REFERENCES *(Contd.)*

Loktak Development Authority and Wetlands International - South Asia, 2003. Extension Proposal. Sustainable Development and Water Resource Management of Loktak lake.

Loktak Development Authority and Wetlands International - South Asia, 2004. Draft Stakeholder endorsed Water Management Plan. Sustainable Development and Water Resource Management of Loktak lake.

Loktak Development Authority, 1996. Management of Loktak lake.

Malhotra, K.C. 2004. Livelihoods improvement of the communities living in the Manipur River Basin. Consultancy Report. Sustainable Development and Water Resource Management of Loktak lake.

Maudgal, S. 2000. Assessment of existing operarting regime for water management. Consultancy Report. Sustainable Development and Water Resource Management of Loktak lake

Ministry of Environment and Forest, Government of India. 1972.The Wildlife (Protection) Act

Mukhopadyay, S.C. 1988. Some aspects of geomorphology of Manipur Area. Indian J. Landscape systems and Ecological studies II (2) :182 - 198

National Bureau of soil Survey and Land use Planning, Regional Centre, Jorhat and Kolkata. 2001. Land capability classes of catchment area of Loktak lake, Manipur.

PHED. 2003. Annual Report

Prasad, B and Chhabra, S.S. 2001. Management plan for Keibul Lamjao National Park, Manipur.

Saha, D. 2003. Strengthening fisheries development component of sustainable development and water Resource management program in Loktak lake, Manipur. Consultancy Report. Sustainable Development and Water Resource Management of Loktak lake

Shamungou, K. H. 1999. Conservation of Manipur Brow- antlered Deer. Wetlands of North- East India. Vol. II. Mass Publication, Imphal.

Shyamananda, R.K and Tombi Singh, H. 1985. Wetlands of Manipur valley: ecological and economic appraisal, and assessment potential, J. Manipur Sc. Assn. (1): 74 -79

Shyamananda, R.K. 1991. Study of nutrient enrichment in Loktak lake with reference to biological indices. Ph. D Thesis, Manipur University.

Singh H. Tombi, 1992. Geo - topography and Physico- chemical condition of Keibul Lamjao National Park (KLNP) Manipur, Workshop on population and habitat Validity Assessment, Briefing Book, Brow Antlered Deer of Manipur, Mysore India.

Singh, H.T and Shyamananda, R.K 1994. Loktak lake Manipur. World wide Fund for Nature, India.

Singh, P 1996. Ecology of Loktak lake with special reference to fish and fisheries of the lake. Ph.D Thesis. 295 pp

Tombi Singh, H. 1989. Limnological study of the major water bodies of Manipur. Technical Report, UGC, New Delhi. No. 1 -2

Tombi Singh, H. 1992. Impact of Hydel project on the environment of Manipur. Technical Report (1991 -1992), Technical Report, Department of Science, Technology and Manipur. Government of India.

Tombi Singh, H. 1992. Study of wetlands Ecosystems of Manipur Valley from Management perspectives of fish, wildlife and environment. Final technical Report, Department of Science Technology and Environment, Government of Manipur.

Tombi Singh, H. 1993. Impact of Loktak Hydro-electric Project on the environment of Manipur. Technical Report, Technical Report, Department of Science, Technology and Manipur. Government of India.

Tombi Singh, H. and Shyamananda, R.K 1988. Status report on the Environment of Manipur. Technical Report, Technical Report, Department of Science, Technology and Manipur. Government of India: 422

Trisal, C.L and Manihar, Th. 2002. Management of phumdis in Loktak lake. Proceedings of Workshop held at Imphal, Manipur (January).

Annex - I

Macrophytes on Phumdis of Loktak Lake

Family	Macrophytes of Loktak	Local name
Poaceae	*Arundo donax*	Luwang tou
	Andropogon zizanoides (Linn.) Nash	Tumnou
	Brachiaria mutica	Paragrass
	Cymbopogon nadus (L) Rendle	Charot
	Coix lacryma jobi Linn	Chaning
	Echinochloa stegnina Retz	Hup
	Erianthus arundinaceus (Retz) Jetweit	Singmut
	Erianthus procerus	Singnang
	Imperata cylindrica	Ee
	Coix lacryma Linn.	Yawa chaning
	Echinochloa sp	Hupkha
	Echinochloa colonum (L) Linn	Urichak
	Echinochloa crusgalli Linn	Urichak manbi
	Cynodon dactylon Linn	Tingthou
	Dactyloctenium aegyptium (L) P. Beauv	Napi porom
	Capillipedium sp.	Wanamambi
	Panicum humidorum Buch Ham ex Hook f	Kangmapal
	Phragmites karka	Tou/Tourel
	Oryza rufipogon Griff	Wainu chara
	Oryza sativa Linn.	Phou
	Saccharum munja Roxb.	Khoimam
	Zizania latifolia (Turcz) Hand Mazz	Khoimom Ishing
	Saccharum spontaneum	Mom
	Setaria pallidifusca Schum.	Hup
	Sacciolepsis myosuroides (R. Br.) Lam	Hup
Cyperaceae	*Carex cruciata* wahl	Humdang
	Scirpus lacustris Linn	Kouna
	Cyperus brevifolius Rottb Hassk	Chumthang macha
	C. *auricomus* Benth	Chumthang napakpi
	C. *pilosus* Vahl .	Chumthang makhok akanba
	C. *esculentus* Linn.	Chumthang makhok athotpa
	C. *sanghinalentus* Vahl.	Chumthang makhok akoiba
	C. *cephalots* Vahl.	Chumthang makhok (Triangular)
	C. *iria* Linn.	Chumthang makhok athotpa & akoiba
	C. *umbellatus* Benth	Chumthang
	Fuirena umbellata Rottb	Lamthangjou

Annex - I *(Contd...)*

Family	Macrophytes of Loktak	Local name
Polygonaceae	*Polygonum chinense* Linn.	Lilhar(Angom Yensil)
	P. hydropiper Linn.	Lilhar
	P. barbatum Linn.	Yellang
	P. orientale Linn.	Chakhong
	P. lapathifolium (L) S.F. Gray	Chakhong manba
	P. glabrum Wild	Chouhaisabi
	Rumex maritimus Linn.	Torong khongchak
	Rumex nepalensis Spreng.	Torong khongchak
Asteraceae	*Gynura angulosa* (D. Don) Moor.	Terapaibi
	Mikania cordata (Burm)	Urihingchabi
	Eclipta prostrata Linn.	Uchisumbal
	Ageratum conyzoides Linn.	Khongjainapi
	Galinsoga parviflora Cav.	Khongjainapi manbi
	Dichrocephala latifolia DC	Awaphagidom manbi
	Dichrocephala sp.	Hangamyela manbi
	Gnaphalium luteo album L.	Phunil
	Tagetes erecta Linn.	Sanarei
	Spilanthus acmella	Lalucouba
Nymphaeaceae	*Nelumbo nucifera* var *N. rubra* Roxb.	Thambal angangba
	Nymphaea pubescens Wild var. *N. alba* Roxb.	Thambal angouba
	Nymphoides indicum (Linn.) O. Kutje	Ngachak komol
	Euryle ferox salisb	Thangjing
	Nymphaea stellata willd	Thariktha
Cucurbitaceae	*Lagenaria vulgaris* Ser.	Koubuyai
	Bryonopsis lociniosa Naud	Kwakthabi
	Trichosanthes bracteats Voigt.	Kwakthabimanbi
	Melothria purpusilla (Blume) Cogn.	Lamthabi
Onagraceae	*Ludwigia octovalvis* (Jacq) Raven	Devo
	L. claveliana Gomez de la manza	Ishing kundo
	L. sassiliflora Roven	Chaoradevo
	Jussiaea suffroticosa L.	Cheiteklei
Zingiberaceae	*Alpinia galanga* (L) willd.	Pullei
	Hedychium coronarium	Loklei
	Gastrochilus longiflora wall.	Lamyaingang

Annex -I *(Contd...)*

Family	Macrophytes of Loktak	Local name
Apiaceae	*Enhydra fluctuans*	
	Oenanthe javanica (Bl) D.C.	Komprek
	Centella asiatica Linn.	Peruk
Asteraceae	*Eclipta alba* Linn.	Komprek tujombi
	Eringium foetidum (L)	Awaphagidom
Convolvulaceae	*Argyreia nervosa* (Burm f) Boj.	Uritujombi
	Ipomea aquatica Forsk.	Kolamni
Cuscutaceae	*Cuscuta reflexa* Roxb.	Dodder
Plantaginaceae	*Plantago alisma aquatica*	Kouthrum
Alismataceae	*Sagittaria sagittifolia* Linn.	Koukha
Amaranthaceae	*Alternanthera pheloxeroides* (Mart) Griseb	Kabonapi
	Amaranthus spinosus Linn.	Chengkruk
Pontederiaceae	*Monochoria hastaefolia* Presl.	Ngachak komol
	Eichhornia crassipes Mart.	Kabokang
Solanaceae	*Solanum nigrum* Linn.	Leipung khangga
	Solanum khasianum Linn.	Shing khangga
Araceae	*Colocasia esculenta* (Linn.) Schott.	Lampal
	Pistia stratiotes Linn.	Kangjao
Rubiaceae	*Stephegyne divercifolia* Hk.f.	Chomlang
	Anotis urophylla wall	Namthibi
Hydrocharitaceae	*Vallisneria spiralis* Linn.	Lairenchak
	Hydrilla sp.	Charang
	Hydrilla zeylanica Vahl	Charangkokphabi
	Hydrilla verticillata (L.F) Royle.	Charang kokchaobi
Salviniaceae	*Salvinia natans* Hoffim	Kangkup
	Azolla pinnata R. Br.	Kangmacha
Malvaceae	*Urena lobata* Linn	Sampakpi
	Hibiscus radiatus Wild	Jubakushum manbi
Balsaminaceae	*Impatiens balsamina* Linn.	Phumkhujang
Dennstaedtiaceae	*Pteridium aquilinum* (Linn.) Kuhn	Laichangkhrang
Marsiliaceae	*Marsilia quadrifoliata* Linn.	Eesing yensang
Trapaceae	*Trapa natans* Linn.	Heikak
Mimosaceae	*Mimosa pudica* Linn.	Kangphal Ekaithabi

Annex -I (Contd...)

Family	Macrophytes of Loktak	Local name
Fabaceae	*Neptunia oleracea* Lour *Syn. N. prostrata* (Lam.)	Ishing ekaithabi
Meliaceae	*Toona ciliata* Roem.	Tairen
Lytheraceae	*Rotala cendifolia* Koehne	Loubuk leiri
Vitaceae	*Cissum repens* Lamk	Phum angur
Rosaceae	*Rubus ellipticus* Sm.	Heijampet
Eriocaulaceae	*Eriocaulon luzulaefolius* Mart	Tharoimakoimanbi
Zuncaceae	*Zuncus sp.*	
Potamogetonaceae	*Potamogeton natans*(Linn) Engl. et. Kraus Var *P. indicus* (Roxb.)	Nganuchil
Selaginellaceae	*Selaginella* monosperme spring	Ishang
Cannaceae	*Canna indica* L.	Laphurit
Lemnaceae	*Lemna minor*	Kangmacha
Melastomataceae	*Osbeckia nepalensis* Hk. f.	Tejpatmanbi
Primulaceae	*Primula euosma* craib	Hidakmanamanbi
Smilacaceae	*Smilax elegans* Wall	Kishum
Liliaceae	*Allium hookerii* Thw	Maroinapakpi
Verbenaceae	*Callicarpa arborea* Roxb.	Hameibol
Dioscoreaceae	*Dioscorea anguina* Roxb.	Kwamanamanbi
Chenopodiaceae	*Chenopodium album* L.	
Orchidaceae	*Malaxis maximowicziana* (K dp) Tang and wang.	Yai-asinbi
Caesalpiniaceae	*Cassia sp.* Linn.	Chuchurame manbi
Commelinaceae	*Commelina obliqua* Ham.	Kabonapimanbi
Passifloraceae	*Passiflora admophylla* Mast.	Twinner
Menispermaceae	*Stephania lernandifolia* walp	Uriheiyenmanbi
Urticaceae	*Elatostema sp.*	
Scrophulariaceae	*Torenia vagans* Roxb.	Scrophularia
Musaceae	*Musa paradisiaca*	Laphu
Iridaceae	*Iris beckerii*	Kombirei

Annex -II
Fish Fauna of Loktak Lake

Family: **CYPRINIDAE**
1. *Amblypharyngodon mola* (Hamilton)
2. *Ctenopharyngdon idella* (Val.)
3. *Cyprinus carpio var nudus* (Bloch)
4. *Cyprinus carpio var communis* Linnaeus
5. *Cyprinus carpio var specularis* (Lacepede)
6. *Catla catla* (Hamilton)
7. *Cirrhinus mrigala* (Hamilton - Buchanan)
8. *Cirrhinus reba* (Hamilton - Buchanan)
9. *Crossocheilus burmanicus* (Hora)
10. *Esomus danricus* (Hamilton)
11. *Hypophthalmichthys molitrix* (Val.)
12. *Labeo rohita* (Hamilton)
13. *Bangara dero* (Hamilton-Buchanan)
14. *Labeo calbasu* (Hamilton)
15. *Labeo bata* (Hamilton-Buchanan)
16. *Labeo gonius* (Hamilton-Buchanan)
17. *Osteobrama belangeri* (Val.)
18. *Oesteobrama cunma* (Day)
19. *Puntius chola* (Hamilton)
20. *Puntius sarana sarana* (Hamilton)
21. *Puntius sarana orphoides* (Val.)
22. *Puntius sophore* (Hamilton)
23. *Puntius ticto ticto* (Hamilton)
24. *Puntius phutunio* (Hamilton Buchanan)
25. *Puntius javanicus* (Hamilton)

Family: **CYPRINIDONTIDAE**
26. *Apocheilus panchax* (Hamilton)

Family: **COBITIDAE**
27. *Acanthophthalmus pangia* (Ham- Buchanan)
28. *Lepidocephalus guntea* (Halmilton)
29. *Lepidocephalus irrorata* (Hora)

Family: **BAGRIDAE**
30. *Mystus bleekeri* (Day)
31. *Mystus cavasius* (Hamilton - Buchanan)
32. *Mystus microphthalmus* (Day)
33. *Aorichthys aor* (Ham - Buchanan)

Family: **SILURIDAE**
34. *Ompok bimaculatus* (Bloch)
35. *Wallago attu* (Schneider)

Family: **SCHILBEIDAE**
36. *Eutropiichthys vacha* (Halmilton)

*Family:***SISORIDAE**
37. *Bagarius bagarius* (Halmilton)
38. *Glyptothorax trilineatus (Blyth)*

*Family:***CLARIIDAE**
39. *Clarias batrachus* (Linnaeus)
40. *Clarias gueripinnus*

Family: **HETEROPNEUSTIDAE**
41. *Heteropneustes fossilis* (Bloch)

Family: **CHANNIDAE**
42. *Channa orientalis* (Schneider)
43. *Channa striatus* (Bloch)
44. *Channa punctatus* (Bloch)

Family: **SYMBRANCHIDAE**
45. *Monopterus albus* (Zuiew)

Family: **AMBASSIDAE**
46. *Chanda nama* (Halmilton)
47. *Parambassis ranga* (Halmilton)

Family: **CICHLIDAE**
48. *Oreochromis mossambica* (Peters)

Family: **GOBIIDAE**
49. *Glossogobius giuris* (Halmilton Buchanan)

Family: **ANABANTIDAE**
50. *Anabas testudineus* (Bloch)

Family: **BELONTIIDAE**
51. *Colisa fasciatus* (Schneider)
52. *Colisa sota* (Halmilton)

Family: **MASTACEMBELIDAE**
53. *Mastacembelus armatus* (Lacepede)

Family: **NOTOPTERIDAE**
54. *Notopterus notopterus* (Pallas)

Annex -III

Mammalian Fauna of The Keibul Lamjao National Park

S.No.	Scientific Name	Common Name	Local Name	Family
1.	*Cervus eldi eldi*	Brow-antlered	Deer Sangai	Cervidae
2.	*Axis porcinus*	Hog Deer	Kharsa	-do-
3.	*Sus scrofa*	Wild pig	Lamok	Smdae
*4.	*Cuon alpinus*	Indian wild dog	Huithou lamlen	Ctenomyidae
*5.	*Vulpes sp.*	Fox	Lamhui	Camdae
6.	*Felis chaus*	Jungle cat	Lamhoudong Fehdae	Felidae
*7.	*F. temmincki*	Golden cat	Tokpa	-do-
8.	*Viverra zibetha*	Large Indian civet	Moirang sathibi achouba	Viverridae
9.	*Viverricula indica*	Small Indian civet cat	Moirang sathibi macha	-do-
*10.	*Paguma larvata*	Himalayan Palm civet		-do-
11.	*Mustela erminea*	Ermine	Sadung	Mustelidae
12.	*Lutra lutra*	Otter	Sanamba	-do-
13.	*Funambulus pennanti*	Five stripped squirrel	Kheiroi	Sciundae
14.	*Rattus rattus*	Common house rat	Uchi	Muridae
15.	*R. booduga*	Indian field mouse		-do-
16.	*Spalax microphtalmus*	Mole rat		-do-
17.	*Golunda ellioti*	Indian Bush rat		-do-
18.	*Cannomys badius*	Bay bamboo rat	Sabi	Spalacidae
19.	*Suncus caeruleus*	Musk shrew	Utin	Talpidae
20.	*Sarex araneus*	Common shrew		-do-
21.	*Pteropus sp.*	Flying fox	Sekpi	Chiropterae
22.	*Rhinolophus sp.*	Great Eastern bat		-do-

Source: Singh, H. Tombi, 1992

**** Recently not sighted (Salam Rajesh, 2004, Personal Communication)***

Annex -IV

Avi - Fauna of The Keibul Lamjao National Park

S.No.	Scientific Name	Common Name	Local Name	Family
1.	*Halcyon smyrnensis*	Smyma king fisher	Ngarakpi	Alcedinidae
2.	*Ceryleudis leucomelanura.*	Indian pied kingfisher		-do-
3.	*C. ingrubris guttulata.*	East Himalayan pied kingfisher	-do-	
4.	*Milvus migrans*	Black kite	Umaibi	Aceipitridae
5.	*Alauda gulgula*	Lesser sky-lark	Tinkhaklen	Alaudidae
6.	*Acridotheres tristis tristis*	Indian myna	Chong-hgaangangbi	Sturnidae
7.	*Gracula religioosa intermedia*	Northern hill myna	Chong-nga amubi	-do-
8.	*Sturnus malabaricus*	Grey head myna	Chongba - nga	-do-
9.	*S. contra suparculiaries*	Burmese pied myna	Chnong-nga amubi	-do-
10.	*Dicrurus odsimiles albrictus*	Northern Indian black drongo	Charoi	Dicuridae
*11.	*D. hottentottus hottentottus*	Spangled drongo		-do-
*12.	*D. annectans*	Crow billed drongo		-do-
13.	*Corvus macrorhynchos*	Lesser Eastern jungle crow	Kwak	Corvidae
14.	*Hirundo daurica*	Daunan swallow	Sembang	Hirundmldae
15.	*Motacilla alba*	White pied wagtail	Khambrangchek	Motacillidae
16.	*M. caspica*	Grey wagtail		-do-
17.	*M. citreola*	Yellow headed wagtail		-do-
18.	*Monaracha zurea*	Sbacknapped blue		
19.	*Ducula bandia griscicapilla.*	Grey headed imperial pigeon	Lamkhunu	Columbidae
20.	*Treron pompadora phayrei*	Ashey headed green pigeon		-do-
21.	*Streptopelia chinensis*	Spotted dove		-do-
22.	*Anas poecilorhyncha poecilorhyncha*	Spot bill duck	Nganu kata	Anatidae
23.	*Anas clypeata*	Shoveller	Nganu khara	-do-
24.	*Anas strepera*	Gadwall	Nganu	-do-
25.	*A. crecca crecca*	Common teal	Nganu-surit	-do-
26.	*A. penelope*	Wigeon	Thangong-mal	-do-
27.	*A. acuta*	Pintail	Meitunga	-do-
28.	*A. querquedula*	Blue winged teal	Surit angouba	-do-
29.	*Tadorna ferruginea*	Ruddy shelduck	Nganuthangong	-do-
30.	*T. tadorna*	Common shelduck	Nganu-chingangbi	-do-
31.	*Netta rufina*	Red crested pochard	Irupi	-do-
32.	*Aythya ferina*	Common pochard		-do-
33.	*A. nyroca*	White eye poachard	Irupi	-do-
34.	*Dendrocygna javanica*	Lesser whistling teal	Tingi	-do-
35.	*D. bicolor*	Large whistling teal		-do-
36.	*Pycnonotus jucosus monticoia*	Assam red wiskered bulbul	Khoining	Pyconotidae
37.	*P. cafer cafer*	Redvented bulbul		-do-
38.	*Turnix sylvatica dussumier*	Little bustard quail	Sorbol	Turmeidae
*39.	*Grus monacha*	T. Hooded crane	Wanumal	Gruidae
*40.	*Grus antigona sharpii*	Burmese sarus	Wainu wainuren	-do-

Annex -IV (Contd..)

S.No.	Scientific Name	Common Name	Local Name	Family
41.	*Amaurornis phoenicurus phoenteurus*	Indian white breasted water hen	Uren konthou	Rallidae
42.	*Gallicrex cinera cinera*	Kora watercock	Uthum	-do-
43.	*Gallinula chloropus indica*	Indian moorhen	Pat uren	-do-
44.	*Porphyrio porphyrio*	Indian purple moorhen	Umu	-do-
45.	*Fulica atra atra*	Coot	Nganu-porom	-do-
46.	*Hydrophasianus chirurgus*	Pheasant tailed jacana	Yen-paraba	Jucanidae
47.	*Metopidius indicus*	Bronze winged jacana	Thamnachenbi	-do-
48.	*Vanellus cinereus*	Greyheaded lapwing	Salang	Charadridae
49.	*Vanellus indicus*	Burmese rewatted lapwing	Salangkak	Charadridae
50.	*V. spinousus duvaucelii*	Spurwinged lapwing	Ngahoibi	-do-
51.	*Pluvialis dominica fulva*	Eastern golden plover	Nong-ong	-do-
52.	*Capella gallinago gallinago*	Fantail snipe	Nong-ong	Rostratulidae
53.	*Ardea cinerea*	Grey heron	Ushai	Ardeidae
54.	*A. alba modesta*	Eastern large egret	Urok	-do-
55.	*Egreta garzetta*	Little egret	Urok	-do-
56.	*E. intermedia intermedia*	Median egret	Langkhongsang	-do-
57.	*Ardeola grayii*	Indian pond heron	Urok lamprai	-do-
58.	*Ardeola bacchus*	Chinese pond heron	Urok lamprai	-do-
59.	*Bubulcus ibis*	Cattle egret	Sandung il	-do-
60.	*Nycticorax nycticorax*	Night heron	Chongkhu	-do-
*61.	*Perdicula manipurensis manipurensis*	Manipur pained bush quail	Sorbon-amuba	Phasianidae
*62.	*Gallus gallus spadiceus*	Burmese red jungle fowl	Layel	-do-
63.	*Bambusicola fytchii*	Assamese bamboo partridge	Wakhrex	-do-
64.	*Francolinus francolinus.*	Black trancolin	Urel	-do-
65.	*F. francolinus melanonotus*	Assam black partridge	Urenbi	-do-
66.	*F. pintadaenus phayrei*	Burmese francolin	Kabo-trend	-do-
67.	*Coturnix coturnix japonica*	Japanese francolin	Sorbol	-do-
68.	*C. coturnix coturnix coturnix*	Common grey quail		-do-
69.	*Falco biarmicus jugger*	Lagger falcon	Khunu-kharang	Falconidae
70.	*Mulvus migrans*	Kite	Umaibi	
71.	*Centropus sinensis intermedius*	Crow pheasant	Nongoubi	Cucumadae
72.	*Tyto atba stertens*	Indian born owl	Irak-maku	Striginae
73.	*T. alva*	White owl		-do-
74.	*Otus spilocephalus spilocephalus*	Eastern spotted scops owl	Maku	-do-
75.	*O. bakkamoena manipurensis*	Burmese collard scops owl		-do-
76.	*Bubo nepalensis nepalensis*	Forests eagle owl		-do-
77.	*Emicurus schistacens*	Slaty backed forktail	Uchinao	Muscicapinae
78.	*E. leschenaulti indicus*	Leschenauth's forktail		-do-
*79.	*E. pupaepops longtrostris*	Jerdon Burmese hoope	Sanganaba chongaraba	Upupidae
80.	*Picordes cathphartus pyrrhothorax*	Manipur crimson -breasted pied woodpecker	Utubi	Picidae

Source: Singh, H. Tombi, 1992

**Currently not sighted (Salam Rajesh, 2004, Personal Communication)*

GLOSSARY

Athaphum(s)	Floating fishing enclosure made up of weedmats
Chullah	Hearths
Hapa	Square piece of cloth fixed in the aqua culture pond bed with the help of bamboo pole, mainly used for fish breeding
Jhum / Pamlou	Shifting cultivation
Kuki	Tribe living in hill area
Lekei	Sub-village community organization
Loktak Ima	Lake goddess
Marups	Informal savings - credit groups
Meities	Communities living in valley region of Manipur
Mera Paibi	Women organization
Naga	Tribe living in hill area
Ngaton	Fingerlings of *Labeo* spp.
Pangans	Muslims
Pengba	*Osteobrama belangeri*
Phum huts	Hutments on phumdis
Phumdis / phum	Floating weedmats
Sangai	Brow antlered deer (*Cervus eldi eldi*)
Sugnu hump	Rock barrier in Manipur River near Sugnu village
Tharak	Fingerlings of *Osteobrama belangeri*

ACRONYMS

BOD	Biochemical Oxygen Demand
BPL	Bellow Poverty Line
CBO	Community Based Organization
CCA	Culturable Command Area
CO_2	Carbon dioxide
CPCB	Central Pollution Control Board
Cusec	cubic seconds
DO	Dissolved Oxygen
ERM	Environmental Resource Management
GIS	Geographical Information System
Ha	Hectare
ICEF	India Canada Environment Facility
IRS	Indian Remote Sensing
IUCN	International Union for Conservation of Nature
K	Potassium
KLNP	Keibul Lamjao National Park
LDA	Loktak Development Authority
Mcum	Million cubic Meter
MGD	Million gallon per day
ML	Milliliter
MLD	Million Liter per day
MoEF	Ministry of Environment and Forest
MoU	Memorandum of Understanding
MPN	Most Probable Number
MSL	Mean Sea Level
MSY	Maximum Sustainable Yield
MT	Metric Tonnes
MU	Manipur University
MW	Mega watt-
NEC	North Eastern Council
NGO	Non governmental Organization
NHPC	National Hydro- electric Power Corporation
NTFP	Non Timber Forest Products
P	Phosphorus
PHED	Public Health Engineering Department
PRA	Participatory Rural Appraisal
Rm	Round Meter
SDWRML	Sustainable Development and Water Resource Management of Loktak lake
Sq Km	Square Kilometer
WAPCOS	Water and Power Consultancy Services
WISA	Wetlands International - South Asia
WWF	World Wide Fund for Nature

Wetlands International is an independent global non-profit organization dedicated solely to the work of wetland conservation and sustainable development. Well-established networks of experts and close partnerships with key organizations provide Wetlands International with the essential tools for catalyzing conservation activities worldwide. Over 120 government agencies, national NGOs, foundations, development agencies and private sector groups support the global and regional programmes of Wetlands International.

Mission : "To sustain and restore wetlands, their resources, and biodiversity for future generations through research, information exchange and conservation activities worldwide".

The Loktak Development Authority is a registered society under Sec. 20 of the Societies Act XXI of 1960. The Authority was reconstituted by the Government of Manipur in July 1987. The Chief Minister or his nominee is the Chairman of the authority and the Project Director is the Member Secretary and also Executive Head of the Authority . The members of the Authority include several Ministers, MLAs, experts, Secretaries/Head of Departments of the State Government concerned with Loktak Lake. The LDA is under the aegis of the Department of Environment, Government of Manipur.

Mission : "To restore and develop Loktak Lake resources and biodiversity for present and future generations through participatory processes, research and conservation activities."

For further information please contact:

Wetlands International - South Asia Programme
A - 127, Defence Colony, New Delhi - 110024, India.
Fax:+91-11-24338906
E-Mail: wisaind@del2.vsnl.net.in
wisa@hathway.com
URL: http://www.wetlands.org

Loktak Development Authority
Leiren Mansion, Lamphel pat, Imphal - 795004,
Manipur, India.
Fax: +91-385-2410631
E-mail: idwisa@sancharnet.in

L O K T A K

...the lifeline of people of Manipur

ICEF