Siphandone Wetlands

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Environmental Protection and Community Development in Siphandone Wetlands Project

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The views expressed herein are those of the authors, and do not represent any official view of the European Commission or the Government of Lao PDR.

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Abbreviations

AFDC	Agriculture and Forestry Division of Champassak Province
AFO	District Agriculture and Forestry Office
ARMCDS	Aquatic Resources Management & Community Development Specialist
CPAWM	Centre for Protected Areas and Watershed Management, Dept. of Forestry
CPUE	Catch per Unit Effort
DLF	Department of Livestock and Fisheries
DoC	Department of Communications
DoF	Department of Forestry
DOF	Deciduous Dipterocarp-Oak, Seasonal, Hardwood Forest
EC	European Commission
EPD	Expatriate Project Co - Director
FCZ	Fish Conservation Zone
GCP	Ground Control Point
GIS	Geographic Information System
GOL	Government of Lao P.D.R.
GPS	Global Positioning System
HIS/RGB	Hue, Intensity and Saturation system and Red, Green and Blue system
LCFDPP	Lao Community Fisheries and Dolphin Protection Project
MAF	Ministry of Agriculture and Forestry
MRC	Mekong River Commission
MXF	Mixed Evergreen + Deciduous, Seasonal, Hardwood Forest
NBCA	National Biodiversity Conservation Area
NDVI	Normalised Difference Vegetation Index
NPD	National Project Co-Director
NTA	National Tourism Authority
PMU	Project Management Unit
PRA	Participatory Rural Appraisal
PSC	Project Steering Committee
SG	Secondary growth forest
SWP	Siphandone Wetlands Project (Environmental Protection and Community Development Project in Siphandone Wetlands)
TEK	Traditional ecological knowledge
TM	Thematic Mapper
UTM	Universal Transverse of Mercator

Lao terms commonly used in the text

Ban	Village
Done	Island
Hou	Channel
Houay	Stream
Nong	Pond
Pa	Fish
Phou	Mountain
Wat	Temple

NB: Transliteration of Lao names into English often varies as no definite rule exists.

Acknowledgements

This publication is a summary of the results and written reports produced by the Siphandone Wetlands Project. While a number of authors appear as contributors to the publication, the work, information and experience presented herewith are the fruit of the effort by a much larger group of people who, in different capacity, were involved with the project and contributed to it.

This particularly concerns the Lao colleagues who were members of the project team, responsible for guiding, implementing, facilitating and delivering the activities. Their direct contribution to the final desk-based write-up phase was hindered by the contingent situation and practical constraints within which this book was produced at the conclusion of the project. Nevertheless their contribution to this work and the project was of fundamental value. The team included Savay Phimmasone, Project Co-Director; Pongsavath Kisouvannalath, Field Team Leader; Visai Inthaphaisy, Bounpheng Philavanh, Bounthong Senesouk, Khamsouk Xayyamanyvong, Field Team members; Vongphone Sithouomphalak, Secretary, Silanh Senethavy, Administrative Assistant and Khaamay Khaittisak, driver; Somphong Bounphasy, Field Assistant.

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Insofar as this book reflects part of the work carried out through the project, it also owes to the contribution of a very large number of people associated with Provincial Government offices at Pakse, District offices at Khong, the Department of Forestry in Vientiane, other Government institutions in Vientiane and CESVI Vientiane office. We wish to thank in particular Ongkeo Bounthavongsin, Director, AFDC; Bounsay Saphangthong and Prachit, Deputy Directors of AFDC; Kampot, Pon, Imphaeng and Tomboun of AFDC; Chanthaviphone Inthavong and Vene Vonghpet, former Directors of CPAWM; Sirivanh Khounthokoume, Alounyadeth Banouvong, Sisay Chounnavanh, Bounhong Mounsouphom, Petsamone Sourivong, Khone vanh Bachanh, Chantone Phothitai who were with the then CPAWM; Sangthong Southamakot, Director of the Division of Forest Resource Conservation at DOF; Salvatore Creti, Amna Smailbegovic and Andrea Vera of CESVI Vientiane Office; Suvan, Suvat and Nokham Ounesavanh with the Agriculture Office of Khong District; Prof Pheng Phaengsintham of the National University of Lao PDR; Bounsouan, Chief, Hydromet Service of Champassak; Nokham Ounesavanh, Head of the Land and Forestry Management & Allocation Committee of Champassak. Many more were also involved in the provision of information, sharing of knowledge, and moreover direct contribution to field and training activities: we cannot mention all by name. However we wish to record the contribution of the following Khong-based organisations: Livestock and Fisheries office; Education Office; Police office; Lao Women Union; Youth Union; Aged People Union; Public Health office. Additional organisations involved or which provided data and advice were the Provincial Government Office, Agriculture College of Pakse, Km 20 Fruit Station, Champassak Provincial Tourism Authority, Champassak Provincial Geological Service, Soil Survey Centre, Vientiane. We sincerely apologise for any possible omission among the many individuals and local organisations.

Unfortunately the authorship could not formally include the fundamental contribution to the project given by Prof. Renato Novelli, who co-directed the project from the inception until late 1998 and was eventually forced to repatriate because of serious illness. He has since recovered and has resumed his work at the University of Ancona. He played a key role in directing the project through most of the implementation period and we are indebted to him for much of what is reported herewith and particularly for laying the foundation of the socio-economic study presented in Chapter 7.

The contributors to this volume were project team members: Giuseppe Daconto was Environmental Planner and eventually took over as European Project co-Director in December 1998; Ian G. Baird was Aquatic Resources Management and Community Development Specialist, also associated with the earlier Lao Community Fisheries and Dolphin Protection Project; Peter Cunningham was Research and Training Assistant (with support from VSO). Among the project short term experts were Antonio Brambati and Giovanni Battista Carulli, geologists; James F. Maxwell, botanist; Stephen Elliott, plant ecologist; Richard Friend, socio-economist. The Ecology Section of the University of Trieste, headed by Prof Enrico Feoli, executed the remote sensing and GIS work, with contribution by Alfredo Altobelli, Cristina Milesi and Elisabetta Rui.

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Last but not least, a large number of people from the many villages of Siphandone assisted us, providing excellent hospitality and company in the best Lao tradition during the many field activities. They own a body of knowledge on the Mekong that far exceeds what is compiled herewith: they readily shared it with us. They should be the ultimate beneficiaries of the awareness of this spectacular wetland which this publication wishes to raise.

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Photo credits: Giuseppe Daconto (cover, photo no. 1,2,3,4,5,6,7,8,11,12,13,14,15,17,20, 23,25, 26,27,28); Ian Baird (16,18,19,21,22); Stephen Elliott (9,10); J.F. Borsani (24).

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Foreword

It is with great pleasure that we present through this publication a summary of the work carried out by the "Environmental Protection and Community Development in Siphandone Wetlands" project. This project was generously funded by the European Commission (Directorate General for External Relations), to which we would like to extend our sincere thanks. CESVI would also like to express its gratitude to the many Lao government institutions whose cooperation was vital to the implementation of the project. We especially thank our direct counterpart institutions: the Ministry of Agriculture and Forestry and the Department of Forestry, the Agriculture and Forestry Division of Champassak Province and Khong District. They played a key role in this undertaking and we benefited greatly from their collaboration and support.

This project is particularly important to CESVI, because it marks our organisation's first medium-term involvement in Lao P.D.R. In our relatively young history (CESVI was established in 1985), we have accumulated valuable experience in providing support to rural development and environmental projects in a number of countries world-wide. Several of these projects were in Thailand, Cambodia and Viet Nam and this involvement has strengthened our commitment to the South-East Asian region. We were therefore delighted to take up the challenge to support this natural resource management project in southern Lao P.D.R.. The issues faced by the Siphandone Wetlands region were not entirely dissimilar from those we had encountered while supporting grassroots projects in partnership with local organisations of the region. We were also very pleased to be able to contribute to the sustainable development of this remarkable site along the Mekong River.

The project proved both challenging and rewarding. The key factor in the success of its implementation was the commitment of both the project team members and also of a large number of local Siphandone people, whose rich body of traditional knowledge thought us many valuable lessons. We hope that we have contributed towards the sustainable management of the extraordinary resources of this unique site, through the technical studies, training, awareness raising and rural development activities that were implemented. We are also pleased that this initial experience has created a broader cooperation with Lao institutions: several other activities have been designed and implemented since this project and we hope that this cooperation develops even further in the future.

The experience we gained in Siphandone in testing and developing methods and approaches for local-level sustainable natural resource management, was not only important in itself, but will also be invaluable in the future. This issue is firmly on CESVI's agenda and we are presently busy supporting a number of related initiatives in Asia, Africa and South America. Effective local-level action is crucial to promote sustainable development. While it is difficult to produce a blueprint to guide activities in very different local contexts, the sharing and in- depth analysis of experiences is fundamental if we are to increase knowledge and expertise on viable options and processes. Therefore we trust that the effort to bring the findings of this project to a broader audience will be appreciated, although a number of results presented herewith are just first steps to address very complex requirements. However, we also trust that the collective effort compiled in this publication may raise awareness on and ultimately contribute towards the sustainable development of this exceptional area and its people and the conservation of its unique environmental and cultural resources.

Maurizio Carrara
President, CESVI

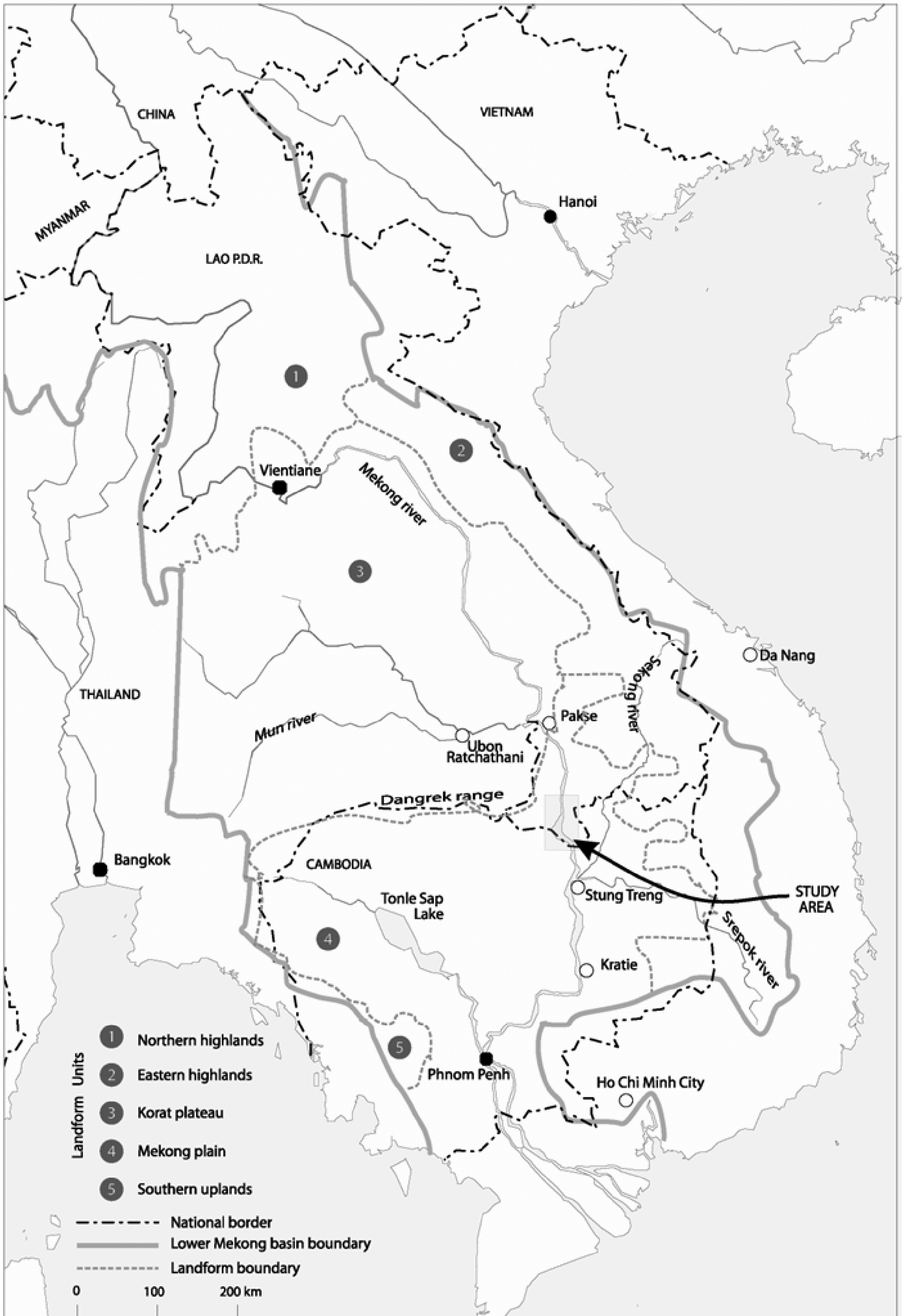


Figure 1. Lower Mekong river basin and study area

Introduction

The Siphandone Wetlands Project

Giuseppe Daconto

Lao P.D.R. is a country of great natural wealth. Its territory lies at the heart of the Indochinese peninsula. Most of this land is mountainous, for it includes an extensive range of the Annamite chain, while its central and southern parts are formed by the Mekong River floodplain. The Mekong crosses into Lao P.D.R. from China, cuts across the mountainous northern provinces, then flows more placidly when it reaches the border with Thailand, along which it runs for over 800 km. This floodplain is the most densely populated region of Lao P.D.R., and it still contains significant wetland habitats, which form an integral and fundamental part of the agricultural and natural landscape of this region.

The Mekong River, just before crossing into Cambodia, braids extensively into a maze of channels and islands and flows over the largest complex of waterfalls (Khone Falls) found in Asia. This archipelago, known as Siphandone, is among the most extraordinary natural sites of Lao P.D.R. and an exceptional riverine landscape. The Lao word "Siphandone" means "four thousand islands": a large number of islands and islets are created by the splitting of the riverbed into a labyrinth of channels, which reach a maximum width of about thirteen kilometres. The area is endowed with rich natural features, from large complexes of waterfalls and rapids to seasonally flooded riverine habitats. This extraordinary landscape is the product of tectonic phenomena which shaped the geology of the Indochina peninsula. Subsequent deposition of sediments and the braiding of the river course across the floodplain gave rise to the archipelago. The present day landscape of Siphandone also shows the influence of human activity over a long period of time. Extensive swathes of forest have been converted to paddy land, which now takes up most of the islands' surface. Each year, when the water level recedes, hundreds of kilometres of river banks and alluvial deposits are reclaimed from the natural vegetation so that people can grow extensive vegetable gardens.

Today Siphandone is home to about 100,000 people, who live in dense rural settlements spread along the river banks and on the islands, growing rice and other crops, catching fish and trading. People's livelihood is closely linked to the river, her resources and seasonal cycle. They have developed over the centuries a very rich capture fisheries tradition, rooted in an extraordinary body of knowledge of the biodiversity and ecology of the Mekong River. The few turbulent channels which bypass the Khone Falls are the site of exceptional fish migrations, on which the integrity of the riverine ecosystem and the basin fisheries rely. The area has a rich and ancient culture and historical remains of national relevance. People settled here a very long time ago by taking advantage of the extensive riverine network and alluvial land to develop rice agriculture and commerce. The Khone Falls have always been the natural southern gateway of Lao P.D.R.:

the cataracts interrupt the navigation along the river, but over the centuries they have been bypassed overland, producing a continuous but controlled relationship between the Lao people and their southern neighbours.

It appears that Siphandone altered little for many centuries; in recent times, however, there have been significant changes. While the population still lives in traditional settlements and sustains itself by and large with semi-subsistence agriculture and fisheries, the very recent opening-up of the country, along with growing market penetration and the improvements to basic infrastructure, have started to bring substantial socio-economic changes. An increasing number of tourists visit Siphandone each year, to admire the waterfalls and the Irrawaddy dolphins, whose movement further upstream is hindered by the cataracts. The site is not only a gateway along the Mekong corridor, but its location also has other important advantages: the floodplain is close to the much more developed Thailand, and it is also bordered by mountainous ranges to the east and the west which have areas still covered by dense humid tropical forests. These are difficult to access and still retain very high biodiversity value.

Siphandone (in particular its southernmost sector of Khone Falls) has attracted growing scientific interest in recent years, due its role as a natural gateway for fish migrations. The complex of falls at Khone is the largest natural obstruction to the water course along the lower river basin. The fauna of the Mekong River has a very high level of biodiversity and is still far from being fully documented. The biology and ecology of the over 400 fish species yet identified in the basin are poorly known. Siphandone appears to act as an ecotone for some species due to the presence of the falls. At the same time it provides a very wide range of niche space for the diversity of hydrological conditions and habitat structures produced as a consequence of the complex morphology of the river channel and the wide seasonal range of the river regimen.

The local population relies mainly on a single rice crop and semi-subsistence fisheries. There are few alternative sources of income. Their livelihood in threatened by an unrelenting demographic growth, and the threat is compounded by the limited availability of agricultural land. A decline in fish catches over the last decades has been widely reported by fisherfolk throughout the area. It is possible that at local level, rapid population growth and the gradual development of trading may lead to over-fishing and to the use of unsustainable fishing practices, threatening the migratory, reproductive or feeding habitats of the fish. The local fishing communities have developed customary management systems for fishery resources, based on local traditional knowledge and consensus-based processes. A broad fisheries co-management programme was promoted between 1993 and 1997 by the Lao Community Fisheries and Dolphin Protection Project (LCFDPP), aimed chiefly at addressing the perceived decrease in fish catches. This programme supported the development of a village-based management system for the fisheries as a joint effort involving both rural communities and the District and Provincial administration.

To further strengthen this pilot programme, in 1996 a project was conceived by CESVI together with the LCFDP project and the local administration. The Siphandone Wetlands Project (SWP) was eventually funded by the European Commission, Directorate General for External Affairs (budget line "Environment") and implemented by CESVI in cooperation with the Lao PDR authorities from 1997 to 1999. The local counterparts were the Agriculture and Forestry Division of Champassak Province (AFDC) and Khong District, while the central government counterpart was the Ministry of Agriculture and Forestry, working through the Centre for Protected Areas and Watershed Management (CPAWM) of the Department of Forestry. The project was coordinated by a Project Management Unit composed of an expatriate director and a Lao director, who were based at AFDC in Pakse. The Project Steering Committee was chaired by AFDC and composed of the Project Management Unit and representatives from CPAWM, the Livestock and Fisheries Department, the Provincial Forestry Office, the Provincial Governor Office, the Provincial Planning and Co-operation Office, Khong District and the Delegation of the European Commission. Although the wetland complex identified as Siphandone falls within the territory of two districts, Khong and Mounlapamok, the project mainly focused its efforts in

Khong District, in order to achieve as effective an impact as possible with the resources available.

The project recognised the need to strengthen the participatory resource management processes established by the LCFDPP, to help the communities formulate rules and gradually adapt them to local circumstances, and to assist the local authorities in developing long-term planning and monitoring of these practices. In addition, it was clear that the planning and monitoring of management and conservation practices needed to be backed up by the acquisition of a good deal of scientific knowledge concerning the geographical and ecological characteristics of the Siphandone wetlands and the socio-economic factors which affect the natural resources of the area. There was also a need for research into the environmental and biological processes which sustain the biodiversity and resilience of the local ecosystem and on the patterns of exploitation of resources by local communities. At the time of the project, little such knowledge had been systematically documented. There had been investigations into the area by ichthyologists, whose findings had confirmed its high level of biodiversity, especially in fish species, but even here, limited information about the biology and ecology of fish species had been recorded. More significant was the wealth of information available through local traditional knowledge of the region's ecology, but this needed to be documented and validated through scientific studies. These constraints compounded the difficulty of supporting sustainable resource management measures.

The SWP's long-term objectives were therefore defined as follows: to promote the conservation and sustainable management of fisheries and other Mekong basin riverine aquatic and forestry resources by empowering local communities to set up effective co-management systems in co-operation with local authorities; and to improve the quality of life of the local communities through socially and environmentally sustainable means. Specific objectives were also identified, namely: (1) to establish, implement and monitor locally managed "fish conservation zones" and to regulate other areas of aquatic resource management, in co-operation with villagers and the government; (2) to promote participatory approaches to managing aquatic resources and fisheries and research into these fields; and (3) to build local capacity to manage the environment in general and aquatic resources in particular on a sustainable basis.

Given local circumstances, the project advocated a pragmatic bottom-up approach, rather than attempting to develop an overall management framework. It was deemed particularly important to base the promotion of sustainable natural resource management on existing local capacities and experiences. The process addressed the crucial issue of decentralising the responsibility for resource management, a policy which had been endorsed and was being directly promoted by the Lao Government, who were delegating authority over the resource base (aquatic habitats and fishing grounds) to rural villages under the supervision and support of the District and Provincial administration. The day-to-day work of the project was implemented by a team of eight local staff, including a field team of five staff seconded from the provincial and district Forestry and Fisheries offices. The project's central office was in Pakse at the AFDC, while the field team was based in the project area, at a station in Done Khone (*Done* is the Lao word for island). They were aided by an expatriate staff, formerly associated with the earlier LCFDPP and now working on a part time basis, and also, for the first year, by an additional expatriate research assistant. A team of expatriate experts also provided short term inputs involving technical tasks, field surveys and project planning and monitoring. The implementation of the project was hindered by a number of staffing problems, including a major disruption due to the repatriation and replacement of the expatriate project director, for health reasons, during the final phase. The project, originally planned to last two years, was eventually concluded in August 1999, after 28,5 months.

The project activities involved a complex set of issues; as is typical of such "participatory" projects, activities were closely interrelated with regards to actors, targets and goals. However, for analytical purposes, they were categorised under five programmes (CESVI, 1997), which are briefly summarised as follows:

1. Wetland monitoring and assessment: this involved a number of research oriented tasks aimed at investigating the salient environmental and socio-economic features of the area, with the ultimate objective of broadening the baseline information available on the wetland site (Figure 2). This programme involved three areas:

    1.1 Fisheries and biological baseline data collection: the collection of time series of catch and effort data for a large number of fishing gear at the project station at Ban Hang Khone, plus data compilation and analysis; the collection of traditional knowledge on fisheries, fish biodiversity and riverine habitats; the collection of observations on selected fisheries practices; observation of avian fauna in Khone Island.

    1.2 Environmental assessment: a wetland habitat identification and mapping study; a remote sensing study and GIS development; a vegetation survey and the development of database on flora; a forest and riverine habitat survey and the identification of habitat management issues; a geological and geomorphological baseline study.

    1.3 Socio-economic assessment: a study based on village and household surveys to outline key socio-economic and resource management issues.

2 Capacity-building and education: this involved on-the-job training for counterpart staff during the implementation of technical tasks; the development of extension material; the production of educational material for schools and awareness raising material on environmental issues; local workshops to give feedback on the results of research and extension work; awareness-raising initiatives with several local target groups concerning issues of natural resource management in the area; exchange visits.

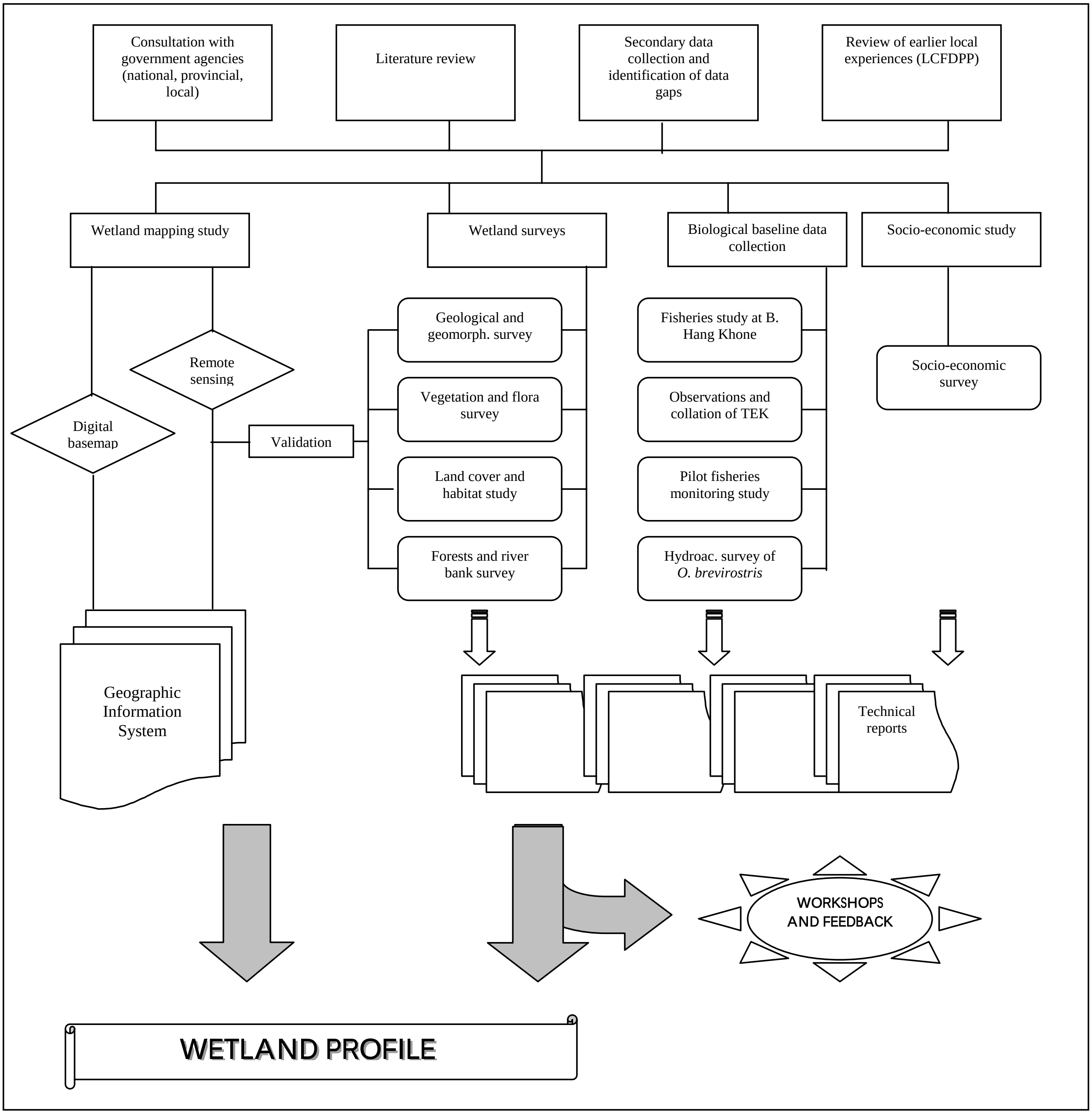
3 Aquatic resource management: this aimed at developing the capacity of local institutions so that they could monitor and assist the village-based fisheries co-management system. A series of semi-structured village surveys were carried out to monitor the community-based processes. The programme was carried out by the field team which was composed of staff from the local authorities, with the objective of establishing basic procedures for the institutionalisation of the process through reviews and regular feedback between villages and the authorities.

4 Community development: this involved a set of rural development activities aimed at testing out small scale rural income-diversification schemes (village tree nurseries, fruit tree grafting, composting); supplying some basic infrastructure (a hospital incinerator, schools in selected villages, etc.); and supporting key government programmes on natural resources (land allocation, gun hand-over, etc.)

5 Project management: this involved the delivery of key project management functions, such as planning, supervision and reporting, coordination and consultation with authorities at various levels; financial and human resources management.

In general terms, environmental management projects tend to adopt one of two distinct approaches to resource management: either a problem-oriented approach, where operational goals and functions are defined mainly on a sectoral line, through a strongly demand driven process, to address a key sectoral concern, be it fisheries management, water resource management, etc.; or an area management approach, where a broad resource management framework is designed, based on a multidisciplinary and inter-sectoral assessment of issues, constraints and goals, through well-structured planning processes. Both these approaches have their strengths and

Figure 2. Outline of the wetland assessment study component.



weaknesses; they also place different demands on the local institutions responsible for planning and implementation. In conditions of limited institutional capacity, a sectoral approach is often better received and can give rise more readily to the momentum necessary to bring about change in entrenched problems and practices. More demanding inter-sectoral programmes require relatively sophisticated inter-agency coordination mechanisms, a range of technical skills and a strong policy drive. In addition, problem-oriented environmental management interventions have distinct limitations when faced with the complexity and interdependence of environmental and socio-economic factors found even in relatively remote rural settings. However, while the two methods are theoretically distinct, in practice they may often be complementary. The Siphandone Wetlands project strove to blend a clear focus on a sectoral management problem (fisheries) with an effort to broaden the local resource management agenda across a wider range of issues. In other words, the fisheries co-management system in Khong was supported both because of its own merit and goals, and also as an entry point for broader capacity-building and participatory processes. These aims were pursued through small-scale village-level pilot activities and at the same time were put into context by technical assessments and surveys carried out within the research components of the project. The near term objective of this research was to advance the knowledge of this unique wetland and its people; its medium-term objective was to provide an initial foundation for a broader appreciation of Siphandone values and functions and of the issues at stake in the area. Its activities successfully produced a description of the general environmental and socio-economic features of the area. [1]

Given the complexity of the area and its ecological features, it goes without saying that the results of some of the research activities are of preliminary and indicative value only. Moreover, some of the studies have been affected by the many contingencies and constraints under which this field project laboured, carried out as it was over a relatively short period of time. The site fully deserves years of scientific investigations and would provide material for an excellent case study on the fundamental aspects of riverine ecology: in the case of the Mekong River ecological research is only in the initial stages. Furthermore, the area provides a unique setting for the study of an artisanal fishery with centuries old traditions and elaborate knowledge and technologies.

Nevertheless, upon conclusion of the project, it was deemed useful to compile some of the information and analysis generated by the project team with the ultimate objective of providing an overview of Siphandone wetlands, its key features, issues, problems and opportunities. It is hoped that this book will enhance awareness of this unique wetland site, as well as contribute to the move to sustainably manage and develop it. Such a result would benefit many: its inhabitants, who strongly depend on the many resources provided by the river; the Lao nation, which not only takes pride in it but also benefits from it; anyone concerned about the preservation of this area and the economic development of its people; and those seeking a better understanding of the culture and way of life which have been supported by the Mekong River over millennia.

[1] The full list of project technical reports is included in Daconto, 1999.

Chapter 1

Siphandone wetlands: an overview

Giuseppe Daconto

Siphandone is known for its complex of rapids and waterfalls and the unique landscape formed by the braiding of the Mekong River. Before the inception of the Siphandone Wetlands Project, the site had been subject to a limited number of scientific investigations (Roberts, 1993; Roberts and Warren, 1994; Roberts and Baird, 1995; Singhanaovong et al., 1996). These were mainly concerned with the extraordinary ichthyofauna of the Mekong River, which is very diverse and undertakes spectacular seasonal migrations. Some of these studies (Roberts, 1993; Roberts and Baird, 1995) pointed out the special features of the riverine vegetation and habitats of the area, such as seasonally flooded forests and riparian vegetation, and noted the still largely unexplored ecological relationships between the hydrological cycle of the river, the aquatic fauna and the plant communities.

These initial observations stressed the importance of undertaking additional investigations into the special features of the wetland site, the variety of its habitats, the complexity of its ecosystem and the wealth of ecological knowledge which has been accumulated by the local people. A review study on fisheries ecology and hydropower in the Mekong River produced by the Mekong River Commission in 1994 emphasised the unique character of the area, its fundamental importance for the further study of the Mekong fisheries ecology and the need for the preservation of its biodiversity and cultural values (Hill and Hill, 1994).

This chapter aims at presenting the main environmental and social features of the site, including a general description of the area, a brief overview of its history, the present demographic conditions and an introduction to the complex range of problems and demands which affect the natural resources and the people of Siphandone.

DESCRIPTION OF THE SITE

Location of the site

The large complex of islands and wetland habitats is formed by the Mekong River before it enters Cambodia, about 760 km from the sea. The area is located in Champassak Province and falls for the most part within the District of Khong. Its most western sector, including the floodplain west of the river channel, lies within the District of Mounlapamok. The provincial capital, Pakse, is about 140 km north, connected to the site by Route 13. Khong village is located on the largest island of the archipelago, Done Khong. Mounlapamok village lies on the right river bank.

The geographical scope of the research activities presented in this study covered two main levels. Most of the resource assessment studies focussed on an area ranging from the northern tip of Done (*island*) San to the border with Cambodia to the south. This site is included between latitude 14° 18' N and 13° 54' N and longitude 105° 44' E and 106° 0' E. It contains the large complex of islands which traditionally goes under the name of Siphandone, encompassing about 43 km of the length of the river corridor. However, the administrative boundaries of the project area were those of Khong District, whose upstream limit goes up to latitude 14° 31' N: therefore a number of activities also involved villages situated along the left bank, north of Done San (see maps in appendices).

If one considers the broader geographical context of the southern end of Champassak Province, it is evident that the study area is at the centre of a region of exceptional biodiversity value. In fact the densely populated Mekong plain is bordered by vast forested areas which cover the mountain range to the east and stretch further into Attapeou Province. This area, centred on the Xe Pian river catchment, has been designated as a National Biodiversity Conservation Area and retains an exceptional diversity of flora and fauna. Its boundary runs about 2 km east of Route 13 approximately as far as Ban Hat. A large sector of the floodplain west of the river channel is less densely populated and still retains lowland forest cover. The adjacent and relatively unknown forested range towards the border with Cambodia is also believed to retain wildlife which have disappeared from the more densely settled river valley; this area was proposed for gazetting as National Biodiversity Conservation Area, to be known as Dong Khanthung.

Climate

The climate is affected by the monsoon cycle, including a SW monsoon (humid-hot) from late March to October and a NE monsoon (dry cold) from November to early March. The dry season is from January to April, while rains fall from May to October, carried by the SW monsoon. During the rainy season precipitation is heavy, humidity and temperature high and there is prolonged cloud cover. Transitions between the two seasons are generally very short. The monsoon-dominated climate therefore presents a marked seasonality which deeply affects the hydrology and ecology of the Mekong, as it does with most tropical Asian rivers.

The Hydrology and Meteorology Department runs a pluviometric station in Khong. The average total annual rainfall in 1979-97 was 1,753 mm. Average total monthly rainfall is presented in Figure 3. There are usually two periods of peak rainfall, in June and August-September. The available time-series of total annual rainfall during 1980-1996 show a degree of erraticity from year to year both in Pakse and Khong (Figure 4), a fact which explains the occurrence of both droughts and floods in the region.

Main hydrological characteristics

The collection of hydrological data on the Mekong basin is coordinated by the Mekong River Commission Secretariat through the Lower Mekong Hydrological Network. In Lao PDR data on the mainstream is collected by the Department of Communication (DoC) and on its tributaries by the Department of Meteorology and Hydrology. The Mekong River stations included in the network closest to the project area are those of Pakse (km 869 from the sea), Ban Channoi (km 767) and Ban Hat Sai Khoume. The last two are within the study area. Additional water level stations within the project area were established a few years ago by DoC at Ban Takho, Ban Khone Tai, Ban Done Saddam Tai, Hou Sahong Thun and Hou Sahong Hang-kon Kiew. With the exception of Pakse station (located over 100km upstream) the records from all these hydrological stations present extensive gaps. Hydrological information within the study area is therefore very limited.

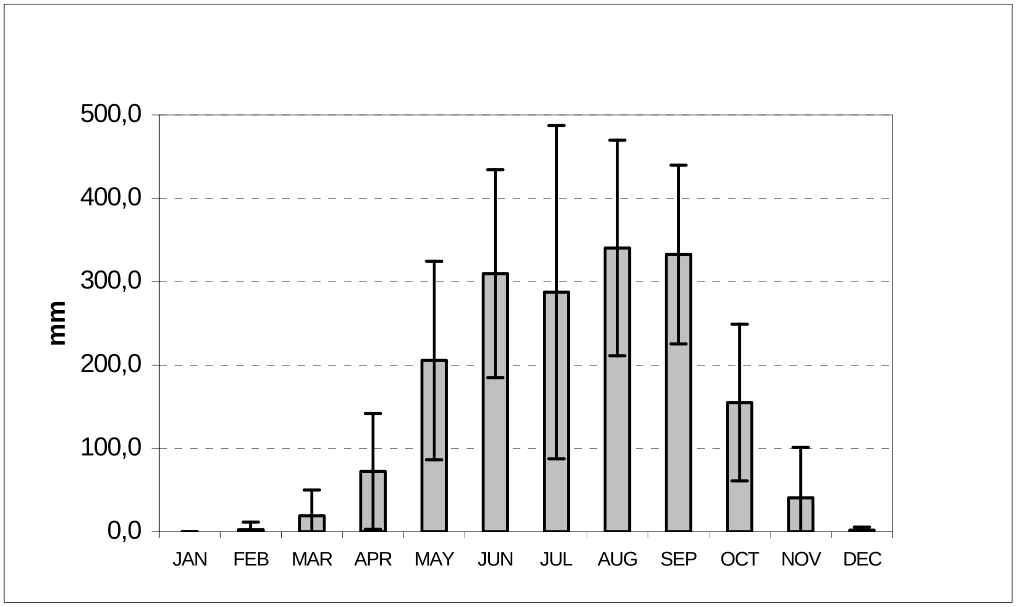


Figure 3. Monthly rainfall in Khong: mean and standard deviation (1979-1997).

Source: elaborated from records of Meteorology and Hydrology Dept, Pakse.

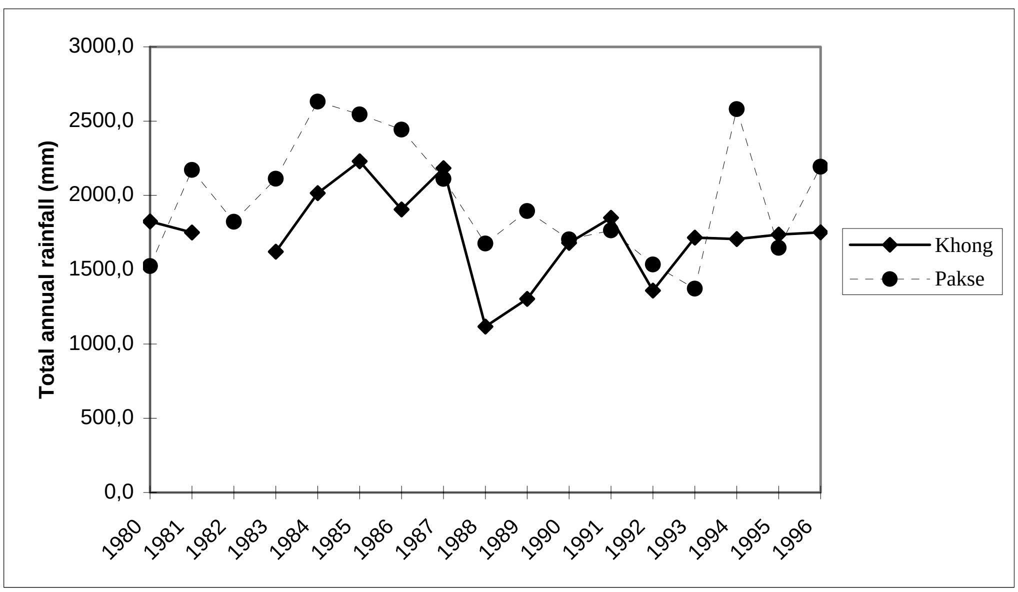


Figure 4. Rainfall in Khong and Pakse (1980-1996).

Source: elaborated from data of Meteorology and Hydrology Department.

The discharge of the Mekong River fluctuates with a marked seasonal cycle. The water level rises rapidly in June and the flood waters are fast and very turbid; they may peak in July and again in August-September. The river often floods the corridor, causing considerable damage to the local population living along its course and to their rice crop grown along the banks. As pointed out by Pantulu (1986), this flooding is crucial for maintenance of the riverine ecosystem: the Mekong River water has a very low content of nutrients and the river food-webs are nourished by allochthonous inputs contained in the detritus collected by the floods; the annual flooding thus prompts a vigorous reproductive season. At the end of the rainy season in October-November the water level falls rapidly and reaches its minimum in April (Brambati and Carulli, herewith); the dry season water flow is clear.

A few minor tributaries (Houay Touay, H. Kammouan, H. Kadian, and others) join the Mekong between Pakse and the Siphandone area. Within the study area, the eastern floodplain is drained by seasonal streams. Houay Phapheng joins the Mekong immediately downstream of Phapheng waterfalls. These streams are dry for several months during the dry season. When the Mekong's water level rises, water may back up into these streams, increasing the flooding of the plain. This process also allows the fish to migrate towards the floodplain's numerous seasonal wetland habitats (ponds, streams, and back-swamps): during the wet season, a large number of fish species rely on this lateral migration to allow them to spawn, after which they return to the main course of the river.

The eastern floodplain (Mounlapamok District) is similarly drained by seasonal streams and also by the Xe Lamphao River which runs along the border with Cambodia and eventually joins the Mekong east of Done Khong. The lower catchment area of the Xe Lamphao includes extensive seasonally flooded low-lying areas and grasslands (Baird and Phylaivanh, 1998). The floodplain has a much lower population density than the left bank of the Mekong, with its long history of settlements and communication: the natural floodplain drainage pattern and associated seasonal wetland habitats have therefore been better preserved.

Table 1. Daily flows at Pakse hydrological station 1956-1990

	Flow m^3/sec
Q min (minimum flow recorded)	1 060
Q 97% (flow which is statistically equalled or exceeded 97% of the record time)	1 450
Q average (average flow recorded during the observed period)	9 790
Q 3% (flow which is statistically equalled or exceeded 3% of the record time)	32 900
Q max (maximum flow recorded)	56 000

Source: Compagnie du Rhone, 1994

Landscape and physical features

The entire area of central-southern Laos (i.e. south of Vientiane) lies within the Mekong River catchment area. Three main physiographic units have been identified in this sector of the basin (Figure 1): the first, the Khorat Plateau to the west, covers most of north-eastern Thailand and also includes the Vientiane and Savannaketh plains. The second unit is formed by the Annamite chain range, which lies to the east along the border with Vietnam. The third unit is the Great Mekong Plain, which covers most of Cambodia and the river delta in Viet Nam. The northern tip of the Great Mekong Plain, the plain of Champassak, lies between the first and second units. The Champassak plain is a triangular-shaped river valley sandwiched between the Phoum Dangrak hill chain to the west and, to the north-east, the southern-most range of the Boulevan plateau. The border with Thailand runs along the Phoum Dangrak hill chain, which separates the Champassak plain from the Khorat Plateau.

Past Pakse, the Mekong River valley is limited to the east by the densely forested hill range, which separates it from the Xe Kong river plain and now falls within the Xe Pian Biodiversity Conservation Area (its highest hill is Phou Muay at 844 MSL). Further south, the undulating river valley widens and the Mekong, before rolling over the Great Plain into Cambodia, crosses a low hill range (highest point Phou Milai, 270 MSL) and the complex of Khone faults which are responsible for generating the extensively braided river pattern and its unique landscape of alluvial islands, rapids and waterfalls, which are known as Siphandone.

The river, which is about 1,5 km wide at this point, first splits north of Done San and braids extensively across the plain in the reaches between Done Khong and the Khone Falls, where sediments have formed a large number of islands. The river corridor widens, reaching a maximum width of about 14 km at Done Khong (between the most eastern and western channels). The elevation within the river corridor ranges from about 50 MSL to 239 MSL (at Phou Luang in Done Khong).

The northern sector of the wetland is characterised by large islands (the main ones being Done San, Done Khong, Done Hi-Gnai, Done Het, Done Koy, Done Khamao) and wide river branches. The main channels contain a series of pools which may reach considerable depth. Detailed information on the bathymetry is limited to dry season hydrographic surveys conducted in preparation for the 1994 Hydrographic Atlas of the Mekong and reported therein. Water depth data is given for the most eastern channel up to Ban Nakasarn and for the channel NW of Done Khong. The deep pools of the channels (depth up to 20 m N of Done San) appear to be produced by the scouring of the bed by river floods. The Mekong River discharge is subject to extreme variations between wet and dry season flows and may reach over 50.000 m^3/sec at this latitude.

The central-western sector of Siphandone (between Done Som and the Cambodia border) presents an extensive complex of a few relatively large alluvial islands (Done Nagkhouat, Done Loppadi, Done Phouman, Done Xangphai, Done Long, Done Than). These are separated by narrow channels, rapids and a very large number of islets. The shallow alluvial areas are covered by vegetation tufts and are often cultivated during the dry season; they become extensively submerged during the wet season. Navigation is difficult in this sector, particularly during the dry season. The central-eastern sector includes the large Done Som, separated from the densely populated coastline by a wide river branch, where Done Khe is found.

The southern sector includes a few sandy islands N of the fault line (Done Tholati, Done Xang, Done Det, Done En, Done Tan). Further south, the river corridor becomes narrower. Along the 10 km reaches across this sector, the river profile presents the highest gradient of the lower Mekong course, dropping from a level of 70 MSL to nearly 51 MSL (Compagnie Nationale du Rhone, 1994). This drop generates the large complex of rapids and falls along the narrow rocky channels (*hou*) found among the most southern islands. The largest islands (E to W) are Done Phapheng, Done Saddam, Done Sahong, Done Khone and Done Saniat. The first three are separated by the channels (from E to W) Hou Phapheng, Hou Saddam and Hou Sahong. The highest step (10-15m), in the eastern-most channel gives rise to the famous Phapheng waterfalls. The drop is higher during the dry season, due to the lower water level.

The western-most part of this southern sector is a labyrinthine expanse of islets and shallow channels which is known as Tholati wetland (approximate surface 14 km^2). This area lies between Done Tholati and Done Xang to the north, Done Det to the east, Done Saniat to the south and the hills in Cambodian territory to the west. It has an attractive and sometimes fascinating landscape, whose appearance changes dramatically depending on the level of the river.

The narrow fast-flowing channels found between the southern islands discharge into a single deep pool situated on the border with Cambodia. The pool's maximum depth is 35m as measured in March 1994 (Stacey, 1996). Irrawaddy dolphins (*Orcaella brevirostris*) are found in the pool. Immediately to the south, the corridor narrows to a width of about 3 km, and from here the river enters Cambodia, where alluvial sediments give rise to more islands, but never generate a complex as extensive as Siphandone.

Land cover and use in the river corridor

The Mekong River corridor within the Siphandone area is a mosaic of different landscape elements. These are the result of the interaction of the river flow with different elements of substrate and also of intensive human pressure. Human population has inhabited and changed

Siphandone's landscape over a very long time. This is an area of ancient settlements, as ruins and various traditions and records attest. The most striking changes are due to land use conversion, in which extensive tracts of forested land have been converted to paddy agriculture. On the basis of geomorphological characteristics, Brambati and Carulli (herewith) have identified six main geomorphological units in the study area. These units and their main physical characteristics and use are summarised in Table 2.

Forested and agricultural areas

Existing forest cover in the study area is a mosaic of different forest types which frequently merge into each other. According to Maxwell (herewith) climax forest type is represented by *mixed evergreen/ deciduous, seasonal, hardwood forest (mxf)*, whose remnants are found in Done Khong and in the floodplain (in the form of patches and also narrow fringes bordering the seasonal streams). The southern-most islands of the Siphandone complex, which have a much lower human population density, are also extensively covered by this type of forest.

Centuries of agricultural practice have been critical factors in the development of *dipterocarp-deciduous oak forest*, which covers extensive tracts of the floodplain. Wood extraction and seasonal fires, as well as the clearing of land for conversion into paddy fields, have contributed to the degradation of this dry forest, which now merges with the agricultural land throughout the river floodplain through extensive *secondary growth* areas.

With the mentioned exception of the southern-most islands and of the hills of Done Khong, all the alluvial islands have been converted to paddy land and generally contain only a very narrow wooded fringe along the coastline: here, remnants of the original forest cover merge with cultivated trees and bamboo. Rice paddies on the islands are frequently scattered with sparse trees, remnants of previous forest cover. Agricultural land also takes up most of the corridor between the left river bank and Route 13 and extends further east into a mosaic of sparse dipterocarp-deciduous oak forest and secondary growth areas. Irrigation is presently being introduced in Khong District through a large scale programme providing villages with water pumps, ditches and supplies through a micro-loan scheme. During the dry season of 1997-1998, the scheme reached over 90 villages of the district, involving a few farming units in each village and enabling them to plant a second rice crop.

Land use conversion in the floodplain is presently extending further east. Wood extraction (for fuelwood and construction) is still very common throughout the existing forested areas. Non-timber forestry products are also widely collected (Elliot, herewith). Forest and habitat conservation measures have been introduced into specific parts of the study area: namely, the Xe Pian NBCA, whose western sector covers a vast swath of the Mekong floodplain; a provincial conservation forest covering the forested hills of Done Khong; and a conservation forest designated by the district to protect the residual evergreen forest in Done Khone. More recently, the rapid implementation of the Land Allocation policy has produced village management plans, including the designation of zones under differentiated management systems within each village's territory. The effective implementation of all these conservation and management measures, whose aim is to ensure sustainable exploitation by the growing population, is still by and large an unmet challenge.

A typical feature of Siphandone and its extensive alluvial deposits is their seasonal utilisation for cultivation. River banks, sand dunes and islets are rapidly cleared of vegetation when the water level starts receding. The prompt availability of water and the easy access through the waterway network turn these extensive seasonally-flooded areas into a very large complex of vegetable gardens. Through the project GIS, we have estimated that, within the 45 km-long reach of river between Done San and the border with Cambodia, and accounting only for the coastline of islands with permanent human settlements and that of the outer river banks, the total length of the coastline is in the order of 700km. This estimate does not include the myriad islets which emerge during the dry season and whose shores are also intensely cultivated.

Wetland habitats

Wetlands can be classified according to a number of criteria, such as the source of water and nutrients, hydrological system, vegetation, etc. (Roggeri, 1995). A number of classification systems have been utilised thus far in the Mekong basin and the development of a standard classification system is currently under way (Dobias, 2000). While several classification systems may complement each other, the ultimate classification guideline should depend on the goal of the classification exercise. Given the limited field-level knowledge of wetland habitats in the region, field investigations on the characteristics of wetlands and of their uses and into local classification systems can provide much-needed bottom-up inputs into such basin-wide exercises.

Siphandone is a large complex of different wetland habitats. The hydrological conditions of the Mekong River vary greatly across the web of channels and over the seasonal river cycle. A general classification guideline was provided by the initial classification system available in Lao PDR, as produced under the Mekong Commission Wetland Programme (Mekong Secretariat, 1993). However, given the broad range of typologies and the fact that this study is only at its initial stage, our wetland identification and description exercise was not aimed at fitting into a formal framework, but rather at facilitating the initial collection and compilation of field evidence from a variety of sources: the geological and geomorphological survey, vegetation surveys, the interpretation of satellite imagery and aerial photos, habitat reconnaissance surveys and compilation of local vernacular knowledge.

The exercise has produced a preliminary identification and description of the main landscape elements and habitat features (Altobelli et al., 1998; Brambati and Carulli, 1999; Maxwell, 1999). Given the complexity of the site, it is recognised that the accurate analysis, classification and mapping of wetland habitats throughout these reaches of the Mekong will require additional work. However, a summary of the information gathered so far is presented herewith (see Table 2 for a schematic outline). Two groups of wetland habitats can be identified: riverine (in-stream) habitats associated with the complex river morphology; and floodplain seasonally wet habitats, including natural and man-made habitats.

1. <u>Riverine wetlands</u>: these include several types of riverine habitats, differentiated by morphological features and flow conditions within the river channel. In-stream flow characteristics of these habitats are still by and large undescribed. The following main types can be identified, based on general morphological and hydrological characteristics:

a) Perennial river channels, ranging from the widest left branches (i.e., east of Done Khong and east of Done Som) to the maze of narrow channels separating the islands in the central and southern sectors. The wide river channels contain deep pools and generally have steep sandy banks, most of which are eroded and unstable (Brambati and Carulli, herewith). Sand bars and rocky outcrops emerge from the river bed when the water level decreases: the minor alluvial deposits of sand bars and banks provide an ever-changing substratum only partially stabilised by the growth of riparian vegetation tufts. Due to hydrological conditions, the morphology of the shores of the channels and the associated vegetation cover are therefore very varied, and include:

- steep sandy shores of the larger islands in the central sector, often cleared of vegetation during the dry season and cultivated;
- rocky shores of the narrow channels separating the southern islands (Hou Sahong and Hou Saddam being the main ones);
- sandy beaches, occasionally found during the dry season at the upstream tip of large islands in the central sector (i.e., Done Tan, Done Khong, Done San) or along reaches of the southern shore of Done Khone and Done Saddam and the eastern shore of Done Saniat, where alluvium tends to be deposited due to local flow conditions.

b) *Perennial waterfalls*, found in extensive complexes across the fault lines in the southern sector of the wetland (see Brambati and Carulli, herewith). The main waterfalls are the spectacular Phapheng, Somphamit and Li Pee.

c) *Rapids*, widely scattered along the rocky channels separating the southern islands, whose shores are seasonally submerged by fast-flowing waters during the wet season and where riparian vegetation is characteristically bent over by the strong currents. Rapids also form in the extensive shallow sectors to the west.

d) *Residual channel systems*: this refers to two rather unique areas, one occurring in the central-western sector, between the right bank and Done Loppadi; and the second between Done Tholati, Done Xang and the Somphamit Fall, which is known as the Tholati wetland. These areas are extensive and shallow, with generally limited quantities of alluvial sediments over a largely exposed sandstone riverbed: during the dry season the water flow is limited to a system of residual micro-channels. The Tholati wetland is a remarkable site, which can be divided in two sub-units (see Table 2 for further details). It is mostly submerged during the peak of the flood season and has been produced by the massive erosion of a pre-existing island (Brambati and Carulli, herewith).

These riverine wetland types are composed of a large mosaic of different habitats, whose morphological and biotic features appear to be strongly dependent upon the interaction of river flow and the substratum. Because of this, the localised characteristics of flow regimens, substratum, depth and hence vegetation cover provide a wide variety of environmental conditions and habitats for the riverine fauna, and possibly also an ample set of niche conditions. Our understanding of the relationship between the fauna and the different riverine habitats is extremely limited. An impressive body of traditional knowledge on ecological matters has been accumulated by the local population over the centuries. This knowledge allows them to skilfully exploit the environmental diversity with an impressive range of fishing gear and techniques, carefully tailored to local and seasonal hydrological conditions and the great diversity and variety of life cycles of the Mekong fauna (Baird, herewith). A proper scientific investigation into these issues would require an extensive research effort over a long time: the site clearly qualifies for the establishment of a long-term aquatic ecology research programme.

2. <u>Floodplain wetland habitats</u>: these are comprised of a variety of seasonally wet habitat types, which are either severely impacted upon by man or entirely man-made:

a) *Seasonal streams* drain the floodplain and the larger islands: these often dry up after the rainy season, but small pools may retain humid conditions for a longer period. Flat alluvial land (both in the mainland and larger islands) is criss-crossed by a web of such streams, which often retain only a very narrow fringe of vegetation along their edges. They may flow into ponds found in depressions across the agricultural land. During the peak of the flood season, river water may back up into these streams and flood the adjoining plain behind the steep banks. These streams play an important role in the reproductive behaviour of laterally migrating fish species. The southernmost islands, lying across the complex of Khone faults (e.g., Done Saniat), contain a series of narrow valleys corresponding to the fault lines, which also have humid habitats (streams and pools, sometimes retained during

Table 2. Overview of Siphandone morphological units.

Geo-morphological units	Main morphological features	Vegetation cover and wetland habitats
Done Khong plains	Sandy alluvium; limited silt deposits near the bottom of the hills. Seasonal streams drain the plain. Ponds scattered throughout agricultural land. Steep river banks are exposed during dry season, frequently eroded. The island is separated from the mainland by wide river channels.	Remnant *mixed semi-deciduous-evergreen forest* is found in the northern half. Almost all of southern half has been converted into paddy land. River bank tops are covered by remnant forest vegetation and village trees. The river banks are cleared during the dry season and cultivated with a variety of crops. Wetland habitats include the wide deep river channels separating Khong islands from mainland; *nong* scattered in paddy land; seasonal streams and ditches, rice paddies.
Done Khong hills	Volcanic rock hills up to ca 250 MSL and narrow stream valleys.	Mosaic of remnants of *mixed semi-deciduous-evergreen forest* and *dry dipterocarp oak forest*, with scattered tree plantations. Seasonal streams in valley bottoms.
Large islands of Som, Phouman, Xangphai, Loppadi, Long, Tholati, Xang, Tan	Permanent large alluvial islands, 6-10 m sand layer. Few relict channels can be identified (i.e. in Done Som). Steep river banks exposed during dry season, frequently eroded. Ponds scattered throughout the paddy land. Short seasonal streams sometimes present in larger islands. River channels wide to narrow, strong current, with deep pools in the wider branches.	The alluvium is almost entirely converted to paddy land. Fringe vegetation is left along the seasonal streams and on the river bank tops, along with village trees. The steep river banks are seasonally cleared and cultivated with a variety of crops. Wetland habitats include wide river branches with occasional deep pools; *nong* scattered in paddy land; seasonal streams draining the alluvium; remnant river branch in Done Som, rice paddies.
Small islands	Small alluvial islands (2-6 m alluvium thickness) often seasonally inundated. Rocky river bottom exposed during dry season with shallow rapids. Many formations of sand bars.	Riverine vegetation, often cleared by farmers during dry season and planted with rice and (along the banks) a variety of garden crops. Frequent rapids and exposed river bed in dry season (micro-channel system). Extensive shallow areas are submerged during wet season. Large variety of flow conditions.
Tholati wetland	It covers an area of approximately 14 km^2. Very thin alluvium, which is relict of larger island(s); sandstone river bottom extensively exposed during dry season; wide system of residual micro-channels; the area is seasonally inundated for several months. Two sectors have been identified: the NW sector, where more sediments are visible; and the S sector, where sediments are very limited and almost barren sandstone blocks are exposed, just upstream of Somphamit waterfall.	This is the most characteristic wetland habitat in the study area. The vegetation cover of the two sectors is relatively different in structure and floral composition (of overall limited diversity). The NW labyrinthine sector (micro-channel system), locally called *boong*, is covered by dense tufts of amphibious riverine shrubs dominated by *Telectadium edule*, along with *Homonoia riparia*, *Rotula aquatica* and *Xanthonnea parvifolia*. The seasonally inundated southern sector (called k*ai-koum* area in Maxwell, herewith) is covered by sparse *Phyllanthus jullienii* shrubs and grasses growing in crevices. Rapids and exposed river bed are common in the dry season, when the water flow is minimal, particularly in the S sector. Extensive areas are flooded during wet season and plants are often entirely submerged for a few months. The area is intensely fished.
Southern islands (Done Som, Done Khone, Done Phapheng and Done Sadam)	Series of hills (max elevation approx. 70 MSL), aligned in NNE-SSE direction and separated by stream valleys corresponding to the NNE-SSE fault system. Cut both to the N and to the S by a E-W fault system. Seasonal streams drain the short narrow valleys between the hills. The minor river branches (corresponding to NNE-SSE and the E-W faults systems) expose the rocky river bottom with rapids during dry season and generate the major waterfalls found across the E-W fault line.	Hills are still covered with *mixed semi-deciduous-evergreen forest*, frequently degraded by wood harvesting and clearing, and merging with village trees. Best forest cover is found in Done Phapheng and Done Saniat. Limited patches of alluvial soils in few valley bottoms and near villages have been converted to paddy. The fast flowing rocky channels expose river bent shrubs and trees during the dry season. River flow in these channels is highly turbulent with rapids. Waterfalls occur at major steps across the sector. Seasonal streams drain narrow valley bottoms (corresponding to the fault lines). They generally dry up during the dry season, with the exception of a few pools. Aquatic plants are found in these streams and small pools where water is left during the dry season.
Southern rocky islets	Sandstone outcrop islets with very limited alluvial sediments, which fringe the larger southern islands (in particular around Done Saniat and towards the Cambodian order), mainly south of the falls. These islets are seasonally inundated by fast currents during the wet season. Within this unit, there is a large deep pool on the border with Cambodia.	Areas with deeper sediments form the so-called Acacia-Anogeissus zone (Maxwell herewith), based on dominant tree cover: *Anogeissus rivularis* and *Acacia harmandiana*. These trees up to 10m tall root sparsely on the limited sediments and are characteristically bent over by the river flow, which submerges the islets at maximum discharge. Scattered shrubs (*Homonia riparia*) also grow on the alluvial sand. These shores are seasonally inundated; river channels have turbulent flow in wet season and the mass of submerged roots and branches probably provides a hiding place and feeding habitats for aquatic fauna. The alluvial islets are often surrounded by adjoining areas where sandstone outcrops are almost entirely exposed and dominated by *Phyllanthus jullienii* (kai koum).

the dry season). The conspicuous vegetation cover conserved on these islands adds to the attractiveness of such habitats.

b) *rice paddies*: these are man-made wetlands; while they were until recently exclusively rain-fed, irrigation is rapidly expanding throughout the area, both in the river plain and on the larger islands;

c) *ponds (nong)* scattered throughout the agricultural land both in the larger islands and in the floodplain. These are typical elements of lowland Lao agricultural landscapes and play an important traditional role in increasing the farmers' food supply, through the seasonal harvesting of pond fish (Baird, herewith).

Some of these floodplain features are typical of agricultural landscapes throughout the Mekong basin. Nevertheless, their close association with the extensive maze of different riverine habitats is what makes the Siphandone landscape a mosaic of water and land, unique in its physical aspect and sheer size. Siphandone is both a remarkable natural landscape and a very specific agricultural landscape. The diversity of habitats, still retained despite the intensive human pressure, provides the local farmers/fishers with a range of resources which they harvest according to the rhythms of the still relatively intact hydrological and ecological cycles.

THE PEOPLE [2]

Brief historical notes

It appears that neither a comprehensive research into the history of the area nor a full compilation of sources has ever been carried out. These very brief notes are based on the few available sources, which focus on the exploration of the Mekong River; a thorough review of the topic is beyond the scope of this work, but if undertaken would greatly benefit the understanding of the past and present conditions of the area.

Over the centuries, Siphandone has been known mainly for the impressive set of sprawling waterfalls which goes under the name of Khone Falls. This wall of water and rapids has had a crucial place in the history of the Mekong region. It is a natural boundary between the Lao territory and the great Cambodian plain. However, it did not prevent the expansion of the Khmer empire, which dominated a vast tract of the lower Mekong basin between the 9th and 15th century. Wat Phu, located 110 km north of the falls, was a major centre of Khmer civilisation and presumably was well connected to the southern centres of the Khmer empire. However, the treacherous river course assisted the later Kingdom of Laos to maintain its relative isolation and hence its security from attacks by external forces. It is reported that one of the first Europeans to visit the Kingdom and write about it, advised the King on how to construct a system of locks to facilitate navigation and trade along the river; but the King turned down the offer, eager to preserve the river as a natural fortification against his neighbours (De Marini, 1663). Thus Khong represented the solid southernmost limit of Laos, both under the first Laotian state of Lan Xang and later under the southern Kingdom of Champasak, which broke away from it in 1793.

The Khone Falls also played a dramatic role in the annals of the European explorers who started pushing north from the Mekong delta and Siam in the 17th century. Geographical explorations soon led to colonial expansion, which culminated in the French colonial enterprise: this gathered

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[2] This section of the chapter refers to Khong District, except for the few details provided on Mounlapamok. The same applies to most of the presentations included in this book, as the administrative scope of the Siphandone Wetlands Project was limited to Khong District. The area of Mounlapamok District had been subject to much less investigation at the time of compiling this information; much more research is required to achieve a full picture of the environmental and socio-economic features of the whole wetland complex.

momentum in the second half of the 19th century and led to the creation of the "French Indochina". The Mekong River theoretically offered a major route for the ambitions of European traders and officials pressing towards inner Indochina and northern China. Many struggled through the thick forests and rapids of the lower Cambodian river course and eventually hit the great Khone Falls: these forced upon them an exhausting detour overland, before they could enter Laos. Francis Garnier left a vivid account of Khone Falls and Khong in his 1866-1868 Mekong Exploration Commission Report. His account[3] and the illustrations drawn by the expedition members still resemble the present-day appearance of the islands and channels (Tips, 1998) .

Establishing navigation along the Mekong between the delta and central Laos up to China became one of the major challenges of colonial Indochina. The Mekong has a strong seasonal discharge and its course has widespread rapids: these features made navigation always arduous and frustrated the traders' desire for a reliable commercial cargo route along the river. Khone Falls were the biggest obstruction to riverine navigation along the lower course. Strenuous attempts culminated in 1887, when two French steam vessels reached Khone Falls (Osborne, 2000). After as futile as they were arduous efforts to find a passage along one of the many rocky channels, the Khone Falls were finally accepted as an insurmountable obstacle for navigation. The French carried the first boats overland upstream of Khone Falls in 1893; soon thereafter they constructed a railway line across Khone Island, which was in operation by the turn of the century between a downstream pier at the southern tip of Done Khone and an upstream pier at Done Det. A bridge joining Done Khone to Done Det was built in 1920 (Osborne, 2000). A locomotive pulled wagons between the two docks built on the two islands, where goods and people were loaded on and off vessels, thus enabling the bypassing of the falls. The railway line remained in operation until the Second World War hit Indochina and caused the collapse of French interests. The railway route is still discernible both from aerial photographs and on the ground, though the rails have been largely removed (they can still be seen as makeshift bridges across streams on the two islands). The Siphandone area remained connected to the north via river navigation and the colonially-built Route 13: the latter was in a dilapidated state during the initial phase of the Siphandone Wetlands Project, but still served commercial transport from and to Cambodia. All the more impressive is the effect of Laos' massive road upgrading programme which saw Route 13 completely restored during the implementation of the project: now there is a fast wide tarmac ribbon to Pakse and Thailand which stops abruptly in the middle of woodlands on the border with Cambodia, waiting hopefully for the southward overland connection to be upgraded, something which has not been done for several decades.

During the 19th and early 20th centuries, Khong maintained its strong role as an important centre of power and administration in southern Laos. This contrasted with the fate of the portion of Champassak Province to the west of the Mekong River, which was subject to opposing claims and temporary handovers between Siam and the French Protectorate of Lao. The history of Laos during the second half of the 20th century, after it gained independence from France in 1954, was soon marred by the cruel war which engulfed the Indochina peninsula for two decades. The long conflict, at that time generally seen as a tangential part of the Vietnam war, brought in fact an incredible toll of devastation and suffering to the people and land of Laos. The peace agreements and eventually the establishment of the Lao People's Democratic Republic in 1975 finally

[3] "Khong was a densely populated community with well-tended fields. Sitandong or Khong Island was the biggest of this whole group. It has given its name to the province. The continuous rows of palm trees, houses, and gardens which line the banks are most pleasant. Small ranges of hills run its entire length forming natural reservoirs from which the rains water the land via small ditches, distributing enough for all the crops. (…) The location of Khong made it an important commercial centre and trade seemed busier than in Stung-treng. The principal traders were Chinese long since established in the country and married to local women. Silk had been introduced in quantity to Sitandong island. Khong maintains relations with the wild tribes of the east by a busy road on the left bank of the river. Beside Khong and on the right bank lies the Cambodian province of Tonly Repou, which was under Siamese control. Since its separation from Cambodia, it has been partly deserted and the mountains which border it are a hideout for thieves" (quoted in Tips, 1998).

brought political stability and unity to the country. During a subsequent overhaul of the local administration, the traditionally independent Khong area was eventually absorbed within the boundaries of Champassak Province, becoming one of its districts. As for the whole country, even this southern region maintained its relaxed rural character and, due to a protracted period of isolation, missed out on the rapid economic development and related social change which affected even the not too distant regions of north-eastern Thailand. Indeed, Thailand's farms and sprawling industries and urban centres have attracted migration from even the better-off regions of Lao PDR, such as the Mekong plain. The prolonged civil conflict and instability which have characterised Cambodia for most of the last decades also undermined the opportunity for the Mekong corridor region to take advantage of its strategic position as a trading route. However, the political and economic climate of isolation and self-reliance has been changing since the mid 80's, following political reforms which have started to promote private investment and closer relations with neighbouring countries. These factors, combined with the recently achieved peace in Cambodia and the proximity to the much more developed Thailand, now place the southern region of Champassak in an entirely new regional context, which offers a wide range of opportunities for the strategically located people of Siphandone.

Population and settlements

Demographic features

The 1995 census (National Statistics Centre, 1995) counted over 65.000 people in Khong District and over 32.000 people in Mounlapamok District, settled in 131 and 65 villages respectively[4]. The two districts contained 19% of the entire population of Champassak Province, and about 2% of the national population. Population growth data for the districts are not available, though figures for the province show an average annual growth rate of 2.4% between 1985 and 1995 (slightly lower than the national 2.8 % rate). The population belongs to the lowland Lao ethnic group. The villages near the border maintain some kin relations with neighbouring villages in Cambodia and steady cross-border boat traffic can be easily observed.

Table 3. Demographic data.

	Mounlapamok District	*Khong District*	*TOTAL*
Number of villages	65	131	196
Average population per village	496	498	497
Max population per village	1,321	1,.649	1,649
Min population per village	132	61	61
Total population	32,228	65,212	97,440
Total no of households	5,369	11,365	16,734
Average household size	5.94	5.74	5.81
Average no of households per village	83	87	85

Source: NSC, 1995

Human settlement

Human settlements are spread along the river banks, both on the islands and on the mainland. One or more villages are found on each of the largest islands, with the exception of Done Saniat where only a few households live. Most of villages have a range of 30-100 households. Among the 131 villages in Khong District, only 10 lie at a distance from the river: these are found along Route 13 and Route 131 and account for about 7 % of the District's population, according to 1995 census data. The largest settlements of Khong District are Ban Khong, the district capital and villages on the left river bank which are main transportation nodes (Ban Hat Sai Khoun, Ban

[4] The updated records consulted in Khong District showed 136 villages in 1998.

Phonsavan) and markets (Ban Khinak, Ban Nakasarn). The district is divided into 14 sub-districts, each of which contains 6-12 villages.

As our geographical analysis has shown (see Chapter 3) population density is very high, ranging between 200-500 people / km^2 on most of the islands with an average value in excess of 400 people/ km^2. This density is comparable to that found in the Mekong delta. Even the southern-most islands, where paddy land is scarce, sustain a relatively dense population, generally in excess of 100 people / km^2. Around 40% of the total area of the inhabited islands is cultivated with rice.

Houses are by and large traditional wooden structures with tin or thatch roofing. Brick or concrete structures are limited to a few religious buildings in the main islands, the railway buildings on Done Khone and Done Det and a number of buildings in Done Khong. A relatively dense built-up area is found between the commercial centres of Ban Khinak and Ban Nakasarn, where the main markets and transportation nodes are found.

Villages are frequently scattered with and surrounded by fruit trees. River banks are intensely cultivated as vegetable gardens. On the large inhabited islands, small patches of forest are frequently found near the villages, and are preserved for religious and social purposes. Temples (*wats*) are sometime found separate from the villages, occasionally located on minor elevations with some vegetation, in contrast with the flat largely barren paddy fields which take up most of the island surface.

Infrastructures and services.

Mounlapamok and Khong districts are pre-eminently rural areas, where infrastructure is minimal. Until very recently, very few households enjoyed a power supply; those who did, had either their own generators or used car batteries. Khong village was eventually connected to the power grid only in 1999. Almost the entire population relies on fuelwood for cooking needs. Khong village has a Post Office and a phone connection. The two main trading centres are the two markets of Ban Khinak and Ban Nakasarn, which lie on the left bank close to Route 13. Thanks to the web of channels and their central position, they are suitably placed to serve the trading needs of a large share of the Siphandone people. Farming and fisheries products are carried by boat from across the wetland and from here they can reach Pakse, the provincial capital, via Route 13.

The main land transportation link is represented by Route 13, which runs from Pakse along the river corridor and enters into Cambodia. It runs 2-4 km west of the river bank in the northern sector of the wetland. Route 13 has just been upgraded and today provides a rapid connection to Pakse and Thailand. The old route track is much closer to the river in the central and southern sectors, running right on the bank in the area of Khinak, while a new bypass about 2 km west of these settlement areas has recently been built. Route 13 is connected to villages on the river bank through short secondary roads, generally not paved, or trails. Khong Island has a dirt ring road and north and south cross-roads. There is also an airfield in the centre of its large southern agricultural plain. Regular public service boats connect Pakse to Khong directly or via Champassak. This mode of transport is widely used by local people for trading purposes and is also popular among tourists, since it enables them to enjoy the river scenery and combine the journey with a stop-over in Champassak to admire Wat Phou.

SALIENT RESOURCE MANAGEMENT AND DEVELOPMENT PROBLEMS

Siphandone, with its vast swathes of alluvial land, easy communication, fisheries, traditional links and strategic location, is a relatively privileged area in Lao P.D.R. when compared to most of the mountainous regions and the living conditions of their people. Nevertheless, human population growth, the persistence of a backward and isolated economic climate for most of its recent history, combined with the havoc brought by the long conflicts, have all contributed to the creation of a long list of problems, which at first sight may be hidden under the sometimes idyllic postcard appearance of this land. These conditions are not exceptional; they resemble those in similar areas of the Mekong corridor in Lao P.D.R. Siphandone stands out, however, because of the exceptional natural features of the area, in which its rice-farming and fishing people have long and densely settled. The rich resources offer both opportunities and problems, which are often specific to this site. This section provides a brief introduction to the main resource management and socio-economic problems of the area: some of these will be analysed in more detail in the following chapters and findings will be reviewed in the concluding chapter.

The advantages and disadvantages of living in the region are clearly perceived by the local people. They are fully aware of the relative prosperity of their condition and the unique opportunities offered by their region, when compared to other areas of the country. On the other hand, there is also a very clear lack of basic services and infrastructure, as well as of opportunities to sustain the growing population and improve its living conditions, and they know that their development is crucial to their future welfare. Table 4 presents a list of the major socio-economic development problems as identified in the 1997 Socio-economic Development Plan prepared by Khong District administrators.

Table 4. Problems identified in Khong District Socio-economic Development Plan (1997)*

- Most productive activities are based on natural resources and are of subsistence level. Trade is very limited. Occurrence of some illegal timber logging.
- Living conditions are generally low.
- Present human population growth is not compatible with economic development. Some villages are overcrowded. There is a lack of economic development options; many young people migrate. Migration abroad is hampered by lack of proper permits.
- The area of productive land is insufficient. The potential expansion of the productive area is constrained by Xe Pian NBCA. Irrigation and the second rice crop are the main option for agriculture development.
- Agricultural extension services need strengthening: more staff and training. Animal husbandry extension services need strengthening.
- Lack of credit finance and technical support for small industries (handicraft) development.
- Insufficient budget for the local authorities. Tax collection needs improvement. The promotion of rural development activities needs financial support.
- Poor public health conditions. Incidence of water borne diseases and poor sanitation conditions are widespread. Clinics need to be built in each sub-district.
- Infrastructures are poor and need development, primarily for transport.
- There is an insufficient number of schools and those available are often in poor conditions. A number of children in school age do not attend. The general education level is low; most women lack education.
- There are problems in village organisations and communications.
- Potential attractions, monuments and archaeological sites need attention, survey, development, promotion and management.

* Not authoritative. Based on the author's summary of draft 1997 District Socio-economic Development Plan' issue list.

Siphandone population live by and large from semi-subsistence farming. The alluvial plain is densely cultivated and land scarcity is a major development constraint, particularly on the islands, where, despite the abundant alluvial land, the people may sometimes experience food security problems. Land scarcity, coupled with extreme climatic events and associated floods, increases the vulnerability of local people. From time to time, water floods seriously affect the rice production: in the great flood of 1996, 20% of the Khong District crop was lost (AFDC Crop Section, pers. comm.).

Population growth on the islands, where all the suitable land has already been converted to agriculture, has prompted farmers to encroach on forest land in the floodplain east of the river. This encroachment conflicts with the need to conserve forestry and biodiversity resources and may also be unsustainable due to poor soils and erratic rainfall patterns. The conflict with conservation goals is particularly evident in the case of agricultural encroachment within the Xe Pian NBCA. However, the recently introduced irrigation system is seen as the main development option in the struggle to increase food security and lift the population beyond subsistence level.

Insufficient economic opportunities have also prompted local labour to migrate to the coffee plantations of the Boulevan plateau, as well as to the provincial capital Pakse and even to other provinces of Laos and into Thailand.

Siphandone is pre-eminently a fisheries area. Almost all households in Khong are involved in fisheries, to one degree or another. The Mekong channels, floodplain streams, ponds and rice paddies are intensely fished, while aquaculture is not commonly practised. Fisheries is an opportunistic activity, which provides local households with a fundamental source of protein; the surplus catch also provides an opportunity for trading. A few villages located in the southern islands, where suitable paddy land is scarce, tend to rely on capture fisheries to a much larger extent: these villages have the most elaborate fisheries traditions and techniques.

However, as is common with artisanal fisherfolk, the people tend generally to identify themselves through their connection with land and rice agriculture, despite the relative importance of the fishery sector in this region.

There is a common perception throughout the area that catches have decreased (Baird, herewith) in the last few years. Although there is no stock assessment data to confirm this perception, it is possible that population growth, the introduction of modern fishing gear, motorization and easier access to outside markets have led to increased harvesting pressure and result in overfishing. A proper assessment of overfishing issues cannot be expected for some time, as initial investigations have so far only managed to highlight the complexity of the fisheries and its resource base. The ecology of the Mekong ichthyofauna and its migration patterns is still almost entirely uncharted territory, and local evidence on economically important fish species has only recently began to emerge (Baird and Flaherty, 1999; Baird, 1999b).

The wetland does offer a wide range of resources, besides the expanse of paddy land and fishing sites: the extensive web of channels, which turn into a web of vegetable gardens during the dry season; significant foraging ground for livestock (buffaloes) in the shallow riverine habitats, such as the Tholati wetland; and some forestry land in the mainland and on Khong island. However, the pressure exerted by human population growth undermines the long term viability of subsistence activities, a fact of which local people are well aware. Forest resources are being depleted for fuelwood harvesting and illegal logging and seasonal fires are common throughout the floodplain. This intense human pressure, which has been exerted for centuries, has by now substantially degraded the vegetation cover of alluvial areas. Floodplain habitats have been fragmented and lost: this factor, combined with high hunting pressure, has strongly reduced the terrestrial fauna.

The livelihood of the local population is not only affected by the overexploitation of the natural resources, but is also compounded by the limited availability of basic services, such as education and health. Most educational facilities are in a dilapidated state and poorly supported by the meagre public administration's resources available.

Due to the general lack of sanitation services and the high population density, public health hazards are significant, particularly caused by faecal contamination and vector borne diseases. As in most rural areas of Lao P.D.R., Siphandone households do not have access to sewage disposal and water supply services: the 1995 Census recorded that 95% of the households in Khong had no toilet facilities of any kind. Only in the main villages do some of the households have piped water and toilets. As the large majority of the people are settled in close proximity to the river, which supplies water for domestic use and also takes care of waste disposal, it is obvious that the crowded villages are potentially exposed to major hazards due to the contamination of surface waters. Diarrhoeal infections are very common and severe epidemics are not unknown: in the 1999 dry season an outbreak of an intestinal epidemic affected a large number of villages and caused a number of deaths in the district.

Vector borne diseases are very common throughout the area, including malaria, schistosomiasis[5] and opisthorchiasis[6]: these are all directly related to the environmental conditions of the area and chiefly to its close association with riverine habitats. In Khong District, limited baseline data and the high frequency of multiple infections make it difficult to estimate the impact of these infections on mortality and the incidence of severe clinical symptoms (Swillen, 1993). Their impact is nevertheless deemed very significant and their occurrence can seriously undermine the health of affected individuals and hinder child growth. The incidence of diseases is compounded by local occurrence of malnutrition, particularly in children.

It is generally felt that Siphandone at present is at a crossroads moving from its past of slow but steady change along mostly predictable lines and a new world brought about by a closer integration with the external economy. This integration is not entirely new: the central position of Siphandone on the course of the Mekong River and historical evidence both attest that the area has been a trading route for a long time. As we mentioned above, a review of the few historical records available and a full investigation of the archaeological remains within the area are long overdue and would probably point out to ancient communication routes along the river valley, which linked the Cambodian plain with the main centres of southern and central Laos.

Changes have surely occurred over the centuries, but the local economy and social fabric have remained fairly homogeneous. In more recent times, however more dramatic innovations have taken place; of particular note are the fundamental changes in the agriculture sector and the development of infrastructure. The introduction of irrigation, the improvement of communications through the upgrading of Route 13, and growing tourism flows are among the most visible factors of change and economic integration. These factors will in time bring sure and steady changes to the natural and human landscape of Siphandone.

A somewhat more open economic climate and growing attention by development organisations and the private sector may also facilitate the arrival of large-scale investment. A much-rumoured

5 Schistosomiasis is endemic in Khong District, caused by infection of *Schistosoma mekongi*. The parasite was first recovered in Khong Island, which has since become known as one of the main foci of the disease in the Mekong basin. Early surveys, undertaken since 1967, showed a high prevalence of infection, up to 63.3% in schoolchildren. Since 1989 WHO has supported mass drug treatments which have significantly reduced the prevalence in target communities. The long term reduction of the prevalence of the diseases would require further drug treatment, vector control, the general strengthening of the health care system and the improvement of sanitation conditions (Swillen, 1993).

6 In Laos opisthorchiasis or liver fluke is due to infection by the endemic trematode *Opisthorchis viverrini*. Cyprinid fish are second intermediary hosts for the parasite. The eating of raw or undercooked fish causes infection in humans and this habit, combined with the general high consumption of fish in Siphandone is deemed responsible for a high incidence of the disease.

plan conceived in the early 1990's for the establishment of a top grade international tourism complex, complete with golf course, casino and five star hotel which could have impacted extensively on the area, has not been implemented, as yet. Nevertheless the area has a high potential for the development of the tourism sector, which should be planned in a manner respectful of local people and their resources.

The Khone Falls have long been identified as one of the most promising sites of the lower Mekong basin for the establishment of hydropower generation: the most recent regional hydropower development plan prepared by the Mekong Secretariat identified twelve sites for mainstream hydropower projects, including Khone Falls. The study proposed the construction of an off-channel at this site, which would by-pass the falls and take advantage of the extreme elevation gradient on this reach of the river to generate hydro-power. An assessment study (Hill and Hill, 1994) on the potential impact of this project on the fisheries and fish ecology noted that critical fish migrations upstream and downstream would not be blocked by the project, which would not entail a dam across the main river course. However the by-pass channel might produce turbine mortality and the flow diversion might also impact on water re-aeration capacity: the lack of data on fish ecology prevented a satisfactory impact assessment. Given these constraints, the study recommended a cautionary approach and one that was most respectful of the unique and ecologically sensitive site of Khone Falls, which should be "preserved from any developments".

The desire within Laos that this unique area of Siphandone should contribute to regional and national development are entirely understandable. Harnessing these opportunities for the benefit of local people and the country as a whole, while at the same time ensuring the establishment of sustainable development patterns in such an ecologically delicate site will be indeed a great challenge.

Chapter 2

Geology, geomorphology and hydrogeology of Siphandone wetlands

Antonio Brambati and Giovanni Battista Carulli

This chapter summarises the findings of a study carried out to ascertain the main features of Siphandone wetlands with regard to: lithology and stratigraphy; tectonics; morphological units and habitats; high hydrological (flooding) risk zones; and pedological characteristics. The study area comprised the Mekong River corridor between 15° 40' N and 15° 74 N latitude, in southern Lao People's Democratic Republic, near the border with Cambodia. The fieldwork was carried out in a relatively short time (from April 21st to May 6th, 1998). Nevertheless the study produced valuable scientific results and has permitted a sound assessment of the themes identified above.

OVERVIEW OF THE RESEARCH PROGRAMME

The research consisted of three phases. The first phase involved an accurate study of the existing material with particular regard to aereophotogrammetric and satellite images as well as to topographic maps of the region. The topographic maps available were:

- a topographic map of the entire area, consisting of the D48-68 "Khong" and D48-80 B. "Takho" sheets, 1986 edition (not for sale), at a 1:100.000 scale, produced by the Service Géographique d'État de la République Démocratique Populaire Lao; this was used as base-map for the cartographic outputs of the present study (Maps 1, 2, 3 in Annex-1).
- Relevant sections of the Hydrographic Atlas of the Mekong River, at 1:20.000 scale (Secretariat of the Mekong River Commission).

The following geological maps and reference materials were also used :

- the 14 E "Khong" sheet on a 1:500.000 scale, re-established and published by the National Geographic Service of Viet Nam in 1961, as well as the respective explanatory notes published in 1962;
- the geological map of the Lao People's Democratic Republic on a 1: 1.500.000 scale, of the Atlas of Mineral Resources of the ESCAP Region, volume 7, published in 1990 by the United Nations, Economic and Social Commission for Asia and the Pacific;
- sheets n. 11-13-14 of the Geological Atlas of the World (on a 1:10.000.000 scale) published in 1976 by UNESCO;

- pedological maps including a "Soil Map of Champassak Plain", a map of the “N.P.K. Nutrient Level in Flooded Rice Soil of Champassak Plain” and a map of the “Soil Reaction (pH KCl) in Flooded Rice Soil of Champassak Plain” produced by the Soil Survey Department.
- satellite images obtained on bands 3, 4, 5 by the Landsat 5 TM on 29.1.1997 and aerial photographs (33 frames distributed over 5 strips), taken by Finmap International OY in February 1991 at an approximate scale of 1:38.000 scale.

Other miscellaneous reports and notes were consulted, namely: several photocopies showing the location of hydrological stations in the lower basin of the Mekong River in 1993 and the curve of monthly flows of the Mekong at the Pakse station in the same year; and several annexes to the Mekong River Commission's report on the Done Sahong Project for the construction of a dam for hydroelectric purposes containing some hydrological details of the area.

The second phase of the study involved a field survey by the two authors to validate available secondary data and to collect field observations and the primary data presented in our technical report (Brambati and Carulli, 1999) and summarised herewith. Data collected in this phase concerned the following: geomorphology, lithology, structural set-up, sedimentology, hydrology, erosion and stability of the river banks and fluvial evolutionary dynamics. Rocks samples were collected for later mineralogical and petrological analyses and soil samples for sedimentological analyses.

The third phase involved validation of secondary data interpretation and field data analysis, management and processing; and the writing of our final report and its respective enclosures, namely: geomorphological aspects of the area, lithological-stratigraphic and structural aspects, the definition of morphological units and habitats, the definition of areas subject to various levels of erosion, the evaluation of lands subject to inundation and of the period of exceptional alluvial events, notes on soils, conclusions and suggestions.

GEOLOGICAL SETTING

The catchment area of the Mekong River covers most of the Lao People's Democratic Republic, except for a small area in the north-east. The Mekong reaches the alluvial plain about 20 km west of the capital city of Vientiane. From this point onwards the Mekong flows quietly on a broad plain, save for a few rapids located towards the Cambodian border which is crossed by the Mekong at Khone Falls.

The territory of Lao P.D.R. is of Gondwanan origin, the entire region forming the eastern margin of the plate called Sinoburmalaya (Hutchinson, 1989). Throughout the Paleozoic, Sinoburmalaya was separated from Indosinia (now the Indochinese Peninsula) by the Paleotethys Ocean. During the Lower Mesozoic, the collision between Sinoburmalaya and Indosinia resulted in the Indosinian Orogeny, which caused the formation of an uplifted area extending up the Malay Peninsula and through south-eastern and central Thailand. During the Cenozoic, the Himalayas orogenic event produced tectonic movements along the ancient suture zones, with mountain building and block faulting.

The hilly and mountainous region which characterises the northern parts of Thailand and Laos is located between the eastern face of the Shan Plateau and the western part of the Indochinese Peninsula. The mountain chain runs north-south; the river valleys cutting through the mountains are drained in the north by the Mekong and in the south by four large rivers which converge to form the Chao Phraya in central Thailand (the Mekong in the Laos territory flows in the easternmost of these river valleys). These rivers run through several major Tertiary-Quaternary sedimentary basins, some of them having a cumulative sediment thickness of 3 km. Given the recent infill of these basins and the subsequent tilting, it is obvious that the area has been tectonically very active during recent times. Most of the Mekong River past Khone Falls has a very young river channel; in fact, the river has changed its course during the Quaternary and has attained its present morphology only in recent times.

GEOMORPHOLOGY

The river corridor on which the study concentrates stretches in a NNW-SSE direction, following the local direction of the Mekong's outer branches. These branches (western and eastern) correspond to the main structural trends of the area and thus are clearly influenced and controlled from a structural viewpoint by the dominant local fault trends.

From a morphological viewpoint, the area includes an alluvial plain fringed to the N, S and SW by modest hills whose heights range from a few dozen metres to approximately 160 metres above the plain level. The alluvial plain, which also extends outside the study area, especially eastwards, corresponds to the area where sediments carried by the Mekong River are deposited. The numerous sandy islands, which can be observed particularly in the southern sector, are portions of the sandy alluvial deposits continuously transported by the river and then isolated through erosion by the various ramifications produced by the braiding of the river channel. The altitude of the plain decrease from approximately 90 m above sea level in the southern sector of Done Khong island, to an average of 70-80 m observed near the Cambodia border. The area thus shows a very slight southward slope, with an average value of less than 0.1%.

The highest hills are found in the Done Khong island. They follow an E-W direction, extending for 3-4 km, cutting the island almost exactly in half. The hills are round and elongated in shape, and follow a NNW-SSE orientation, in accordance with the dominating structural trend (see section on Tectonics); their altitude is around 200 MSL (maximum 239 MSL). Due to the structural trend, these elevated landforms slope gently towards the north and are slightly steeper in the southern side. The hill chain extends further east, outside the surveyed area, across the left bank of the Mekong, towards Vietnam.

Minor, isolated landforms (generally below 100 MSL) rise in small areas of the islands of Khong (in its western and southern parts), Hi-Gnai, Khamao, Koy, Tan, Sadam and Saniat. This relief forms a small part of a range which is mostly situated to the south and to the west, i.e. in Cambodian territory.

The Somphamit and Phapheng waterfall complex is a remarkable morphological element of the area, located approximately 4 km. north of the southern boundary. These waterfalls are aligned with a E-W direction, as they are set on faults belonging to the second most dominant structural trend within the area, i.e. the one in an E-W direction (see section on Tectonics). The presence and role of the direct faults are marked by a morphological drop of a few metres: this drop gives rise to the waterfalls and corresponds to a section of the fault range which stretches southward over a number of minor parallel faults. These in turn create minor drops, where less spectacular waterfalls have formed (e.g., north of Done Saniat). Due to the presence of these waterfalls, the real slope value across the area is lower than the average value mentioned earlier. Downstream of the waterfalls, deposits of sandy sediments are less frequent, due to the increased erosive power of the waters flowing over the drop: a remarkable increase in rocky outcrops of the pre-Quaternary substratum can be observed here.

Similar erosion phenomena exist upstream, especially N and NW of the Somphamit waterfalls, where sediment erosion is due to the regressive return of the waters which increase their speed when they approach the waterfalls. This process explains the vast outcrop of rocks which surrounds Done Tholati, and spreads out beyond its southern coast; the sandy island of Tholati is therefore a residual landform of a larger alluvium deposit, and will probably not last for long.

GEOLOGY

Stratigraphy

Throughout the area there are outcrops of pre-quaternary substratum, which consist of: volcanic rocks; quartz sandstones, sandstones and marls; there is also a recent alluvial cover. Fourteen samples were collected from the most significant outcrops, in order to determine their mineralogical composition and structure. Nineteen soil samples were also collected from the alluvium cover to determine sediment grain size and carbonate content (Brambati and Carulli, 1999).

The Pre-Quaternary substratum

In the Pre-Quaternary substratum the following fundamental rock types were identified:

Volcanic rocks. Volcanic rocks are widespread only in the northern section of the area, and make up all of the northern hills, i.e. those crossing the island of Khong in an E-W direction, those east and west of the same island and the intermediate rock outcrops visible in the Mekong River bed along the same line. The position of the volcanic rocks can be clearly seen: they run E-W, with a dip to the north, or NNW, and a 20°-25° slip. They are lythotypes with a clear porphyric structure, visible to the naked eye, with millimetric phenocrysts of vitric quartz and of whitish feldspars, sometimes intensely kaolinized. The dominating colour is dark reddish when fresh fractured; this becomes dark brown with alteration. Sometimes the volcanic rocks are intensely kaolinized, causing the noticeable earthy and whitish colour of certain outcrops. These rocks are found in banks where stratification is indistinct and whose thickness range from a few decimetres to a few metres. Sometimes layers few metres thick have ellipsoidal inclusions (bearing signs of exfoliation) with major axes up to a few decimetres in length. Some of these rocks may be defined as acid ignimbrites, and more precisely from rhyolitic to dacitic. These rocks are formed by an explosive volcanic activity in nearby areas, with the emission of extremely acid and viscous lava, which was accompanied by an intense emission of gas and the throwing out of scoria. Rolling down the slope of the volcanoes, enormous clouds and burning landslides advanced with great speed and considerable destructive power. The age is Lower and Middle Triassic (known as Middle-lower Indosinian in the French geological literature).

Quartz sandstones. These are widespread from the southern edge of the island of Khong to the Cambodian border, throughout the central and southern sectors of the area under study. In the central sector there are outcrops at Khinak, on the eastern banks of the Mekong, and along its minor channels. In the southern sector there are extensive outcrops of quartz sandstones especially south of Done Tholati on the low hills of Done Saniat; these are also found as far as the Cambodian hills. This type of rock forms the waterfalls of Somphamit and Phapheng. Here some thin layers of shale outcrop a few centimetres thick can also be observed: these indicate the final process of the torbiditic sequence and the presence of a pelagic facies interbedded in the thick torbiditic layer. Quartz sandstones are extremely compact and resistant, and are dark grey in colour, even blackish at times. Clasts are formed mainly by grains of quartz solidly cemented together. There are much smaller amounts of other minerals, but these are often hard to see with the naked eye. The almost monomineralogical composition attests to a very high level of maturity. These deposits may well be produced by resedimentation processes; they are proximal turbidites made up of minute particles of drift deriving from the breaking down of the volcanic flows described earlier. Their chronostratigraphic age is in the Upper Triassic - Lower Cretaceous (Middle Indosinian).

Sandstones and marls. In the extreme SE sector of the study area (in the neighbourhood of Bungngam village) less cohesive pinkish-brown sandstones occur. They alternate with blackish marls and probably represent a facies of the same dark grey sandstones formation. Their chronostratigraphic age is in the Upper Triassic - Lower Cretaceous (Middle Indosinian).

Quaternary cover

In the quaternary cover the following four main types of recent deposits can be identified.

Alluvial sands. These are the dominant deposits in the area. Almost the entire structure of the islands consists of these deposits (with the exception of the outcrops of rocks from the pre-Quaternary substratum mentioned earlier). From a mineralogical point of view, they are made up primarily of quartz grains, while from a sedimentological viewpoint they are mostly medium to fine sands.

Laterites. These are widespread deposits which occur especially in the south-eastern sector of the area (on the road to Ban Nakasarn, and on the outskirts of Ban Napèng and Ban Takho). They have the peculiar appearance of spherule "carpets", with an average diameter of around 1 cm., reddish in colour, oxidised, of a dark shade, with an earthy appearance; they are quite friable and often loose but at other times weakly cemented together.

Rough drifts. Fragments of the rocky substratum, with extremely variable dimensions, are found either at the foot of hills due to limited gravitational transport, or in the river beds of those minor tributaries of the Mekong River which flow from the left.

Clays and silts. Across the alluvial plain and more frequently near the present course of the Mekong River, there are limited zones of siltstones, clays and dark silts: these can be identified particularly where visible cross-sections have been produced either by natural causes (the erosive activity of waters) or by artificial ones (road breakdowns).

Tectonics

Two tectonic trends are very distinct: a more ancient trend in an E-W direction; and a more recent trend in a NNW-SSE direction. Within the area studied, the Mekong River has established its course on the latter trend.

E-W Trend

This trend is shown by the distribution of the outcrops in the northern sector and is characterised by the volcanic rocks of the hills of the island of Khong, all of which run almost exactly by E-W, have a north-dipping and a 30°-40° incline.

The quartz sandstones which form the rocky outcrops found in the central and southern sectors, from the first rapids to the Cambodian border, have an opposite position. Although they are all in E-W direction, their dip is towards the south, with an incline ranging from around 30° at the outcrops of Khinak to 40°-50° in those further downstream. Only at the southern end of the area, (south of Done Saniat and of Ban Hang Khone), do the quartz sandstones dip much more steeply, and in the opposite direction. This situation, which is limited to the area, can be interpreted as a drag fold with a very short radius, caused by the presence of one of the direct faults related to the quartz sandstones.

The structural outline of the entire area deriving from the tectonic arrangement described above is that of a vast and gentle anticlinal with an E-W axis: the northern part consists of volcanic rocks while the southern one consists of quartz sandstones. In this fold-structure there is a series of direct faults which lies in the same direction, but opposite dip, with reference to the strata they concern. In the northern sector these faults dip to the south at a wide angle and it is possible that they are responsible for the pushing of the more recent sandstones below the level of the more ancient vulcanites. In the southern sector, by contrast, northward sloping faults are easily visible, in the wide angle (60°-70°) fault planes which are found in more than one

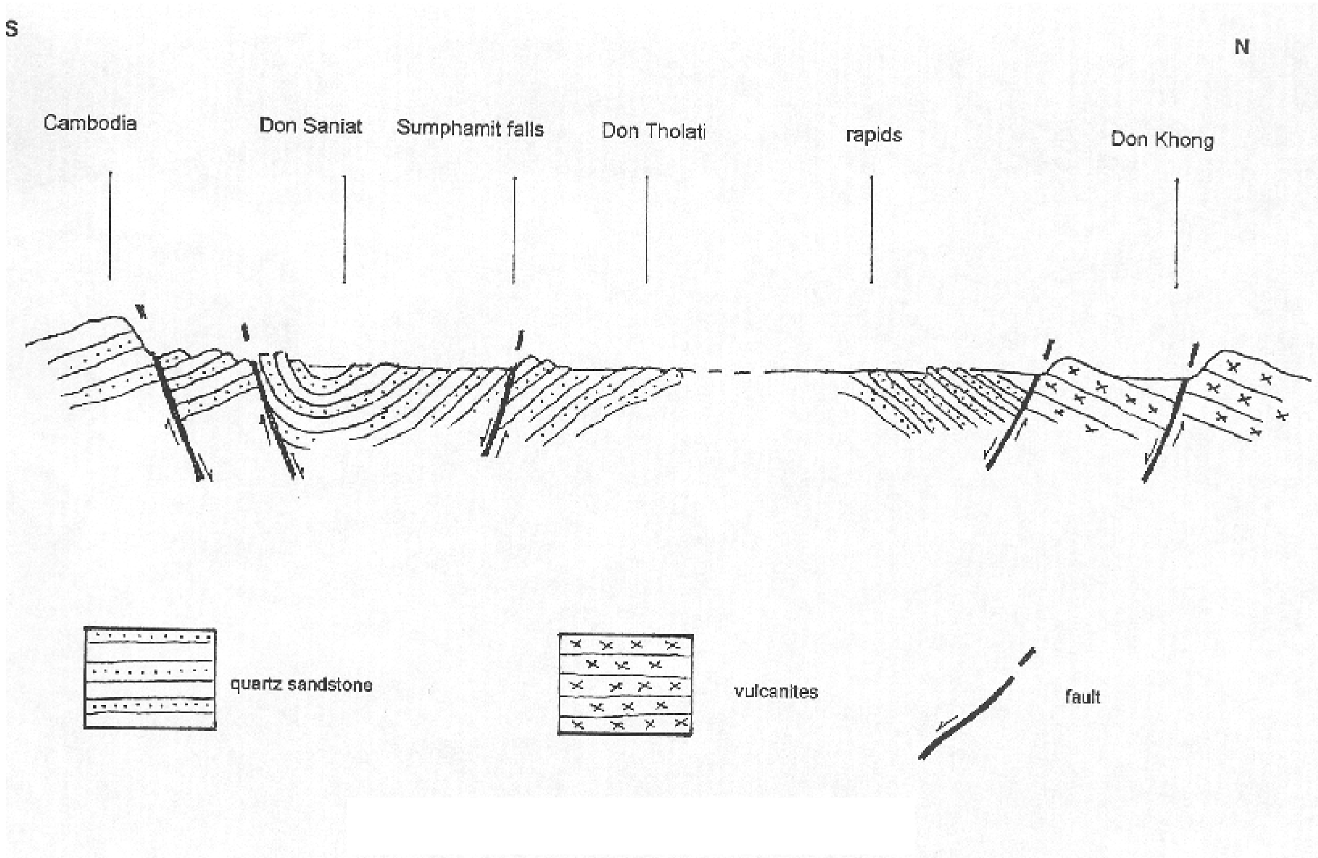

Figure 5. Schematic N-S cross-section (not in scale).

location (Somphamit, Done Saniat waterfalls). On the fault surfaces strongly vertical slickenslides are evident; they indicate clearly that the layers slipped neatly one over the other, with no sideways or transverse movement involved.

The presence of these faults with opposite dip explain how the original anticlinal structure was deformed in an ample graben with an E-W axis, the tectonic pilasters of which are, in the N, the hills of the island of Khong and, to the south, the hills in the Cambodian territory. This structural interpretation is illustrated by the geological section of Figure 5 (not drawn to scale).

NNW-SSE Trend

All the aforementioned structures are first generation structures, which were later shifted by sub-vertical disjunctions with a NNW-SSE direction. These disjunctions pushed the entire range a few Km sideways to the right, breaking up the range into separate hills. These now run in a broken line, increasingly northward in position as one goes west, a few hundred meters apart.

It is interesting to note the role these transcurrent faults have played in the arrangement of the present morphology. They have certainly structurally controlled and conditioned the course of the Mekong River: the main river branches, especially those of the western end (between Done Long and Done Hi-Noy) and eastern ends (between Done Som and the eastern bank of the river), are set on these faults. This last structural trend is a consistent part of the whole regional structural formation and can be explained by the broader phenomenon of the *Mae Ping-Tonle Sap line*, one of the great structural features which characterise the Vietnamese chain (Rainboth, 1996). This line, together with others, marks the eastern transgressive line, that is to say the transfer limit of the Indian plaque in its clash with the Asian one.

MORPHOLOGICAL UNITS AND HABITATS

Morphological units were identified based on the physical features of the region: it is assumed that these features are fundamental elements for the identification of habitats in a wider sense. Two main morphological elements can be identified within the study area:

(a) hills formed by cleavaged acid volcanic rocks featuring faults in a NNW - SSE direction. This fault system has led to the formation of raised blocks (raised that is relative to the surrounding plain), which at times are transcurrent towards the SE and obstruct the course of the river at several points. The river is compelled either to go round them or intersect them (this happens when, due mainly to tectonic factors, parts of the ground are relatively low or more likely to be hit by fluvial erosion). The E-W fault trend often affects the course of the river, which turns at a right angle towards both east and west at various points. In the southern sector, the course of the river is also affected by outcrops of great banks of highly resistant sandstone dipping to the south. These obstructions mainly consist of the hills rising in the middle of the island of Khong and east and west of the two main river branches (at Ph. Mailai and Ph. Lem);

(b) alluvial deposits consisting of medium to fine-grained quartz-feldspathic white sands. These alluvial deposits have almost entirely buried the hills and consist of a thin layer of sand which grows gradually thicker from the south (4-6 metres) to the north (10-12 metres). These deposits almost entirely cover the underlying formations (acid volcanic rocks in the north and torbiditic sandstones in the south). The thinning of these alluvial deposits, from north to south, clearly points to their instability, especially during flood events. The meandering of the secondary branches of the Mekong River in recent time is attested to by relict channels, such as those observed on the islands of Done Som and Done San, as well as in Khong island itself. This instability of the islands is shown most clearly by the system of fragmented islands in the area south of Done Khong and along the western branches of the river up to the island of Done Tholati, and in the group of islands north-east of the village of Khong. The first group of islands, which can be described as "dolphin-shaped", is probably the remains of one or more larger islands (see also the group of islands of Done Tholati). Clearly erosive phenomena affect larger islands and cause them to split: they create new sections of the river bed, but these are offset by the closing of secondary branches of the river, which therefore become relict.

The islands can be divided into three main classes based on their altitude with reference to the dry season water level: the islands in the first class have an altitude of 8-10 metres, those in the second class have an altitude of 6-7 metres, while the islands in the third class have an altitude of 3-5 metres. The latter in particular are residual landforms of previous islands whose sub-horizontal surface is almost completely gone: only camel hump shapes are left. An additional class with an altitude of 2-2.5 metres includes recently formed sand banks or sand banks remodelled from older islands which have been destroyed.

The erosive phenomenon can be observed in the complete removal of the thin alluvial cover which is particularly evident in the sector south of the island of Tholati, which is characterised by continuous outcrops of south-dipping torbiditic sandstones. In the dry season, the entire area features minute residual river courses which form a thick network in the direction of the layers, E-W, NNW - SSE; a few run in a N-S direction.

Some of the larger islands, aside from the island of Khong, are stronger and more stable. This is either because they coincide with areas having less fluvial energy (for instance the island of Khamao, surrounded to the west by a minor channel which seems to be drying up); or because their size makes them intrinsically more stable. However, these are exceptional cases. Based on these geomorphological and evolutionary observations, the following morphological units and habitats were defined (see Map 3 in Annex-1).

i) Morphological unit of the plains of the island of Khong. This morphological unit consists of two sub-units (Map 3 A and B), divided by the hills represented by isohypse 239 Ph. Louang e Ph. Hinlékfai. The N and S boundaries are set by two branches of the Mekong River. Both sub-units consist of wide expanses of rice-fields. Along the edges of the island, where most of the human settlements are located, these morphological sub-units feature a modest crown of forest trees; in the remaining areas this type of vegetation is only rarely found. The outcropping grounds consist mostly of medium to fine-grained white sands and lack true soil, save for those areas close to the northern hills, where reddish silt can be seen, derived from the breakdown of the rhyolitic rocks which form the hills. Deposits of reddish-brown silt form a surface cover at the foot of the hills; this is from a couple of metres to about ten metres thick. These deposits are particularly evident along the southern border of the island, around the villages of Muangsèn-Nua and Muangsèn-Tai. The strip parallel to the eastern branch of the Mekong River (Map 3 : C) can also be included in this unit.

ii) Morphological unit of the hills of the island of Khong. This morphological unit consists of a series of hills densely covered with forest, separated by incisions made by streams; these are mostly in a NNW-SSE direction. The valley contours follow the fault system which lies in the same direction. The hills are over 200 metres in altitude, with the larger ones in the south of the area. They are aligned in an E-W direction and become smaller towards the north in accordance with the systems featuring an east-west direction. The transitional areas between the plains and the hills can be identified by detritic deposits which are sometimes quite large. This morphological unit is covered by dense forest and has no permanent human settlements. Similar but smaller hills can be found on the nearby island of Hi-Gnai, as well in the adjacent eastern river corridor.

iii) Morphological unit of the large islands. This morphological unit includes the islands of Som, Phouman, Xangphai, Loppadi, Long, Tholati, Xang, Tan, Koy and Hi-Gnai. These islands are flat and are surrounded by either secondary or primary river branches. Their altitude range from 8-10 metres to 6-7 metres above the dry season water level: the higher altitudes can be found at their northern ends, while the lower ones are located at their southern ends. They also feature rice cultivation, except for coastline, where most of the settlements are located, and where forest trees are present. The general features of this morphological unit are very similar to those of the sub-units of the island of Khong, save for the island of Hi-Gnai, which features a modest hill that makes it more similar to the morphological unit of the hills of the island of Khong.

iv) Morphological unit of the small islands. This morphological unit consists of a number of islands which are all the remains of larger islands. Their altitude range between 2 and 3 metres above the river bed, and they are often shaped like camel humps; less frequently, they are flat and retain the same altitude as the original islands, namely approximately 4 - 5 metres above the river bed. All these islands are uninhabited - except for occasional settlements on the larger ones - they have sparse vegetation, and the bottom of the channels intersecting them features "boong" vegetation (see Maxwell herewith) rooted into the rocky bottom floors. The larger groups of islands are found just east of the island of Khamao, between the islands of Long, Done Than, and Phouman, along the course of the river north of Tholati and in the region of Houal and Hatkhikhoay. These islands sometimes consist of newly-formed banks with altitudes of just 2 metres above the dry season water level and can thus be easily submerged and washed away except for those with a higher altitude, which can only be completely submerged by major floods.

v)Morphological unit between the islands of Tholati and Saniat (Tholati wetland). This morphological unit has a totally unique habitat. The area consists of denuded river bed covered by a thin layer of sandy alluvial deposit. It features several outcropping sandstone banks which dip southward and are associated with the remains of a complex river system of micro-channels. It is completely invaded by “boong” vegetation (see Maxwell, herewith) and features a type of lunar landscape. It is reasonably safe to say that this region was once covered by alluvial deposit of which the islands of Tholati and Xang are the residual forms; their future now is uncertain.

South of the fault systems giving rise to Somphamit and Phapheng waterfalls, a transitional sub-unit can be identified: it is a sector of the step which separates the southern region from the northern one. The southern area, which includes the island of Saniat and reaches an altitude of approximately 80 metres, should be classed with the nearby morphological unit of the islands of Som, Sahong, Sadam, Phapheng as well as with the nearby hills of the region to the east.

vi) Morphological unit of the southern islands (Done Som, Done Khone, Done Phapheng and Done Sadam). This morphological unit stands out from the previous ones as it is comprised of a series of hills with an altitude of approximately 70 metres, separated from one another by stream valleys set into the NNE - SSE fault system. The hill systems are aligned in the same direction and are cut at their northern and southern edges by faults with an E-W direction along which flow minor river branches. All these hills are covered by dense forest. They frequently feature diffused surface lateritic deposits with millimetric spherules. This morphological unit can be divided in two separate sub-units: one north (Map 3: Z) and one south (Map 3: N) of the Somphamit - Phapheng fault line. However their boundary is uncertain and is mostly defined by the lower limit of the backward erosion of the stream incisions.

vii) Morphological unit of the southern rocky islets. This morphological unit forms a very small part of the area under study, just north of the Cambodia border. However, it probably extends downstream across the Cambodian border. It is characterised by the presence of numerous rocky islets which have created a unique riverine habitat. The rather small islets consist of outcrops of torbiditic sandstones which also characterise the morphological unit of Tholati wetland. Despite its similarities with the Tholati unit and the small islands unit, this morphological unit must be considered separately, due to the rocky rather than sandy nature of the system and also because it is located downstream from the great Somphamit - Phapheng fault.

CONDITIONS OF THE MEKONG RIVER BANKS AND HYDROLOGICAL CONSIDERATIONS

The general assessment has pointed out the widespread conditions of degradation of the river banks, due partly to the rapid evolution of the system of riverine islands: this seems to indicate that some of the groups of small islands may be the product of a degradation process of one or more larger islands. Evidence of the river's meandering can be found in old or scoured channels, while the presence of a wide rocky plateau covered with fragments of sandy alluvial deposits several metres thick is evidence of impressive erosive phenomena which can be traced back to the recent past: see, for instance, the region downstream of Tholati Island.

During the field survey, the authors observed the conditions of the river banks along an extensive section of the river network. The banks were ranked into four classes: stable, mainly stable, mainly eroded and eroded. The results of these observations are summarised in Table 5.

Table 5. Conditions of river banks.

	Surveyed slopes (total length)	*Stable*	*Mainly stable*	*Mainly eroded*	*Eroded*
Km	126	21.0	23.0	36.0	46.0
%	100	16.7	18.2	28.6	36.5

The fourth class includes those river banks where erosion is very marked and has actually given rise to a number of microcliffs with vertical walls which have led to the collapse of parts of the ground, as well as landslides; these have uprooted trees and even destroyed dwellings. The prevailing condition of instability throughout the study area is emphasised by the fact that only 16.7% of the surveyed river banks could be classified as stable (a result which may be extrapolated to the entire area); a slightly larger length of the banks (18.2%) is classified as mainly stable, yet it must be said that these parts show signs of local, incipient and acute erosion. These should therefore be considered more realistically as unstable areas which could be subject to further breakdown in the near future, particularly if the river regime of the past few years, which has been responsible for considerable erosion, will maintain its features.

As pointed out in the section on the morphological units, it is also clear that the most unstable areas are located in the south-central part of the study area, where the islands are somewhat smaller than those in other areas and of lower elevation above the dry season water level (estimated between 2 and 6 metres). These island systems are therefore liable to being eroded along their outer edges and also risk being submerged by flood waves. However, this does not mean that other islands are safer and not subject to inundation: local inhabitants often report that even in the best conditions most of the larger islands have been occasionally flooded along the edges. The only islands that are even partly free from flooding are those with an altitude of 10-12 metres. The groups of small islands and sand banks with an elevation between 2 and 7 m above the dry season water level, have thus been identified as areas subject to inundation.

The high frequency of river banks undergoing erosion (36.5%) stands out; if we add those dominated by erosion (28.6%), the total figure of 65.1% clearly indicates that degradation of the riverine system in the study area is considerable. The critical nature of the situation is further exacerbated if we consider than additional 18.2% of bank length was classified as potentially subject to erosive phenomena in the near future. The erosive processes observed are violent and destructive and will attack all of the smaller islands sooner or later, even threatening parts of the larger ones, which may result in rockfalls.

Although data on the fluvial regime within the study area is not available, the risk of flooding can be inferred by analysing the flow rate of the river at Pakse. Graphics 1, 2 and 3 illustrate by way of example three typical flood levels (minimum, maximum and mean) recorded between 1960 and 1977. These feature the following values: 24600 m^3/day, 56000 m^3/day and 42000 m^3/days respectively in 1992, 1978, and 1970. The river has reached a maximum flooding level of 8 metres in the area surrounding Siphandone, a level which increases gradually in the northern region.

The analysis of flow rates during the same period (1960-1997; graph. 4) has revealed short term flood wave periods of three years with a decrease in flow rates by just one cycle each during the 60s and 70s and the 80s. Further floods are therefore to be expected: these flood cycles will cause considerable erosion and the drowning out of areas either in cycles of three years or in cycles of a multiple of three - approximately 17-18 years - with extreme events occurring in the latter cycle. These figures also suggest that the destructive 17/18 year cycle - which hit the region between 1994 and 1997 - is now growing weaker but will probably return in 2011-2012 / 2014-2015.

In conclusion, it must be stressed that human activities are also contributing the erosion of the river banks. The most dangerous activities are the building of dwellings along the banks, the terracing of river banks for agricultural purposes (mostly to grow vegetables), the building of steps or steep paths to provide easier access to the river, and lastly the cutting of the trees that grow along the banks of the river and whose roots helped to stabilise them. These activities should therefore be discouraged for the sake of the preservation of river bank stability.

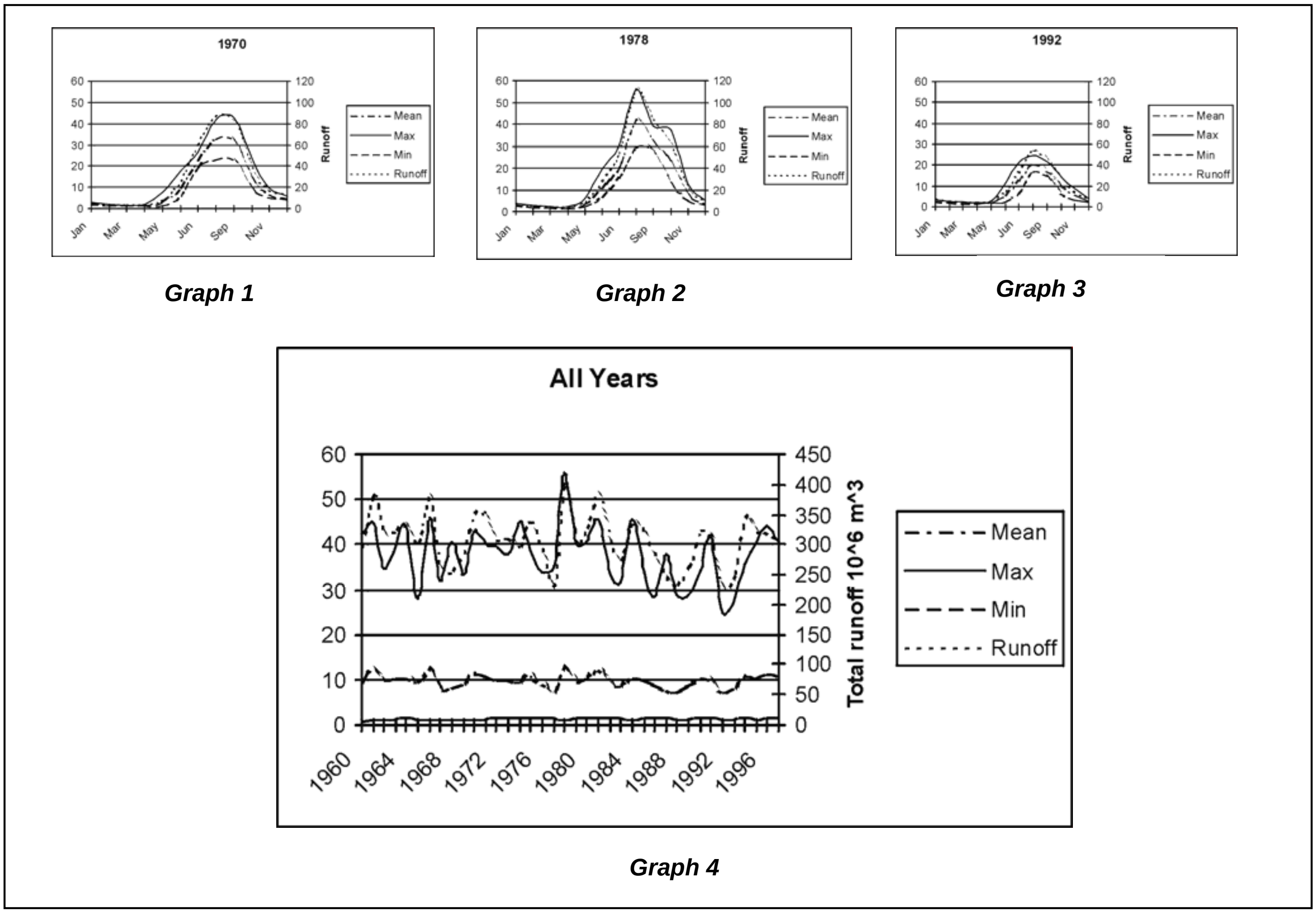

Figure 6. Hydrographs for the Mekong River at Pakse.

NOTES ON SOILS

A broad analysis of soils was carried out by the Lao Soil Centre Service according to FAO methodology; their findings were published in 1994-95. This analysis, whose results were available in the form of soil maps, includes: the map of soil reaction (pH KCl) in the flooded rice soil of Champassak plain (Figure 7) and a soil map of Champassak Plain (Figure 8), which classifies the soils as reported in figure. The first map is based on pH measurements following chemical etching with KCl, and here the soils of the study area were classified under four main types (Figure 7). This investigation showed that the majority of the area has acid or very acid soils; this acidity gradually increases towards south. The lowest values are measured throughout the area; only in the northern sector - the islands of Khong, Hi-Gnai and Done San - pH values range between 3 and 4.

On the basis of the available soil classification map (Figure 8), Cambisols (CM) seem to prevail, particularly on the island system along the border with Cambodia, south of the island of Khong. This system features to the east a similar system of islands which is characterised by alternating Fluvisols (FC) and Luvisols (LU). The same feature is also found along the left bank of the Mekong River. Of special note is the island of Khong, which is characterised by Cambisols in its northern sector and Luvisols in the southern sector.

Figure 7. Soil KCl reaction (Soil Survey Dept.)

Figure 8. Soil classification. (Soil Survey Dept.).

***Table 6. Legend for soil classification map.*.**

ARENOSOLS (AR)	Ferralic Arenosols Haplic Arenosols	o h	CAMBISOLS (CM)	Gleyic Cambisols Dystric Cambisols Eutric Cambisols	g d e	REGOLSOLS (RG)	Eutric Regolsols	e
FLUVISOLS (FL)	Dystric Fluvisols Eutric Fluvisols	d e	ACRISOLS (AC)	Ferric Acrisols	f	LUVISOLS (LV)	Gleyic Luvisols Ferric Luvisols Haplic Luvisols	g f h
GLEYSOLS (GL)	Distric Gleysols	d	ALISOLS	Gleyic Alisols Ferric Alisols Haplic Alisols	g f h	LEPTOSOLS (LP)	Umbric Leptosols Dystric Leptosols Eutric Leptosols	u d e

With regard to texture, sandy loams prevail, save for the island of San (north of Done Khong) where loams predominate, and along the bank to the left, on the island of Khong, where clay loams prevail. The grain size analysis carried out on 18 soil samples collected during the field survey largely confirmed available secondary data; these analyses have also provided us with greater details on the granulometric distribution of the soils in the area (Figure 8). They mostly consist of loams which are variously sandy or clayey. All collected soil samples have been subjected to calcimetric analyses which, however, revealed a total absence of carbonates**,** as was to be expected given the considerable acidity of these soils (Brambati and Carulli, 1999).

This analysis was carried out to validate available information, as a soil survey was not envisaged as a separate component of the study. It is incidentally worth noting that interesting soil profiles were spotted on several occasions on the island of Khong (at Muangsèn Nua and Muangsèn Tai and in proximity to the landing site).

RECOMMENDATIONS

The survey revealed a number of problems which require appropriate long term solutions. Based on the results of this initial study, we recommend that the following actions be undertaken.

i. A detailed analysis of the conditions of the river banks should be carried out at a number of critical points so that low cost pilot measures to protect the most severely eroded river banks be proposed. A few areas could be identified for pilot actions, with due consideration being given to local interests and requirements. The mitigation of erosive phenomena, which are certainly compounded by human activities, requires that the local population should be adequately informed and encouraged to refrain from terracing the river banks. Above all, to the felling of trees along the banks must be stopped and a tree-planting policy promoted.

ii. A fundamental prerequisite for devising possible measures for the protection of areas subject to inundation is a thorough assessment to check, update and integrate the network of datum points. It is especially important to measure carefully the elevation of the islands, especially those that are inhabited or frequently subject to floods.

iii. Flood forecasting capacity based on further study and modelling exercises should be developed. Data currently available suggests that floods come in short and medium term cycles, yet further investigation is required in this area in order to develop fool-proof forecast models. Such a study should include: the involvement of the Department of Meteorology and Hydrology, the Department of Communication and the Mekong River Commission; a review of available flood forecasting capacity as developed by earlier activities; this should be applied in Champassak province and in the study area in particular. Also needed is the collection of hydrological data in the region of Pakse/Siphandone in order to define the river flow rate and flow levels, the correlation periods and the streamflow data for river floods; the collection of rainfall data and meteo-climatic data for the same region (hydrological and rainfall data collection should also be extended to tributaries). Data should be collected over the longest period possible and should be critically analysed before being processed. Essential stations for the analyses are Pakse (and perhaps also Savannaketh), Ban Hat Sai Khoume and any other station in the study area. Also vital is the application of forecast models and ground feedback based on field observation; this should give due regard to earlier modelling case studies carried out in the country.

iv. The study of soil characteristics should be supported through further analysis and classification.

Chapter 3

Study of land cover in Siphandone wetlands through remote sensing and development of a wetland GIS

Alfredo Altobelli and Giuseppe Daconto

Environmental management and resource development projects need to be based on knowledge of the main land characteristics of the area under investigation. At the inception of the Siphandone Wetlands Project, no systematic information describing the large wetland complex of the Mekong River corridor was available. The limited information on natural features which did exist was restricted to specific topics and generally not well related to geographic data.

One of the main goals of the Siphandone Wetlands Project was to build a knowledge base of the area, its natural resources and the livelihood system of its people. This was accomplished through investigations into topics of fundamental relevance for the region, such as the biological diversity of the aquatic fauna, flora, etc.. At the same time the project attempted to introduce an area-wide approach to the study of the ecosystem and livelihood systems. This approach was needed in order to broaden the knowledge of the complex riverine landscape of Siphandone, descriptions of which had previously focussed mainly on prominent landmarks and features. The approach also aimed to provide the necessary geographical context for the gathering of the thematic baseline information on selected environmental and resource management topics.

The target area is large, stretching along an approximately 40km-long reach of the Mekong River from Done San to the Cambodian border (see Figure 1 and maps in annexes). The archipelago covers an area of approximately 400 km^2 between the outer banks of the river. Furthermore, an extensive area of the adjacent floodplain also plays an important role in supporting the mixed semi-subsistence economy of the 100.000-plus people who are settled along the river. A number of sites are difficult to reach and access conditions vary along with the water level of the river: navigation along certain channels is hampered by turbulent waters during the rainy season, while the same channels often become too shallow for navigation during the dry season.

The geographical study had two main components, which were intended to complement field-level investigations:

1. Land cover study: this activity aimed at producing a description of land cover and use patterns throughout the project area. The riverine landscape of the area presents a wide range of natural conditions and habitats. Agricultural practices and long-established human settlements have often altered natural features, so that the present-day landscape of

Siphandone is a complex mosaic produced by both natural geomorphological processes and human activities. The primary objective of this task was to identify the main land cover classes throughout the wetland area and to generate a land use / cover map at a scale of 1:50,000. Given the characteristics of the area, the operational conditions and the resources available, the project opted to undertake the study through remote sensing technology.

2. The development of a geographic information system (GIS) to compile and present the baseline information collected through various project tasks.

LAND COVER STUDY

Images from the LANDSAT 5 and SPOT 2 satellites were used. The former, with its Thematic Mapper sensor, is particularly useful for the study of forests and agriculture, since the Thematic Mapper spectral bands were designed for the accurate measurement of vegetation patterns. The panchromatic SPOT 2 image, on the other hand, has the advantage of registering data at a 10-metre ground resolution. The images used were the most recent (1997 and 1996 respectively) cloud-free dry-season images of the study area available. Images recorded in the dry season allow for the identification of the highest number of vegetation types, since deciduous vegetation is largely leafless then and thus can be easily distinguished from evergreen vegetation. The interpretation of this satellite data was assisted by the use of field surveys and any topographic maps and aerial photographs available. The data used comprised:

- a LANDSAT 5 TM scene of January 29th 1997 (path 273, row 322, quadrant IV) and a SPOT-2 panchromatic image of November 27th 1996 (path 126, row 050), in digital form;

- an infrared colour composite positive film (24 x 24 cm) of the study area, on a scale of 1:500,000, which was a radiometrically and geometrically corrected version of the same LANDSAT TM image; a print of this positive film, scaled at 1:100,000, was used during field surveys to assist ground-truthing;

- topographic maps at 1:100.000 (SGN, 1982), sheets D-48-56, D-48-68, D-48-69, D-48-80,D-48-81;

- topographic maps at 1:50,000 (AMS, 1965, series L7015): sheets 6137 I and II (set incomplete);

- Hydrographic Atlas of the Mekong Mainstream (1994) at scale 1:20,000, (based on 1991 aerial survey): sheets I-098 to I-104;

- black & white aerial photographs (ca. 1:38,000, from a February 1991 aerial survey by the Department of Communications, Ministry of Communication, Transport, Post and Construction). These were useful for identifying vegetation patterns, populated areas and landscape features.

Field surveys

A first reconnaissance survey in October 1997 (wet season) enabled us to identify main vegetation facies and to gain a first general overview of the landscape elements of the area, particularly the river channels and islands. A second survey in January/February 1998 (dry season) focused on the validation of an initial digital classification of Landsat imagery and was based on the identification of several ground control points (GCPs) throughout the area, which included islands and the floodplain east of the river channel, up to few km from the Route 13.

During the second survey it was also possible to reach a number of riverine areas usually difficult to access, such as the Tholati region.

Field surveys were carried out by the project team. During the second survey the project team was joined by two staff members of CPAWM, who were involved in the ground validation work. Project field staff gave logistic assistance to both surveys and helped in the collection of floral specimens. The preliminary findings from the surveys were presented to and discussed with District and Provincial officials in a workshop in Pakse at the end of the second survey.

GCPs were selected in homogeneous land units. Suitable landmarks were utilised wherever possible and each GCP was identified on 1:20,000 map sheets. GPS positioning and interpretation of aerial photographs assisted the operation in the field. At each site information on vegetation cover and substrate was collected. Most of the sites were photographed. Each GCP was marked on the 1:20,000 map as well as on the prints of the pre-classified image. The visual interpretation of major units in the Landsat TM colour composite and of the aerial photographs helped to confirm the identification and classification of GCPs, which became training areas for the digital classification.

Image pre-processing

The satellite imagery underwent the following pre-processing steps:

1. geo-referencing, whereby each image pixel was assigned its actual geographical co-ordinates and the images were registered against a universally recognised coordinate reference system, in this case Universal Transverse of Mercator (UTM);

2. HIS/RGB transformation: this procedure permits the conversion of pixel data between the two main colour displaying systems (Red, Green and Blue system and Hue, Intensity and Saturation system). It was used to merge the two different satellite images with different resolution (the SPOT panchromatic data at 10 m resolution with the LANDSAT TM data at 30 m resolution). This was done in order to obtain an image which would combine the most advantageous features of each satellite, that is the multispectral characteristics of the LANDSAT TM and the higher geometric resolution of the SPOT (Carper et al., 1990; Chavez et al., 1991).

3. production of colour composite images: the spectral information stored in the separate LANDSAT TM bands can be integrated by combining them into a RGB colour composite image. This procedure is widely used for image interpretation and classification, since, when a colour composite image is displayed, each terrestrial component takes up a specific colour, according to the band combination used. Many combinations of bands are possible. The spectral information is combined by displaying each band in one of the three primary colours (red, green and blue). Combinations of bands 3, 2, and 1 (displayed as red, green and blue) result in a "true colour composite", while combinations assigning a primary colour to one or more infrared bands are known as "false colour composites" (Lilles and & Kiefer, 1994). Combinations of bands 4, 3 and 2 ("colour infrared composite") and of bands 5, 4 and 3 (always in the red, green and blue order) are very useful for studying vegetation types since they provide the greatest degree of vegetative discrimination (Fuller et al., 1994; Lilles and & Kiefer, 1994). In a colour infrared composite image, green vegetation appears reddish, bare soil grey-brownish and water appears bluish. In a 543 RGB colour composite image, vigorous vegetation appears green, bare soil reddish and water bluish.

4. the calculation of the Normalised Difference Vegetation Index (NDVI), which helps to discriminate between the different types of vegetation on the basis of their green biomass (Rouse et al., 1974). The NDVI is derived from the normalised difference of the reflected solar radiation in the red and the near-infrared wavelengths. NDVI values vary between –1

and +1, where negative values account for the presence of water and positive ones are registered for vegetation. NDVI values around zero are typical of bare soil. NDVI values assisted in validating the land cover classification.

Digital image classification

A digital classification of satellite images based on areas of known, homogeneous land characteristics ("training sites" or "areas") is called supervised classification. With a supervised classification the analyst develops the spectral signatures of the training sites (for example different types of vegetation, soil, etc.). Then the computer assigns each pixel of the image to the cover type to which its signature is most similar.

Decisions about how similar signatures are to each other are made through statistical analysis (algorithms or classifiers). Several classifiers may be used. One of the most common classifiers used with remotely-sensed images is the Maximum Likelihood algorithm. This algorithm assumes that the distribution of each class is multivariate normal within spectral space (i.e. training areas must represent homogeneous classes). The algorithm considers the mean as well as the variability of brightness values in each spectral class in order to calculate the probability of pixel membership to each class. The output image is a thematic map in which each pixel represents the most likely class occurring within that pixel.

Results

In our study, the SPOT image was resampled to the UTM 48-N system using the 1:20,000 topographic maps, by means of a first order linear mapping function and the Nearest Neighbour resampling method. In this method the value of a pixel in the output image is determined by the value of the nearest pixel in the input image. The Root Mean Square (RMS) error for this operation was 9.28, that is less than one SPOT image pixel (10 meters).

The LANDSAT TM image was then registered to the UTM 48-N system using the SPOT geometrically corrected image. The RMS error for this operation was 11.76, that is less than one LANDSAT image pixel (30 meters). After geometric correction, HIS/RGB transformation was applied to the three LANDSAT TM bands 5, 4 and 3, the TM band 3 (0.63 - 0.69 µm) being replaced with the SPOT panchromatic band (0.51 - 0.73 µm). The results are shown in the following table:

Table 7. HIS/RGB procedure and results.

Original bands (30 m) -RGB system- ⇒	*RGB/HIS (Transformation 30m)* ⇒	*HIS/RGB Transformation (30m → 10m)* ⇒	*Merged bands (10 m) -RGB system-*
TM 5	Hue	Hue	New red channel
TM 4	Saturation	Saturation	New green channel
TM 3	Intensity	SPOT panchromatic	New blue channel

Two 543 RGB colour composite images were obtained by assigning the red colour to the band 5, the green to the band 4 and the blue to the band 3. This was done both on the original TM bands (obtaining an image at 30-meter resolution) and on the merged bands (obtaining an image at 10-meter resolution). The colour composite images thus obtained retained the classification characteristics of the TM sensor and also allowed the resolution of fine ground features such as dirt roads and other elements of the agricultural landscape (Altobelli, et al. 1998).

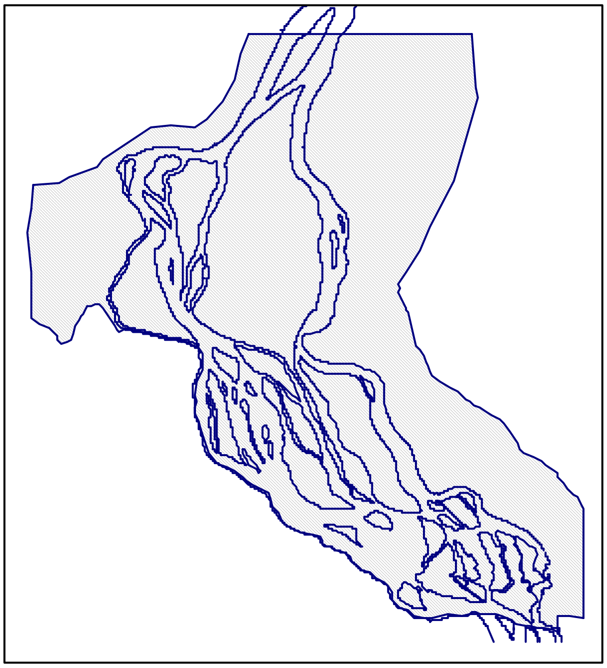

Figure 9. Land cover study area.

The ground truth data, the RGB colour composite and NDVI images, the digitised maps and the aerial photographs were used to identify the training areas in the 543 RGB colour composite image at ten-meter resolution, and to produce a training map. A supervised classification of bands 3, 4 and 5 at 10-meter resolution was carried out by means of this training map utilising the Maximum Likelihood algorithm. The final classification produced at 1:50.000 (reproduced at a reduced scale in annexes) identified nine land cover classes (Table 8).

For the calculation of the frequency of each class of land cover, a study area was identified which encompassed the river corridor and the key floodplain landscape elements between 1576895N and 1538772S. The eastern boundary was set roughly 3km east of Route 13 (coinciding approximately with the western boundary of Xe Pian NBCA), while the western boundary was a wide loop arbitrarily drawn to include all the cultivated land identifiable through the satellite imagery in the floodplain (Figure 9).

Table 8. Frequency and coverage of the classes of land cover in the study area

Class name	Area (square km)	%
1. Deciduous Dipterocarp-Oak Forest (DOF)	113.9	16.2
2. Mixed Evergreen-Deciduous Forest (MXF)	45.8	6.5
3. Secondary Growth	206.4	29.3
4. Sand Bank/Bar Vegetation	30.1	4.3
5. Boong area	12.1	1.7
6. Rice paddies	141.4	20.1
7. Bare soil	40.7	5.8
8. Water	113.4	16.1
Total	703.8	100

The study allowed us to identify agricultural landscape units, such as the paddy areas, which take up most of the large sandy islands. Agricultural land also takes up most of the corridor between the left river bank and Route 13 and extends further east into a mosaic of sparse DOF and secondary growth areas. The latter class (for a description of the forest facies, see Maxwell herewith) takes up vast areas in the floodplain, as a consequence of the impact of human pressure on the natural vegetation and because of the established and still expanding pattern of land use conversion, due to farming areas encroaching on the woodlands.

Few forested areas survive on the islands; the main ones are the forested hills in Done Khong and MXF area in the northern part of the same island. The southern islands, due to their thinner alluvium deposit and irregular topography are less suitable for rice cultivation and thus still preserve some forest cover, although this is in various stages of degradation.

The high spatial resolution of the spectral signature obtained through the HIS/RGB transformation allowed us to identify the key elements of the river landscape across the maze of channels formed by the Mekong and to produce the first relatively detailed description of the wetland landscape. The classification identified riparian vegetation, which covers river banks and the sand bars exposed during the dry season. It is difficult to identify this class with a distinctive vegetation facies, because it is often produced by the degradation of the MXF which probably used to dominate in the region, as well as by the establishment of villages along the river banks and the islands' coastline; these villages have vegetable gardens and planted trees. Nevertheless, this riparian vegetation is a key element of Siphandone landscape, fringing the river channels and the islands and covering the smaller islets and sand bars.

The digital classification also identified a more particular class of riparian vegetation which occurs in the Tholati wetland area and in the central-western sector of Siphandone, also called "*boong*" vegetation (Maxwell, herewith). In addition, the images taken during the dry season identified elements of barren soil or bedrock, which become exposed when the river level is low and which characterise the rocky channels found especially in the southern sector of the study area (e.g., around Somphamit waterfalls).

DEVELOPMENT OF GEOGRAPHIC INFORMATION SYSTEM

A geographic information system (GIS) was developed to compile, store, retrieve and present the geographically-referenced data collected during various investigations undertaken by the project. Due to operational conditions, it was decided to use a simple system to build the initial database. The GIS Cartalinx (Clark Labs) was selected because it allows a simple acquisition of vector data.

The initial data acquisition was carried out by staff at the Mapping Unit of DoF/CPAWM. A member of staff from the University of Trieste joined the CPAWM staff for a training session which also covered the principles of the remote sensing techniques which were used for the land cover classification study (Milesi, 1998). The vector database was refined and finalised at the University of Trieste and then installed at the project office in Pakse for validation and use.

The GIS database was built through the digital acquisition of topographic data provided by the Hydrographic Atlas of the Mekong Mainstream (1994) at scale 1:20,000. This Atlas provides a detailed description of the topography of the Mekong River corridor up to about 3 km from the river bank. The following topographic elements were recorded as separate thematic features:

- (i) coastline: river banks and large islands with settlements
- (ii) infrastructure: roads, footpaths, railway, bridges
- (iii) riverine in-stream morphology: islands without settlements, islets, sand bars, exposed riverbed
- (iv) floodplain wetland habitats: seasonal streams (*houay*) and ponds (*nong*)
- (v) district boundaries
- (vi) international boundaries

Villages were identified by comparing available topographic maps with records kept by Khong District. While the transliteration of the Lao names of villages and locations in the Latin alphabet does present variations which complicate accurate identification, close consultation with local counterparts and field surveys were used to overcome this problem. A list of 113 villages of Khong District was compiled and each settlement was identified and recorded in the GIS database.

During the implementation of the project, the GIS was utilised to facilitate the presentation of the main thematic features of the study area through vector images. The system allowed the documentation and reporting on various project activities which required, for example, the identification of villages, selected from a large number of settlements, which were involved in specific project activities or affected by natural resource management issues under investigation (e.g., the location of specific fisheries activities, the identification of villages involved in fisheries management). The database was also utilised to determine the basic geographical features of the study area, such as areas and contours of landscape elements (e.g., for geomorphological analysis). Examples of maps produced through the GIS system are included in the annexes.

Table 9. Surface of main (settled) islands

Island	*Area(km²)*	*Island*	*Area(km²)*	*Island*	*Area(km²)*
Done Khong	88.50	Done Phapheng	2.72	Done Houat	0.67
Done Som	22.13	Done Det	2.50	Done En	0.65
Done Khamao	17.65	Done Tan	2.49	Done Phouan	0.65
Done Xai	16.24	Done Nangkhouat	2.12	Done Hi Noy	0.62
Done Hi Gnai	12.89	Done Than	1.89	Done Chom	0.51
Done Loppadi	10.87	Done Lek fai	1.86	Done Khe	0.49
Done Saddam	6.76	Done Saniat	1.77	Done Dong	0.44
Done Khone	6.26	Done Khamao	1.74	Done Pueay	0.40
Done San	6.09	Done Xom	1.62	Done Chon	0.35
Done Long	4.82	Done Xang	1.24	Done Het	0.31
Done Phouman	4.46	Done Phang Khao	1.19	Done Liang	0.28
Done Xangphai	4.01	Done Tholati	1.02	Done Somhong	0.26
Done Nangloy	3.82	Done Het	0.88	Done Dong	0.21
Done Sahong	3.21	Done Kaden	0.85	Done Vay	0.18
Done Koy	2.93	Done Puay	0.82	Done Xang	0.11

The project also developed in pilot form a village database which would store and present socio-economic data about the villages. The database was developed in Microsoft Access by importing data on basic demographic indicators from the National Census. The database was merged with the GIS database file to attribute census indicators to respective villages. This has enabled, for example, the determination of the total population residing on the islands, as well as their population densities (Table 10).

The project team judged it premature to develop a more sophisticated GIS system within the limited life-span of the project and resources available: this would have required a much larger effort in data capture and management and might have proved too demanding within the context of the project. The system proved accurate and at the same time was simple enough to be used in the basic operational conditions of the project, where it facilitated the documentation and management of a vast set of geographical data collected across the extensive wetland area. It also has the potential to be further developed into an integrated information system covering the complex wetland area: this would be able to address the more sophisticated resource management and planning requirements, which are likely to arise from the further elaboration of area wide studies and management instruments.

Table 10. Population density of selected islands (based on 1995 census)

Island	*Population*	*Population density (inhab./ Km²)*	*Island*	*Population*	*Population density (inhab./ Km²)*
Done Sombong	277	1065.4	Done Xangphai	1,245	310.5
Done Houat	565	843.3	Done Lek fai	571	307.0
Done Chon	262	727.8	Done Than	549	290.5
Done Hi Noy	393	633.9	Done San	1,270	261.3
Done Tholati	549	536.1	Done Som	5,682	256.8
Done Khe	210	428.6	Done Nangkhouat	514	242.5
Done Long	1,812	375.9	Done Phouman	1,077	241.5
Done Kaden	309	363.5	Done Xom	347	214.2
Done Tan	885	355.4	Done Khone	1,310	209.3
Done Loppadi	3,811	350.6	Done Sadam	863	127.7
Done Det	876	350.4	Done Sahong	349	108.7
Done En	226	347.7	Done Khong	9,311	105.2
Done Xang	415	334.7	Done Phapheng	144	52.9

CONCLUSIONS

The Siphandone wetlands consist of a complex of landscape elements over a vast area, with a large number of settlements occurring along the river banks and on the islands. Natural resource management issues and rural development issues vary within the study area, due to geographic and socio-economic factors. The Siphandone Wetlands Project initiated the collection and compilation of baseline information on the area and its people. The study of the landscape of the river corridor through the land cover classification exercise and the setting up of a geographic information system facilitated the analysis and documentation of environmental features and resource management issues.

The progress achieved within the project was consistent with the basic goal of producing a preliminary environmental profile of the wetland area. It is hoped that these initial investigations will pave the way for more systematic and detailed assessments of the wetlands. The wetland complex and its people are facing important development challenges: population growth, the introduction of irrigated agriculture, the development of transport infrastructure and the establishment and growth of the tourism sector are among the key factors soon to bring about an entirely new economic landscape and a new range of opportunities for the local people. As these challenges arise, it is vital that the ecological functions of the riverine ecosystem and the recreational and conservation value of the natural features of the area should be properly recognised and valued and that a comprehensive and integrated management approach be adapted to the future development of the area.

Area-wide management and planning are relatively new concepts in Lao P.D.R, where institutional capacities are often very limited and management responsibilities are strictly drawn along sectoral lines. The effective implementation of area management strategies, such as master planning, needs to be fully integrated with a process of institution-building if it is to avoid being reduced to a mere paper exercise. Siphandone needs to embrace this kind of process. The Siphandone Wetlands Project, carried out in a relatively short period and at a time of initial attention on the area, aimed at introducing such an approach and at providing a fundamental profile of the area which will hopefully serve as the foundation stone for solid management of the area's resources. It is hoped that future developments will heed these recommendations and will take forward the study and the development of management measures for this exceptional wetland site.

Chapter 4

Vegetation in the Siphandone Wetlands

J. F. Maxwell

The Siphandone Wetlands area is characterized by its complex of channels, rapids, and waterfalls with numerous sandbars and islands, many of which are submerged during the rainy season (May-October) (Daconto, herewith). The highest points are Phou (mountain) Louang-Phou Khong at *c.* 239 m on Khong Island in the northern part of the study area and a hill *c.* 150 m high at the southern tip of Khone Island at the southern tip of the research area. Lowland elevations range from *c*. 75 cm on the plains of Khong Island to *c.* 60 m in the southern part of the area. The area has been settled for a long time and there is evidence of an ancient civilisation on Khone Island where the remains of a Buddhist temple is found on the top of the hill on the southern part of the Island. This temple must be hundreds of years old and would indicated that a town of some permanency and size was in the area to support the temple. Large scale exploitation of the natural resources in the area was done by French colonialists from the latter of last century until 1941 when the Japanese took over up to 1945. The impact of settlement and long history of exploitation in the region has resulted in the presently devastated condition of the forest.

This chapter[7] summarises the findings of surveys carried out by the author during the following periods: October 1997--end of the rainy season, Mekong River water level high; late January-early February 1998--dry season, river level falling; late April-early May 1998--driest and hottest time of the year, river level lowest; and Mid-September 1998--peak of the rainy season, river level high (Maxwell, 1999). The surveys enabled the collection of plant specimens which were carried to Chiang Mai University Herbarium for identification, while duplicates were also kept at the Biology Department, National University of Lao (Vientiane). 731 species (134 families) were identified (Appendix 2).

The climate in southern Lao is monsoonal with two distinct seasons, *viz*. rainy and dry. The rainy season is from late May-October, followed by a cool, dry period from November-February, and a hot, dry season during March-early May. The average amount of annual rainfall on Khong Island during 1979-1997 is 1753 mm. Records indicate that the amount of rainfall in Champasak Province has declined since 1980.

[7] The findings of this study have been published in the Natural History Bullettin of the Siam Society, 48:1 (2000).

MIXED EVERGREEN + DECIDUOUS, SEASONAL, HARDWOOD FOREST (MXF)

A MXF was the original forest in most of the area without riverine (fluvial) vegetation. Remnants of this MXF are now scattered throughout the area and range from being more evergreen to more deciduous in composition. Centuries of cutting and burning have left some MXF areas so degraded that they merge with other forest facies and village/ cultivated areas. This is vividly seen on several hills on Khong and Khone Islands as well as on the Cambodian mainland during January-May when the deciduous components of the MXF are either leafless or with new leaves. This provides a distinct contrast with the evergreen members of this association. The most intact lowland remnants of MXF are found on the northern part of Khong Island, east side of Sahong Island, and the southern parts of Xang and Tholati Islands. MXF areas have the highest canopy, densest understorey and ground flora, richest soil, and are shadier and cooler than surrounding areas. Some tall evergreen trees in the MXF are: *Pterospermum diversifolium* Bl. (Sterculiaceae), *Sandoricum koetjape* (Burm. f.) Merr. (Meliaceae), *Dipterocarpus alatus* Roxb. *ex* G. Done and *Hopea ferrea* Pierre *ex* Lanes. (both Dipterocarpaceae), *Homalium tomentosum* (Vent.) Bth. (Flacourtiaceae) *Irvingia malayana* Oliv. *ex* Benn. (Irvingiaceae), *Knema conferta* (King) Warb. (Myristicaceae), *Calophyllum inophyllum* L. (Guttiferae), *Lepisanthes tetraphylla* (Vahl) Radlk. (Sapindaceae), *Carallia brachiata* (Lour.) Merr. (Rhizophoraceae), and *Diospyros bejaudii* Lec. and *D. malabarica* (Desr.) Kostel. var. *siamensis* (Hochr.) Pheng. (Ebenaceae). Deciduous members include: *Anogeissus acuminata* (Roxb. *ex* DC.) Guill. & Perr. (Combreraceae), *Chukrasia tabularis* A. Juss. (Meliaceae), *Terminalia mucronata* Craib & Hutch. (Combretaceae), *Tetrameles nudiflora* R. Br. *ex* Benn. (Datiscaceae), and *Pterocarpus macrocarpus* Kurz (Leguminosae, Papilionoideae).

Evergreen woody climbers are: *Melodorum thorelii* Pierre *ex* Fin. & Gagnep., *Uvaria cordata* (Dun.) Alst., *U. dac* Pierre *ex* Fin. & Gagnep. (all Annonaceae), *Erycibe subspicata* Wall. *ex* G. Done (Convolvulaceae), *Rourea minor* (Gaertn.) Leenh. ssp. *minor* (Connaraceae), *Myxopyrum smilacifolium* (Wall.) Bl. var. *smilacifolium* (Oleaceae), *Ancistrocladus tectorius* (Lour.) Merr. (Ancistrocladaceae), and the rattan *Calamus palustris* Griff. var. *cochinchinensis* Becc. (Palmae). Some evergreen vines are: *Piper retrofractum* Vahl, *P. sylvaticum* Roxb. (Piperaceae), and *Rhaphidophora peepla* (Roxb.) Schott (Araceae). Most of the understorey is evergreen with *Glycomis parva* Craib (Rutaceae), *Memecylon amplexicaule* Roxb., *M .edule* Roxb. var. *edule* (Melastomataceae), *Rhodamnia cinerea* Jack (Myrtaceae); *Ixora finlaysoniana* Wall. *ex* G. Don, *I. nigricans* Wight & Arn. var. *nigricans*, and *Diplospora viridiflora* DC. (all Rubiaceae); *Lepisanthes fruticosa* (Roxb.) Leenh. (Sapindaceae), and *Pseuderanthemum latifolium* (Vahl) B. Han. (Acanthaceae) as common examples. *Desmos velutinus* (Hance) Ast (Annonaceae), *Eurycoma longifolia* Jack (Simaroubaceae), and *Clerodendron godefroyi* O.K. (Verbenaceae) are some deciduous representatives.

Marginal sandy and rocky areas between the MXF and the high water level of the river include some species which distinguish this habitat. *Quassia harmandiana* (Pierre) Noot. (Simaroubaceae), an evergreen tree; *Sampantaea amentiflora* (A.S.) A.S. (Euphorbiaceae), an evergreen treelet; and *Mallotus thorelii* Gagnep. (Euphorbiaceae), a deciduous shrub, are typical representatives.

The ground flora is diverse and includes both evergreen and deciduous members. Some evergreen species are: *Hedyotis nodiflora* Wall. *ex* G. Don (Rubiaceae), *Begonia yunnanensis* Lev. (Begoniaceae), *Gomphostemma lucidum* Wall. *ex* Bth. (Labiatae) and the ferns *Bolbitis hookeriana* K. Iw. (Lomariopsidaceae) and *Tectaria impressa* (Fee) Holtt. (Dryopteridaceae). Deciduous perennial herbs include: *Boesenbergia rotunda* (L.) Mansf., *Curcuma longa* L., *Globba schomburgkii* Hk.f. var. *schomburgkii, G. thorelii* Gagnep., *Kaempferia harmandii* Gagnep., and *Zingiber zerumbet* (L.) J.E. Sm. (all Zingiberaceae), *Alocasia odora* C. Koch and *Typhonium roxburghii* Schott (both Araceae), and *Habenaria trichosantha* Lindl. (Orchidaceae).

The ferns *Adiantum philippense* L. and *A. zollingeri* Mett. *ex* Kuhn (Parkeriaceae), and fern ally *Selaginella repanda* (Desv.) Spr. (Selaginellaceae) are also present. *Aeginetia indica* Roxb. (Orobanchaceae), a leafless root parasite, is also found in shaded MXF places.

DECIDUOUS DIPTEROCARP-OAK, SEASONAL, HARDWOOD FOREST (DOF)

Severe degradation or destruction of MXF areas has resulted in the development of DOF which is a secondary, fire-climax, kind of facies which differs considerably from MXF. DOF areas are open, have thin and rocky soil, and survive burning during the dry season (January-May). This kind of forest is dominated by several members of Dipterocarpaceae, *viz. Dipterocarpus obtusifolius* Teijsm. *ex* Miq. var *obtusifolius*, *D. intricatus* Dyer, *D. tuberculatus* Roxb. var. *tuberculatus*, *Shorea obtusa* Wall. *ex* Bl., and *S. siamensis* Miq. var. *siamensis*. The oak component, *Quercus kerrii* Craib var. *kerrii* (Fagaceae) is now rare due to exploitation. The DOF is typically leafless from about January to April and lacks bamboo. Other common, but not dominant, deciduous trees there are: *Cratoxylum formosum* (Jack) Dyer ssp. *pruniflorum* (Kurz) Gog. and *C. maingayi* Dyer (Guttiferae/Hypericaceae), *Terminalia alata* Hey. *ex* Roth, *T. chebula* Retz. var. *chebula*, *T. corticosa* Pierre *ex* Gagnep., and *T. mucronata* Craib & Hutch. (Combretaceae), *Xylia xylocarpa* (Roxb.) Taub. var. *kerrii* (Craib & Hutch.) Niels. (Leguminosae, Mimosoideae), *Sindora siamensis* Teysm. *ex* Miq. var. *siamensis* (Leguminosae, Caesalpinioideae); *Vitex limoniifolia* Wall. *ex* Kurz and *V. peduncularis* Wall. *ex* Schauer (Verbenaceae), *Spondias pinnata* (L.f.) Kurz (Anacardiaceae), *Schleichera oleosa* (Lour.) Oken (Sapindaceae); *Haldina cordifolia* (Roxb.) Ridsd., *Gardenia sootepensis* Hutch., and *Morinda tomentosa* Hey. *ex* Roth (all Rubiaceae), *Bombax anceps* Pierre var. *anceps* (Bombacaceae), *Diopyros ehretoides* Wall. *ex* G. Don (Ebenaceae), *Tristaniopsis burmanica* (Griff.) Wils. & Wat. var. *rufescens* (Hance) Parn. & Lug. (Myrtaceae), *Strychnos nux-vomica* (Loganiaceae), and *Careya arborea* Roxb. (Lecythidaceae). There are a few evergreen trees in the DOF, *viz. Mammea siamensis* (Miq.) T. And. (Guttiferae), *Wendlandia tinctoria* (Roxb.) DC. ssp. *orientalis* Cowan (Rubiaceae), and an occasional *Irvingia malayana* Oliv. *ex* Benn. (Irvingiaceae). *Irvingia* and *Pterocarpus macrocarpus* Kurz (Leguminosae, Papilionoideae), a deciduous tree, are often also found in MXF.

Aporusa villosa (Lindl.) Baill. (Euphorbiaceae), *Gardenia obtusifolia* Roxb. *ex* Kurz and *Catunaregam tomentosa* (Bl. *ex* DC.) Tirv. (both Rubiaceae), *Indigofera wightii* Grah. *ex* Wight & Arn. and *Lespedeza henryi* Schindl. (both Leguminosae, Papilionoideae), *Buchanania glabra* Wall. *ex* Hk. f. (Anacardiaceae), and an occasional *Gardenia cambodiana* Pierre *ex* Pit. (Rubiaceae) are some deciduous understorey species. *Memecylon scutellatum* (Lour.) Naud. (Melastomataceae), an evergreen shrub or treelet and *Phoenix humilis* Roy. var. *humilis* (Palmae), an evergreen herb, as well as *Cycas siamensis* Miq. (Cycadaceae) a very distinctive treelet, are also common. *Aganosma marginata* (Roxb.) D. Don (Apocynaceae), a deciduous woody climber and *Holarrhena curtisii* King & Gamb. (Apocynaceae), a deciduous shrub, are frequently seen. *Erianchne triseta* Nees *ex* Steud. (Gramineae) dominates many areas and also readily burns along with *Apluda mutica* L. (Gramineae), which is less common.

Although the woody flora in DOF is similar throughout the wetland, there are distinct differences in the ground flora which are based on exposure and drainage factors. Hills with DOF, such as Phou Kouang and Phou Khong on Khong Island, as well as those on the mainland east of Khong Island, have more rocky, *i.e.* eroded, soil, better drainage, and sparse ground flora in comparison to the DOF in the Jahn-Khinak Villages area on the mainland. These areas have mostly flat terrain, thicker soil, denser ground flora, and are flooded during the latter part of the rainy season (September-October). This kind of area can be considered a savanna. Due to habitat destruction and rice cultivation, savannas are either absent or very small and degraded on the islands. The differences in well-drained and seasonally flooded habitats are mainfest with the ground flora, many species of which are either more abundant in or only found in savanna areas.

These species are best seen in September-October when they are flowering. Some annual representatives in savanna are: *Polygala brachystachya* DC. (Polygalaceae), *Drosera indica* L. (Droseraceae), *Mitrasacme erophila* Leenh. ssp. *erophila* (Loganiaceae), *Centranthera cochinchinensis* (Lour.) Merr. var. *cochinchinensis* and var. *lutea* (Hara) Yama., *Lindernia viscosa* (Horn.) Bold., and *Torenia benthamiana* Hance (all Scrophulariaceae); *Fimbristylis schoenoides* (Retz.) Vahl, *Scleria neesii* Kunth, and *Rhynchospora rubra* (Lour.) Mak. (all Cyperaceae); *Coelachne perpusilla* (Arn. *ex* Steud.) Thw. and *Eremochloa ciliaris* (L.) Merr. (both Gramineceae).

Deciduous perennials are also common with: *Abelomoschus moschatus* Medic. ssp. *tuberosus* (Span.) Bors. and *Decaschiata harmandii* Pierre (both Malvaceae), *Trigonostemon reidioides* (Kurz) Craib (Euphorbiaceae), *Murdannia scapiflora* (Roxb.) Roy. (Commelinaceae), *Hypoxis aurea* Lour. (Amaryllidaceae); *Habenatia apetala* Gagnep., *H. rumphii* (Brogn.) Lindl., *Liparis acutissima* Rchb. f., and *Peristylus densus* (Lindl.) Sant. & Kapad. (all Orchidaceae); *Fimbristylis disticha* Boeck., *F. globulosa* (Retz.) Kunth, *Scleria levis* Retz., *S. psilorrhiza* Cl. (all Cyperaceae); *Eriachne triseta* Nees *ex* Steud. and *Mnesithea laevis* (Retz.) Kunth var. *laevis* (both Gramineae). *Aeginetia indica* Roxb. (Orobanchaceae), noted above as being present in MXF, also grows in wet savanna areas.

The herbaceous ground flora in rocky, well-drained DOF is mostly perennial, deciduous, and as in savanna areas is barren in the hot-dry season. Some common examples of deciduous perennials are: *Aphaenandra uniflora* (Wall. *ex* G. Don) Brem. (Rubiaceae), *Barleria strigosa* Willd. (Acanthaceae), *Amorphophallus parvulus* Gagnep. (Araceae), *Habenaria dentata* (Sw.) Schltr. (Orchidaceae), *Scleria levis* Retz. and *S. lithosperma* (L.) Sw. var. *linearis* Bth. (Cyperaceae), *Arundinella setosa* Trin. var. *setosa* (Gramineae), and *Oleandra undulata* (Willd.) Ching (Oleandraceae). *Thunbergia similis* Craib (Acanthaceae) and *Lygodium flexuosum* (L.) Sw. (Schizaeaceae), both deciduous vines, are also common. Annual herbs include: *Sonerila erecta* Jack (Melastomataceae), *Borreria brachystemma* (R. Br. *ex* Bth.) Val. (Rubiaceae), *Thorelia montana* Gagnep. (Compositae), *Torenia violacea* (Aza. *ex* Blanco) Penn. (Scrophulariaceae), *Digitaria siamensis* Henr. and *Sporobolus harmandii* Henr. (both Gramineae). *Cassytha filiformis* L. (Lauraceae), a leafless, hemi-parasitic, autotrophic, epiphytic vine is also found throughout the year on undergrowth. *Curcuma zedoaria* (Berg.) Rosc., *Stahlianthus thorelii* Gagnep. (both Zingiberaceae), *Murdannia loureiri* (Hance) Rao & Kam. (Commelinaceae), *Amorphophallus koratensis* Gagnep. and *Pseudodracontium lacourii* (Linden & Andre) N.E. Br. (both Araceae), and *Crinum wattii* Baker (Amaryllidaceae), all deciduous, perennial, ground herbs which flower when leafless in April-May, are common in DOF. *Geodorum attenuatum* Griff., *G. recurvum* (Roxb.) Alst. (Orchidaceae), and *Stemona burkillii* Prain (Stemonaceae), a vine; also flower druing this time with very immature leaves. *Curcuma gracillima* Gagnep., *Globba schomburgkii* Hk. f. var. *schomburgkii*, and *G. thorelii* Gagnep. (all Zingiberaceae) are deciduous, perennial, ground herbs which flower from August to October while having leaves.

There is also another DOF habitat which is found on exposed rhyolite bedrock with patches of thin soil, especially in depressions, which only has herbaceous ground flora. The Phou Kow Gayo area on the west side of Khong Island is the best place to see this very exposed habitat which is completely dry and barren in the hot-dry season and green in the rainy season--especially September-October. Some of the species found in this kind of bedrock habitat are either sparse or absent in savanna areas are: *Polycarpaea corymbosa* (L.) Lmk. (Caryophyllaceae), *Hedyotis gracilipes* (Craib) Fuku. var. *gracilipes* and *H. tetrangularis* (Korth.) Walp. (Rubiaceae), *Heliotropium strigosum* Willd. (Boraginaceae), *Psilotrichum ferrugineum* (Roxb.) Moq.-Tand. (Amaranthaceae), and *Fimbristylis obtusa* (Cl.) Ridl. (Cyperaceae)--all annuals. Some deciduous perennial representatives are: *Leptochloa malabarica* (L.) Veldk. (Gramineae) and *Cheilanthes belangeri* (Bory.) C. Chr. (Parkeriaceae). *Salomonoia cantoniensis* Lour. var. *cantoniensis* (Polygalaceae), *Zornia gibbosa* Span. (Leguminosae, Papilionoideae), and *Rhynchospora rubra* (Lour.) Mak. (Cyperaceae) are some annual herbs which are more common in bedrock areas than in savanna. *Utricularia minutissima*

Vahl (Lentibulariaceae), *Burmannia coelestis* D. Don (Burmanniaceae), annuals, and *Hypoxis aurea* Lour. (Amaryllidaceae), a perennial herb, are found approximately equally in both habitats.

SECONDARY GROWTH (SG)

Since the area has had a long history of forest destruction there are various stages of degradation which are present in the form of secondary growth. As noted above, DOF is a kind of secondary growth, but it differs from ofter SG associations in that it is fire-climax. The species found in SG differ from those found in MXF and DOF, however in many places a clear distinction between these forest types is vague due to merging of forest facies. Most SG species are deciduous and grow in open, single-canopied places, while none of them can be considered dominant. Typical SG trees are: *Cratoxylum formosum* (Jack) Dyer spp. *pruniflorum* (Kurz) Gog. (Guttiferae/Hypericaceae), *Casearia grewiifolia* Vent. var. *grewiifolia* (Flacourtiaceae), *Ziziphus nummularia* (Burm. f.) Wight & Arn. (Rhamnaceae), *Microcos paniculata* L. (Tiliaceae), *Bauhinia malabarica* Roxb. (Leguminosae, Caesalpinioideae), *Dalbergia nigrescens* Kurz var. *nigrescens* (Leguminosae, Papilionoideae), *Alangium salvifolium* (L.f.) Wang. ssp. *hexapetalum* (Lmk.) Wang. (Alangiaceae), *Feronia limonia* (L.) Swing. (Rutaceae), and *Streblus asper* Lour. var. *asper* (Moraceae), which is evergreen. Typically SG areas have many spiny or thorny woody climbers and scandent species, *e.g. Capparis micrantha* DC. (Capparaceae), *Ziziphus cambodiana* Pierre var. *cambodiana* and *Z. oenoplia* Mill. var. *oenoplia* (Rhamnaceae), *Harrisonia perforata* (Blanco) Merr. (Simaroubaceae), *Acacia megaladena* Desv. var. *megaladena* (Leguminosae, Mimosoideae), and *Caesalpinia hymenocarpa* (Prain) Hatt. (Leguminosae, Caesalpinioideae). Inermous, deciduous, woody climbers and scandent species include: *Olax scandens* Roxb. (Olacaceae), *Calycopteris floribunda* (Roxb.) Lmk. (Combretaceae), and *Congea tomentosa* Roxb. var. *tomentosa* (Verbenaceae). *Bridelia tomentosa* Bl. (Euphorbiaceae), a deciduous, inermous woody climber or tree, is also common. The robust grass *Thysanolaena latifolia* (Roxb. *ex* Horn.) Honda (Gramineae) often forms dense thickets along with deciduous shrubs, *e.g. Helicteres hirsuta* Lour. (Sterculiaceae), *Colona auriculata* (Desf.) Craib (Tiliaceae), and the evergreen *Memecylon scutellatum* (Lour.) Naud. (Melastomataceae). Common vines include: *Cayratia trifolia* (L.) Dom. var. *trifolia* (Vitaceae), *Bauhinia penicilliloba* Pierre *ex* Gagnep. (Leguminosae, Caesalpinioideae), *Abrus precatorius* L. (Leguminosae, Papilionoideae), *Dioscorea bulbifera* L. and *D. glabra* Roxb. var. *glabra* (Dioscoreaceae). Secondary growth herbs, many of which are also weeds, are: *Eupatorium odoratum* L. (Compositae), *Hyptis suaveolens* (L.) Poit. (Labiatae), *Crotalaria verrucosa* L. (Leguminosae, Papilionodeae), *Costus speciosus* (Koen.) J.E. Sm. (Zingiberaceae), and *Amorphophallus paeoniifolius* (Denn.) Nichol. (Araceae). *Cissus modeccoides* Pl. var. *modeccoides*, *C. quadrangularis* L. (Vitaceae), and *Smilax extensa* Wall. *ex* A. DC. (Smilacaceae) are some examples of vines.

Weeds, that is more ephemeral (*i.e.* annual) herbs, include some species which are typically found in rice fields and can be seen when these places are wet. These include: *Dopatrium acutifolium* Bon. (Scrophulariaceae), *Utricularia bifida* L. var. *bifida* and *U. minutissima* Vahl (Lentibulariaceae), *Eriocaulon quinquangulare* L. (Eriocaulaceae), and *Burmannia coelestis* L. (Burmanniaceae). *Grangea maderaspatana* (L.) Poir., *Sphaeranthus indicus* L. (both Compositae), and *Ammannia baccifera* L. (Lythraceae) are some species which flower and fruit when the fields are dry.

Some weeds found in sandy, often seasonally inundated areas, are: *Spilanthes paniculata* Wall. *ex* DC. (Compositae), *Glinus lotoides* L. (Aizoaceae), *Polycarpon prostratum* (Forssk.) Asch. & Schw. (Caryophyllaceae), *Polygonum plebeium* R. Br. (Polygonaceae), *Cyperus pygmaeus* Rottb. (Cyperaceae); *Digitaria bicornis* (L.) Roem. & Schult., *Eragrostis amabilis* (L.) Nees, *and Eleusine indica* (L.) Gaertn. (all Gramineae).

Oryza sativa L. (Gramineae), sticky rice, is the most common crop grown while home gardens have a variety of vegetables, spices, and fruits. Some of these plants are: *Anethum graveolens* L. (Umbelliferae, dill), *Brassica chinensis* L. (Cruciferae, Chinese cabbage), *Capsicum annuum* L. (Solanaceae, chili), *Citrullus lanatus* (Thunb.) Matu. & Nak. (Cucurbitaceae, water melon), *Ipomoea aquatica* Forsk. (Convolvulaceae, water morining glory), *Lypopersicon lycopersicum* (L.) Karst. (Solanaceae, tomato), *Nicotiana tabacum* L. (Solanaceae, tobacco), and *Solanum melongena* L. (Solanaceae, egg plant).

Cultivated fruit trees include: *Annona squamosa* L. (Annonaceae, custard apple), *Cocos nucifera* L. (Palmae, coconut), *Mangifera indica* L. (Anacardiaceae, mango), *Tamarindus indica* L. (Leguminosae, Caesalpinioideae; tamarind), and *Chrysophyllum cainito* L. (Sapotaceae, star apple). Bamboos (Gramineae, Bambusoideae) are also commonly planted for their general construction utility, edible shoots, and ornamental value. These include: *Bambusa bambos* (L.) Voss. *ex* Vilm., *B. vulgaris* Schrad. *ex* Wend. var. *striata* (Lodd. *ex* Penny) Gamb., *Dendrocalamus longispathus* Kurz, and *Thyrsostachys oliveri* Gamb. *Samanea saman* (Jacq.) Merr. (Leguminosae, Mimosoideae; rain tree) and *Ceiba pentandra* (L.) Gaertn. (Bombacaceae, kapok), and to a lesser and more recent extent *Tectona grandis* L. f. (Verbenaceae, teak) are also commonly seen.

EPIPHYTES AND EPILITHS

Vascular epiphytes are common, especially on older trees, and include evergreen, hemi-parasitic shrubs, *viz*. *Helixanthera pulchra* (DC.) Dans., *Macrosolen lowii* (King) Tiegh., and *Scurrula parasitica* L. (all Loranthaceae); deciduous ferns: *Davallia denticulata* (Burm. f.) Mett. *ex* Kuhn (Davalliaceae) and *Drynaria quercifolia* (L.) J. Sm. (Polypodiaceae), and *Pyrrosia adnascens* (Sw.) Ching (Polypodiaceae) which has fronds which dry and shrivel during the dry season and become succulent and green again when it rains.

Due to extensive exploitation for cultivation and habitat destruction, epiphytic Orchidaceae are generally sparse. Some examples are: *Cymbidium bicolor* Lindl., *Dendrobium venustum* Teijsm. & Binn., and *Smitinandia micrantha* (Lindl.) Holtt.

Vascular epiliths are also found in the study area, although they are not as common as epiphytes, and are found in places lacking water. Several ferns have been observed to grow on rocks, *e.g.* *Adiantum zollingeri* Mett. *ex* Kuhn (Parkeriaceae), a deciduous species which is also a geophyte: while *Drynaria bonii* C. Chr., which is deciduous, and *Pyrrosia stigmosa* (Sw.) Ching (both Polypodiaceae), being evergreen, are more commonly epilithic than epiphytic.

BEDROCK

The bedrock in the study area consists of rhyolite and sandstone which is often interbedded with shale and chert. All of these kinds of rocks are found above the major Sompamit-Pah Peng fault line, while only sandstone, shale, and chert are found below it. Laterite is found on top of sandstone bedrock on the mainland, especially in the Kinak Village area. The bedrock has had no effect on the vegetation in the area, that is MXF and DOF are found on all rock types there.

WETLAND AREAS

Seasonal fluctations in the level of the Mekong River and tributary streams have resulted in a distinct riparian vegetation with a predominance of rheophytic and amphibious plants. Seven categories of habitats can be distinguished which are based on river flow, bedrock conditions, and substrate. The entire area is submerged under c. 3-8 m of fast flowing, turbid water from about August-November and is exposed from about January-May, the time when many species flower and fruit. The bedrock is rugged sandstone with some interbedded shale.

Sand Bars

The sandy banks of the islands and sand bars have within the past 5-10 years, become infested with *Mimosa pigra* L. (Leguminosae, Mimosoideae), a deciduous shrub from tropical America which forms dense, thorny growth. This species is rapidly expanding at the expense of native vegetation and is also extremely difficult to eradicate.

Marginal, mostly amphibious, trees include *Crateva magna* (Lour.) DC. (Capparaceae), *Combretum quadrangulare* Kurz (Combretaceae), and *Salix tetrasperma* Roxb. (Salicaceae), which has been over-exploited. *Saccharum spontaneum* L. and *Phragmites vallatoria* (Pluk. *ex* L.) Veldk. (both Gramineae) are large, vigorous grasses found in sandy areas. *Homonoia riparia* Lour. (Euphorbiaceae), a common amphibious shrub, and *Oxystelma esculentum* (L.f.) R. Br. (Asclepiadaceae), a vine, are also found in this habitat. Weeds and home gardens are common on the exposed banks from about January to June.

Boong Area

Shallow, rocky places with permanent river flow are characterised by having dense tufts or small islands of vegetation on sandstone bedrock where there is a general absence of sand. The vegetation here is rheophytic and most of its components are not found in other places in the wetland. This area in locally known as *boong* and is restricted to an area north of the fault line and south of Tholati Island. *Telectadium edule* H. Baill. (Asclepiadaceae) dominates, while *Homonoia riparia* Lour. (Euphorbiaceae), *Rotula aquatica* Lour. (Boraginaceae), and *Xanthonnea parvifolia* (O.K.) Craib var. *salicifolia* (Pierre *ex* Pit.) Craib (Rubiaceae), all shrubs, are also common. The fern *Meniscium proliferum* (Retz.) Sw. (Thelypteridaceae) and *Lophopogon intermedius* A. Camus (Gramineae), a grass, are also found here.

Kai Kum Zone

Gohk kai kum is the Lao name for *Phyllanthus jullienii* Beille (Euphorbiaceae), a shrub, which is the dominant species in the region below the “boong” area and above the falls. This place is flat, rugged sandstone bedrock which is completely exposed from December to May. There are channels through the bedrock and patches of sand in some places. Amphibious herbs such as *Hygrophila incana* Nees (Acanthaceae) and delicate *Cryptocoryne tonkinensis* Gagnep. (Araceae) are also present

Acacia-Anogeissus Zone

This is a unique area below the falls which is the deepest zone of submergence in the wetlands. It is dominated by two species of current-bent, deciduous trees up to 10 m tall, *viz*. *Anogeissus rivularis* (Gagnep.) Lec. (Combretaceae) and *Acacia harmandiana* (Pierre)Gagnep. (Leguminosae, Mimosoideae) which grow on seasonally dry, sandy and rocky places. *Homonoia riparia* Lour. (Euphorbiaceae) is found in amphibious places there.

Channels

I have included this as a distinct wetland zone since some of the species found in these places seem to most common in this habitat. Channels include shallow to dry, seasonally flooded, rocky (sandstone) and sandy riverine areas with scattered shrubs and treelets, mostly 1-2.5 m tall. *Morinda pandurifolia* O.K. var. *oblonga* (Pit.) Craib (Rubiaceae), *Eugenia mekongensis* Gagnep. (Myrtaceae), *Gymnosporia (Maytenus) mekongensis* Pierre (Celastraceae), and *Blachia cotoneaster* Gagnep. (Euphorbiaceae) are common here. *Vincetoxicopsis harmandii* Cost. (Asclepiadaceae), a tufted herb, is also present. *Fimbristylis aestivalis* (Retz.) Vahl var.

aestivalis and *F. brunnea* Cl. (Cyperaceae) are common, deciduous, perennial, ground herbs found in both the *Acacia-Anogeissus* zone and in channels. Most of the woody plants in this habitat have also been bent by river flow.

Seasonal Streams

Some of the larger islands, *e.g.* Khong and Khon, have seasonally dry drainage streams while true seasonal streams are found on the mainland. These places have rocky beds and sometimes have isolated pools where aquatic plants, *e.g. Hydrilla verticillata* (L.f.) Roy. (Hydrocharitaceae) grow. The vegetation is mostly degraded MXF without riverine facies.

Aquatics

Several species of perennial herbs requiring a constantly wet environment are found in the area. Floating aquatics include *Eichhornia crassipes* (Mart.) Solms (Pontederiaceae), an introduced species which often covers ponds and stagnant water bodies in other places. This plant is uncommon in the Mekong River since it is washed away each year during the rainy season. *Ipomoea aquatica* Forsk. (Convolvulaceae), an amphibious vine, is cultivated for its edible vegetation both on sand banks and on the surface of the water nearby.

Nymphaea nouchali Burm. f. (Nymphaeaceae) and *Nymphoides indica* (L.) O.K. (Gentianaceae/Menyanthaceae) root in substrate while its leaves and flowers float. Submerged aquatics rooting in mud include: *Hydrilla verticillata* (L.f.) Roy. and *Ottelia alismoides* (L.) Pers. (both Hydrocharitaceae), *Potamogeton crispus* L. var. *crispus* (Potamogetonaceae), and *Ceratophyllum demersum* L. (Ceratophyllaceae). These species appear to be floating when the water level is low. *Utricularia aurea* Lour. (Lentibulariaceae), *Lemna perpusila* Torr. (Lemnaceae), both floaters; and several species rooting in the bottom of ponds and wet ditches, *e.g. Cyanotis axillaris* (L.) D. Don (Commelinaceae), *Monochoria vaginalis* (Burm. f.) Presl (Pontederiaceae), and *Typhonium flagelliforme* (Lodd.) Bl. (Araceae) are other aquatic herbs found in mostly seasonally dry areas away from the Mekong River. *Hydrocera triflora* (L.) Wight & Arn. (Balsaminaceae) and *Hydrolea zeylanica* (L.) Vahl (Hydrophyllaceae) are annual herbs found in savanna areas which root in mud in both amphibious and aquatic habitats. There is also a filamentous green algae which is very dense in the Mekong River during February-March, but is absent by April May.

Marsilea quadrifloia L. (Marseliaceae), an amphibious fern rooting in sandy substrate, is often completely exposed when the river is low. The entire plant is edible, however I have not seen it cultivated.

Chapter 5

Deforestation and the potential for forest restoration in the Siphandone wetlands

Stephen Elliott

The Siphandone Wetlands support a dense and rapidly growing human population, resulting in a wide range of environmental problems such as over-exploitation of natural resources and erosion. In the initial phase of the Siphandone Wetlands project two key issues of deforestation and river bank erosion were identified as requiring further study in order to design mitigation measures that could be implemented in the future. Therefore field work was undertaken in October-November 1998 to meet the following objectives: (i) to assess local perceptions of the problem of deforestation and river bank erosion in the Siphandone Wetlands; (ii) to assess local support for mitigation activities to address these problems; (iii) to assess the current condition of surviving forest and deforested areas in terms of their potential for restoration; and (iv) to make recommendations as to the technical methods that might be employed to revegetate the river banks and restore forests.

This chapter summarises the findings of that study (reported in Elliott, 1998) based on the evidence gathered through interviews with community leaders at 13 villages (B. Dong, B. Don Xom, B. Hang Khone, B. Houayhai, B. Khinak, B. Khone Neua, B. Khone Tai, B. Loppadi Chok, B. Nalan, B. Senhatgnai, B. Senhom, B. Senlam, B. Venthong) and with local officials, as well as field observations at potential reforestation sites, existing plantations and at nurseries already established in the area.

Data to assess the feasibility of reforestation were gathered mostly by informal, semi-structured, participatory discussions with key village community members and through direct observation of areas identified by the local people as being suitable for reforestation. Discussions were guided by a set of prepared questions. However the situation in each village and the attitudes and patience of the meeting participants varied considerably among villages and therefore the actual questions asked at each village were modified accordingly. Questions covered use of forest products, collection of firewood and timber, the need for tree planting, selection of sites and species for planting, establishment of village tree nurseries and the logistics of tree planting and caring for trees after planting. Surveys along the river banks were carried out using local boats and were guided by a map showing the severity of erosion produced by an earlier geological-geomorphological survey (Brambati and Carulli, herewith).

In marked contrast to most of the rest of Laos P.D.R. the Siphandone wetlands support a human population of very high density and rapid growth rate, with cultivatable land in very short supply. In eight of the thirteen villages surveyed, families have access to less than one ha of cultivated land, whilst no villages average more than 2 ha of cultivated land per family. Several villages reported that many families have insufficient paddy land to meet their basic subsistence requirements and that several families have no paddy land at all. Landless families help those who own land with harvesting etc. usually in exchange for rice. In the dry season, the landless seek waged employment in towns, often entering Thailand to find work. Until the time of the survey, rice production was deemed to barely meet subsistence requirements, although with significant variations among villages depending on land availability, population density and flooding hazards[8].

Since most of the flat land is already occupied with rice cultivation the villagers grow other crops on the faces of the river banks on exposed and highly erodable soils. Also exposed sand bars are cultivated when the river is low. Cultivation of such temporary and unstable land is a further indication of the severity of the land shortage problem. Crops cultivated on river banks and sand bars include chilli, tobacco, lettuce, onion, beans, peanut. Other minor crops grown in the area include citrus fruits, banana and cassava.

Most families in the sample villages own at least 2 animals with buffaloes outnumbering domestic cows by about 2:1. Buffaloes work in the rice fields during the rainy season and are then allowed to wander at will on dry rice fields and in the forest. Their preference for eating herbaceous plants acts as an effective weed control mechanism and their selective preferences among the various tree species growing in the forest can cause significant modification of the forest structure leading to domination of regenerating forests by non-palatable species.

DEFORESTATION

The enormous pressure on land outlined above has resulted in severe deforestation throughout the Siphandone wetlands. The land use cover map produced by the Siphandone Wetlands Project shows very little forest remaining in the area (Altobelli and Daconto, herewith). Observations in the field confirmed that all the remaining forest is in a highly degraded condition but the potential for regeneration was high. The largest remaining forest fragments are in the centre of Khong Island and in the southern parts of the southernmost islands (Khone, Sahong, Sadam and Phapheng). On the mainland, along the eastern bank of the Mekong, there are substantial stretches of degraded deciduous dipterocarp-oak forest and in the south, mixed evergreen-deciduous forest.

The main causes of deforestation have been identified as follows:

Logging for timber : Most of the forest on the islands is practically devoid of commercially valuable timber tree species, indicative of extensive large-scale logging operations in the past. Already timber for local use is apparently in short supply. Villagers most commonly listed the following as favoured timber tree species for house construction: *Dipterocarpus obtusifolius, D. alatus* (*mai yang*), *D. tuberculatus* (*mai goong*), *D. intricatus* (*mai tabaeng*), *Shorea obtusa* (*mai chik*), *S. siamensis* (*mai haang*), *Pterocarpus macrocarpus* (*mai doo*), *Xylia xylocarpa* (*mai daeng*), whilst only *Hopea odorata* (*mai kaen*) was favoured for boat construction. Most villagers reported that these species are now rare or absent in local forests and therefore most timber is not cut locally but purchased from markets either within Laos or from Cambodia. However such statements might have been influenced by the presence of District Forest officers at the village discussions. Nevertheless, even where villagers admitted to cutting timber locally, they mostly agreed that local timber supplies are insufficient to meet future needs.

[8] This survey was carried out when the large scale introduction of irrigation had just begun in the area.. The effects of this important development are still not well assessed (Friend, herewith). On the other hand, the underlying problem of land scarcity and forest degradation remains, due to the almost complete conversion of forest land which has already occurred throughout the islands.

Firewood collection: Within the project area, all cooking is carried out on open wood fires. Very little charcoal and no electricity or gas is used. Species preferentially selected by the villagers for firewood supply include *Combretum quadangulare* (*mai gaer*), *Memecylon scutellatum* and *M. edule* (both *mai meud*), *Hymenocardia punctata* (*mai hua ling*), *Shorea obtusa* (*mai chik*), *S. siamensis* (*mai haang*), *Cratoxylum formosum* (*mai tieow*), *Eugenia cumini* (*mai wah*), *Lagerstroemia calyculata* (*mai bheuay*), *Antidesma acidum* (*mai mukmaew*), *Terminalia mucronata* (*mai singkum*) and *Microcos paniculata* (*mai khongsom*). Extensive cutting of live trees for firewood can be observed in forest areas. With a rapidly growing population in the area and very little forest left, firewood collection is undoubtedly the greatest single threat to all remaining forest on the islands. The absence of large tree stumps in most of the forest areas inspected indicated that deforestation for firewood production has been having a major impact on forest structure for decades and very few trees from the original primary forest survived. However, the forest clearly has great potential for rapid regeneration. Even in clear-felled areas, tree stumps of 50-70 cm height are left to coppice and they contribute considerably towards vigorous natural regeneration. Villagers said that the rotational period used for firewood production in deciduous dipterocarp-oak forest was about 20 years. As the population grows and the remaining forest shrinks, this rotational period will most likely be reduced as the villagers are forced to cut smaller, younger trees to meet their basic requirements for firewood. However, most villagers thought that there would be no shortage of firewood available locally in the near future. Only Ban Senlam and Ban Houayhai anticipated a local shortage, whilst at Ban Loppadi Chok and Ban Khinak, firewood is already purchased from outside.

Browsing : Browsing by domestic cows and buffaloes is another factor leading to further degradation of the forest and altering patterns of regeneration following tree felling. The influence of browsing might not be entirely negative, as in open areas it might reduce competition experienced by the regenerating trees.

Fire : Local perceptions of the frequency and potential threat of fire to forests varied greatly among the villages surveyed. Observations in the field suggested that fire was frequent in most places throughout the project area. Fire protection could therefore have a significant effect in improving the condition of surviving forest fragments (provided other degrading factors are also controlled) and in the successful establishment of planted trees.

Effects of deforestation on the local population

The main impact of deforestation on the human population is a reduced supply of wood, both timber for construction and firewood for cooking. Already most villages depend on imported supplies of timber and a few also have to purchase firewood or charcoal from outside the village. This situation can be sustained only as long as external supplies continue to exist. Planning to deal with this problem is an urgent priority, since new plantations to meet the wood supply cannot be created instantaneously.

In general, villagers reported that they did not rely on the forest very much for non-timber forest products: just bamboo shoots, a little honey, resin (known locally as *kissi*), a few edible fruits and vegetables and a few medicinal plants. Given local conditions, further deforestation is unlikely to have much effect on the villagers in terms of losses of essential forest products. It appeared that no recreational activities relied on the forest and at only one village (B. Senhatgnai) was forest being conserved for spiritual reasons, namely as a place where the guardian spirits of the village were said to reside.

Impact of deforestation on wildlife

The Siphandone Wetlands have undergone a process of habitat loss and species extirpations very similar to that experienced by other developing areas of SE Asia. The main effects of deforestation on wildlife have been:

- reduction in the total area available as wildlife habitat;
- fragmentation of remaining forest into small isolated patches, each incapable of supporting viable populations of wild animals;
- an increase in edge effects whereby outside influences penetrate into the middle of remaining forest fragments; and
- a reduction in the habitat complexity of the remaining forest fragments and niche space available to wildlife through continued tree felling and chopping.

The factors outlined above first began to affect wildlife on small islands and in areas with high human population density. The first species to become extirpated were large animals, especially carnivores at the top of the food chain and those requiring large home ranges. For example villagers said that large cats, sambar deer, serow, wild dogs and peacocks disappeared from the area approximately 20-40 years ago. The largest mammals reportedly still existing in the area are muntjak deer and wild pig, but distribution of these animals is very patchy and probably limited to the larger islands still retaining some forest cover. The impact of forest habitat degradation on birds in Khone islands is reported by Cunningham (herewith). Although the area has lost several large mammal species, it reportedly still retains a wide diversity of smaller animals including several civet species, porcupine, pangoline, rabbits, monitor lizards, many species of snakes (including python and cobra) and many bird species. The continued presence of small carnivores such as small jungle cats and birds of prey indicate that food chains are still relatively intact. Plant diversity is also high (see Maxwell, herewith) and such a diverse vegetation undoubtedly supports a diverse array of insect species.

The potential for natural forest regeneration

An increased commitment to forest protection and restoration in the area is justified to conserve what remains. In particular, conservation activities should be strengthened within the remaining forest in the centre of Khong Island, already designated a Provincial Reserved Forest. Furthermore the forest areas on the southern islands should receive some protected status and active conservation programmes initiated.

All forest areas observed during field work supported vigorous natural regeneration. The most important source of natural regeneration is growth of coppices from surviving tree stumps. The fact that villagers cutting trees for firewood always leave behind tree stumps about 50-70 cm tall suggests that villagers are well aware that forest regeneration proceeds more rapidly when tree stumps are left behind, enabling another cut for firewood within about 20 years in deciduous dipterocarp-oak forest. Seedlings establishing either from the soil seed bank or from the seed rain are also common in all areas of degraded forest observed. The seed rain is probably a more important source of natural regeneration than the soil seed bank. Most seasonally dry tropical forest tree seeds lack dormancy or have fairly short dormancy times (the maximum length of seed dormancy of more than 300 species tested at the Forest Restoration Research Unit, CMU was 253 days (Elliott et al., 1997)). Therefore if the factors causing deforestation listed above were to be prevented or reduced, even the most severely degraded forest areas would regenerate naturally and fairly rapidly from coppices, existing seedlings and the seed rain.

Therefore tree planting needs play only a minor role in carrying out restoration of natural forest ecosystems for the purposes of wildlife conservation or to provide areas suitable for ecotourism. However an intensive local education programme would be necessary before activities aimed at restoring natural forest ecosystems would receive local support: during interviews conducted in the villages, restoring forest for ecological purposes such as biodiversity conservation was a concept incomprehensible to everyone interviewed during field work, including district forest office staff. Any forest conservation effort should address this problem and at the same time the widespread need for economic benefits.

In nearly all villages surveyed, villagers expressed a strong interest in establishing new plantations of valuable timber tree species. The most favoured species for timber plantations was teak, because of its high economic value and an already established export market through Thailand. Many teak plantations (mainly on Khong Island) and a few *Dipterocarpus alatus* (*mai yang*) plantations (on the southernmost islands) have already been established with great success. Villagers suggested two types of areas for the establishment of cash-generating timber plantations: small family-owned plots, such as 0.5-2 ha home gardens, managed by individual family groups to provide private cash income; and community forests: such as larger areas (2-10 ha) be managed by the village committee, where timber would be used for community projects or sold to generate revenue for community use. For community forests other species, in addition to teak, were considered appropriate.

All areas suggested as community forest sites already supported vigorously regenerating, secondary forest, actively exploited for the chopping of firewood. Replacing such areas with plantations of timber trees would obviously have a serious effect on firewood supplies, including increased destruction of remaining forests, decreased self-sufficiency and higher fuelwood prices. One possible outcome might be that increased cash income from the sale of timber trees fails to compensate for the increased time, effort and cash needed to obtain daily supplies of firewood or other fuels for cooking. These economic trade-offs require further study. To avoid potential shortages of firewood, villagers should be encouraged to maintain local supplies of firewood or create new supplies by establishing village woodlots close to the villages. Management techniques should be developed to increase the productivity of firewood tree species. Furthermore, the efficiency of burning firewood could be increased through the substitution of open fires with more efficient stoves, resulting in less firewood being cut per year.

Villagers agreed that one of the main factors currently inhibiting the establishment of timber plantations was lack of seeds or seedlings. Commercial logging has been so thorough in the area that very few mature, fruiting trees of valuable timber tree species survive locally for the collection of seed. Furthermore only the poorest formed or slowest growing trees escaped logging. Seedling production would therefore require close attention in any future forest regeneration activity. Existing local nursery and institutional capacities should be adequately strengthened towards meeting local demand.

With regard to forest restoration, the following recommendations are made:

1. An education program to explain the benefits of encouraging regeneration of natural forest ecosystems should be initiated.

2. Training and financial support should be provided to enable local forest staff to initiate an active conservation program to protect and restore the existing Provincial Forest Reserve in the centre of Khong Island. Forest on the southern islands should also be designated a Provincial Forest Reserve.

3. A survey should be undertaken to quantify local needs for fire wood and timber and to determine how these needs could be met by plantations without further degradation of natural forest areas.

4. The use of high efficiency cooking stoves should be promoted to reduce demand for firewood.

5. The use of non-wood energy sources for cooking should be investigated.

6. Model, demonstration village tree nurseries and plantations for fire wood and timber production should be established, where experiments to increase efficiency and productivity can be carried out.

7. Training of district forestry personnel and technical and financial support should be provided to enable production of seedlings at the district forest office nursery to be resumed. Full time staff should be employed to run the nursery. The nursery could be used to produce

seedlings of both commercial tree species for the establishment of plantations and seedlings for forest restoration, but support should be on condition that at least half the nursery is used for the production of non-commercial tree species to carry out enrichment planting of degraded natural forest areas, especially within the Provincial Forest Reserve.

8. Seeds should be obtained through reliable suppliers for consideration of maintaining genetic diversity and seed quality.

RIVER BANK EROSION

In addition to destruction of valuable agricultural land, erosion along the river banks often necessitates the moving of buildings and increases pressure on remaining land and forest resources. Although erosion is undoubtedly a natural process, it is exacerbated by several human activities. Removing vegetation from the river banks and replacing it with cultivated crops probably accelerates erosion, as does the clearing of vegetation to provide landing areas for boats. Continuous digging of the river banks to harvest edible insects probably also contributes to bank erodibility. Erosion was observed to be most severe where the river flow is rapid within narrow channels (especially in the southern part of the project area) and less severe along the stony banks of the eastern bank of the Mekong. Local people regard river bank erosion as an inevitable natural process and are largely resigned to its effects. The quantification and seriousness of the problem varied greatly among the villages surveyed, but was generally considered significant to severe.

Our surveys along the river banks revealed that most obvious trees contributing towards stability of the steeper river banks were fig trees with dense root mats (*Ficus microcarpa* var. *microcarpa* (*ton hai*), *Ficus curtipes* (*ton mak deua*), *Ficus heterophylla* (*mak not khua*) and *Ficus altissima* (*ton mak deua*)) and other (non-fig) species such as *Streblus asper* (*mai som pho* or *mai kho som*), *Pterospermum diversifolum* (*mai ham ao*) and *Anogeissus rivularis* (*mai lum saeng*). The latter is particularly useful since it can withstand long periods partly submerged. In addition several grasses appeared to consolidate the more gently sloping banks and were said by villagers to be the most effective at slowing down erosion: *Saccharum spontaneum* (*yah lauo*), *Phragmites vallatoria* (also *yah lauo*) and *Apluda mutica* (*ton oo*). Growing partly submerged in the river were several shrubs which probably reduce erosion of the lower parts of the river banks including *Homonoia riparia* (*ton khai noon*), *Crateva magna* (*phak kum*) and *Phyllanthus reticulatus* (*kok kang pa*). Other shrubs commonly growing on stabilised sand banks included *Barringtonia acutangula* (*kok kang khong*), *Combretum trifoliatum* (*ton kae*) and *Sida rhombifolia* (*nha khud*).

At several villages, villagers described a local method used to slow down river bank erosion. The method involves building a fence of bamboo or branches of *Shorea obtusa* (*mai chik*) along the bottom of the river bank and back-filling the space between the face of the river bank and the fence with soil, tree branches and sometimes coconut husk. The top of the terrace thus formed is then planted with grasses, *yah lauo* (both *Saccharum spontaneum* and *Phragmites vallatoria*). This system was said to delay river bank erosion for 1-2 years, but villagers said that eventually low flow during the dry season undermines the roots of all plants and the terrace collapses. The system could be further strengthened by planting fig trees and *Streblus asper* on top of the bank and shrubs and trees capable of growing submerged along the lowest parts of the bank in front of the fence e.g. *Anogeissus rivularis* (*mai lum saeng*), *Homonoia riparia* (*ton khai noon*), *Crateva magna* (*phak kum*) and *Phyllanthus reticulatus* (*kok kang pa*). The feasibility of such an approach can only be tested by experiment. Problems with implementing this method on a large scale could be that villagers would have to give up valuable land along the river banks where vegetables are currently cultivated. It would also hinder access to the river and block footpaths currently running along the river bank. However, the system could be tested for mitigation purposes in selected sites.

Chapter 6

Aquatic biodiversity in the Siphandone wetlands

Ian G. Baird

Biodiversity refers to the abundance and the variety within and among fauna and flora, as well ecosystems and ecological processes, and is generally classified at the ecosystem, species and genetic levels (Kottelat and Whitten, 1996). Freshwater biodiversity, which concerns the species and habitats found primarily in inland waters, has received much less attention than other ecosystems, even though many freshwater habitats are under serious threat, and many aquatic organisms face imminent extinction (Kottelat and Whitten, 1996; World Bank, 1998). Nevertheless, aquatic biodiversity remains critically important to the livelihoods of vast numbers of people, giving it an undeniable practical socio-economic and cultural value (Claridge, 1996; Ahmed *et al.*, 1998; Baird *et al.*, 1998).

This chapter considers aquatic biodiversity and its importance in the Siphandone Wetlands, and particularly Khong District, Champasak Province, where vast wetlands in the mainstream Mekong River are situated. Content is largely limited to aquatic fauna, as Siphandone's flora is dealt with by Maxwell (herewith). Special emphasis is put on indigenous fish and fisheries, although other aquatic organisms are briefly reviewed, based on the limited information generated by the author's own observations. An attempt is also made to compile available relevant information scattered in reports and some scientific papers. It must be emphasized that the scientific data available on Siphandone's biodiversity are still very limited, and that a significant number of initial findings await further investigation and review.

AQUATIC BIODIVERSITY IN ASIA AND THE MEKONG RIVER BASIN

There are approximately 25,000 fish species known globally, of which about 10,000 are freshwater species. Another 500 need freshwater during a part of their lifecycle (Kottelat and Whitten, 1996). It has been estimated that there are probably about 5,000 taxonomically undescribed fish species, most of which are freshwater dwelling. Freshwater fish diversity is rich globally, considering that inland areas only constitute 0.008% of the world's water (Kottelat and Whitten, 1996). In Asia, there are more than 3,500 species of freshwater fishes, making the continent an important area for inland fish biodiversity (Kottelat, 1989; Zakaria-Ismail, 1994; Kottelat and Whitten, 1996; Rainboth, 1996).

The Mekong is the eleventh longest river in the world, and the sixth largest in terms of total annual discharge (Pantulu, 1986). Originating in the high mountains of Tibet, the mighty river travels about 4,200 km through China, Burma, Laos, Thailand, Cambodia and Viet Nam, before finally converging with the South China Sea. Ichthyologists generally agree that the Mekong basin supports a higher diversity of freshwater fish species than any other river basin in Asia (Zakaria-Ismail, 1994; Kottelat and Whitten, 1996; Rainboth, 1996; Vidthayanon *et al.*, 1998). Some believe that only the Amazon River basin, and possibly the Congo River basin, support a richer array of freshwater fish species globally (Vidthayanon *et al.*, 1998).

A few tentative estimates have been produced on the number of fish species expected to occur in the Mekong basin, based on available identification and zoogeographical considerations: these estimates range from 500 to 1,200 (Kottelat and Whitten, 1996; Rainboth, 1996; Vidthayanon *et al.*, 1998). Over 400 species have actually been recorded from the Mekong basin thus far (Kottelat and Whitten, 1996). Vast differences in estimates of fish species diversity illustrate that much is still unknown about the fish fauna of the Mekong (Kottelat and Whitten, 1996). While it is unclear whether the actual number of fish species found is closer to 500 or 1,200, recent studies in Laos have revealed a large number of previously undescribed species, as well as species not previously recorded from Laos. Kottelat (1989) reported on only 244 species of fish from the Mekong basin in Indochina, and Taki (1974) reported that just 201 species occur in the Mekong basin in Laos. However, by 1996, 265 species were known from just Laotian waters, and by 1998, 357 species were recognised as occurring (Kottelat, 1998). Illustrative of how little is known, during surveys of the Nam Theun and Xe Bang Fai Rivers in central Laos in March 1996, 54 species not previously recorded from Laos were collected, of which 29 were new species to science (Kottelat, 1998). Since 1998, ichthyological studies in northern and southern Laos have revealed a large number of additional species previously not known from Laos, including over 100 not yet known to science (*pers. comm.*, Dr. Maurice Kottelat, May, 1999). That being the case, it seems possible that the actual number of fish species found in the Mekong River Basin might be closer to 1,000 than to 500. However, only future investigations will provide a definite answer.

Zakaria-Ismail (1994) pointed out that the Indo-Chinese peninsula (including the Mekong basin) has a very high concentration of ostariophysan fishes, especially from the families Balitoridae, Sisoridae and Cobitidae. Although the Indo-Chinese peninsula is probably not the centre of origin of these groups, it is likely to be an area of rapid speciation (Zakaria-Ismail, 1994). Interestingly, Zakaria-Ismail (1994) found that 48% of the fish genera of the Mekong and Chao Phraya River basins are endemic to just those basins, and that endemism is especially high in the Mekong basin. This suggested to him that Mekong basin has not had water exchange with other river systems for a long time, although the Mekong River has undergone many shifts throughout history, and the present Mekong basin was probably broken into various river basins in the past (Rainboth, 1996). Indochina has a complex geological, hydrological and climatic history, which has heavily influenced speciation and species distribution patterns (Kottelat and Whitten, 1996; Rainboth, 1996).

The lack of biodiversity information has several dimensions, which are largely still unexplored in the Mekong basin. This concerns genetic differences among populations of the same species. Genetic analysis is only beginning to be used with Mekong fish species, and then for a few species only (Kottelat and Whitten, 1996; *pers. comm.*, Zeb Hogan, 2000). It also concerns the lifecycles of species of native fish in the Mekong basin, which are poorly known. Lack of information makes it difficult to manage and conserve species (Kottelat, 1989; Kottelat and Whitten, 1996). Relationships within communities of species are even more poorly understood. Fish community diversity is an important aspect of aquatic biodiversity to consider (Rainboth, 1996).

Many large fish species found in the Mekong River basin and Siphandone have only been known to science for a short time. For example, *Probarbus labeamajor (pa eun khao)* reaches 70 to 80 kg in weight, but the Mekong endemic fish was only described in 1992. *Aaptosyax grypus* *(pa sanak gnai),* another large Mekong endemic fish reaching up to 30 kg, has been known only since 1991. *Osphronemus exodon (pa men),* still another Mekong endemic fish weighing over 5 kg, was described in 1994. If these large species have only been known to science for less than ten years, it seems highly likely that many smaller species remain unknown to science (Roberts, 1993a; Rainboth, 1996; Baird *et al.*, 1999a).

Apart from fish, other aquatic groups from the Mekong exhibit high levels of biodiversity. For example, in the Lower Mekong basin (Thailand, Laos and Cambodia) 160 species of freshwater molluscs are known, of which 116 species are believed to be endemic to the basin. There are 121 gastropods (including 111 endemics) and 39 bivalves (including 5 endemics) known to date (Gargimony and Bouchet, *In litt.).* This makes the Mekong basin one of the most diverse in the world in terms of inland shellfish. However, only about 500 km of the mainstream Mekong River, including the Mun River in Thailand, have been studied in depth (Gargimony and Bouchet, *In litt.).*

The Mekong basin is believed to support a high diversity of crustaceans, although taxonomic investigations of crabs and shrimps have so far been very limited. Only seven species of crabs and ten species of shrimps have been recorded from the Mekong so far, although these statistics probably account for just 15% of the species that actually occur (Kottelat and Whitten, 1996).

Even less is known about the biology and ecology of zooplankton and aquatic macrophytes: since few surveys have been done, much of the Mekong remains uninvestigated in relation to these groups (Kottelat and Whitten, 1996). For example, there is virtually no information recorded about zooplankton from Laos, Cambodia and Burma (Kottelat and Whitten, 1996). There is also little known about aquatic macro invertebrates in the Mekong. This is unfortunate, considering that they are recognised as being fundamentally important for benthic communities (Kottelat and Whitten, 1996).

AQUATIC BIODIVERSITY IN SIPHANDONE WETLANDS

Fish

Between 1993 and 1999, the author recorded at least 201 fish species in 109 genera and 39 families from the Mekong River and adjacent tributaries below the Khone Falls, near Hang Khone Village, Khong District, Champasak Province (see Appendix 3). Of those, five species were non-native. No species were found to occur above the Khone Falls but not below it, although, as explained later in this chapter, a number of species found below the Khone Falls do not occur above. Although available records do not point out an exceptional level of diversity, the Siphandone area retains a diverse fauna of international significance. Moreover, fish species included in Appendix 3 are only those observed from the Mekong River below the Khone Falls at Hang Khone Village (and areas in close proximity) or in tributaries not more than a few kilometres from the mainstream Mekong River. It is assumed that some fish species that occur in the Siphandone Wetlands have probably not yet been collected due to having restricted distributions and specialised habitat preferences. Others probably only occasionally move into the Siphandone Wetlands from other parts of the Mekong basin, and are therefore rarely encountered. However, all the fish species commonly occurring in fish catches have already been collected since 1993. See Baird *et al.,* (1999a) for a more comprehensive list of fish species found throughout southern Laos.

Virtually all of the 201 fish species collected from below the Khone Falls came from local fish catches using a variety of fishing gears (see Roberts, 1993a; Roberts and Baird, 1995; Claridge *et al.*, 1997; Baird, 1998). Vidthayanon *et al.*, (1998) considered that about 100 freshwater fish species in Thailand are of "economic importance". Depending on how one defines "economic importance", there are probably many more species that are significant to local people in Laos. Roughly dividing up the fish species according to importance in local fisheries in Khong, the author found that six species were essentially never consumed by locals, 30 were "economically insignificant", 58 were consumed in relatively small quantities, 49 were moderately significant in fisheries, and 58 were highly important. If all the fishes caught in relatively small, moderate and high quantities are considered to be "economically significant", 165 species can be said to be important to local people living in southern Laos below the Khone Falls. However, if only moderately and highly important species are considered, 107 species can be classified as important. Laos certainly has other fish species that are economically significant apart from those recorded from the Khone Falls and Siphandone.

Both anadromous and catadromous[9] fish species are found in the Siphandone Wetlands. The pangasid catfish *Pangasius krempfi (pa souay hang leuang)* is believed to undergo long migrations up the Mekong River from the Mekong Delta and South China Sea in Viet Nam at the beginning of each rainy season in order to spawn upstream in Laos or Thailand (Roberts and Baird, 1995; Baird *et al.*, 1999a). In contrast, the anguilla eel *Anguilla marmorata (pa lat meo* or *pa lai fai fa)* probably spends most of its life in the Mekong River and tributaries before returning to salt water to spawn (Roberts and Warren, 1994; Roberts and Baird, 1995; Baird *et al.*, 1999a).

It is commonly believed that the giant catfish, *Pangasianodon gigas (pa beuk)* is the largest fish found in the Siphandone Wetlands and the Mekong basin. However, the up to 350 kg giant is actually outweighed by the giant stingray *(Himantura chaophraya) (pa fa lai)*, which reaches up to 500 kg, and also occurs in Siphandone (Roberts, 1993a; Baird *et al.*, 1999a). Both species are listed as "endangered" in the 1996 IUCN Red List of Threatened Animals (IUCN, 1996). A number of other fish species found in the Mekong River at Siphandone are included in IUCN's Red List of Threatened Animals (IUCN, 1996). The seven-striped barb *Probarbus jullieni (pa eun ta deng)* is listed as "endangered", as is the freshwater herring, *Tenualosa thibaudeaui (pa mak phang).* Another species historically reported from the reaches just below the Khone Falls, the sawfish *Pristis microdon (pa salam)* is listed as "endangered". Individuals of the species have, however, not been encountered in the Khone Falls area for well over 20 years (Baird, 1993a; Baird *et al.*, 1999a). The featherback *Chitala blanci (pa tong kai)* is a common species in Siphandone Wetlands (see Baird, 1994; 1998; Baird *et al.*, 1999a; 1999b), but is listed as "near threatened". Others are listed in the Red List of Threatened Animals as "data deficient". They include the large cyprinid *Aaptosyax grypus (pa sanak gnai)*, the barb *Probarbus labeamajor (pa eun khao)*, and the large pangasid catfish *Pangasius sanitwongsei (pa leum*) (IUCN, 1996). Another Siphandone species not listed by IUCN that may warrant future listing is the freshwater croaker *Boesemania microlepis (pa kouang)*, which has declined throughout much of its range (Roberts, 1993a; Roberts and Baird, 1995; Baird *et al.*, 1999a; 1999c).

Fortunately, no fish species from the Siphandone have so far been reported to have become extirpated from the area or extinct, although some of the largest species, including *Pangasianodon gigas (pa beuk), Pangasius sanitwongsei (pa leum), Aaptosyax grypus (pa sanak gnai)* and *Catlocarpio siamensis (pa kaho)* have been heavily reduced, and are now very rare (Baird *et al.*, 1999a). Others, like the migratory freshwater herring *Tenualosa thibeaudaui (pa mak phang)*, can still be found, but have declined dramatically in recent decades (Roberts, 1993a; Roberts and Baird, 1995; Baird *et al.*, 1999a).

Information on feeding behaviour and ecological relations is limited. However, Baird and Phylavanh (1999a) identified 35 types of wild fruits, 13 types of fresh leaves, three varieties of flowers, and bark and roots in the stomachs of a number of species of fish dissected at Hang Khone Village, just below the Khone Falls. Eight species of pangasid catfish were found to be the most important consumers of fruits and leaves, although other species, such as *Tor tambroides (pa koua), Leptobarbus hoeveni (pa phong), Hypsibarbus spp. (pa pak)*, and

[9] Anadromous refers to species that spend part of their lives at sea but spawn in freshwater.
Catadromous refers to species that spend most of their lives in freshwaters but spawn in salt waters.

Osphronemus exodon (pa men) were also shown to consume large amounts of plant material. Local fishers from Hang Khone and Hang Sadam Villages, both just below the Khone Falls, believe that fish consume at least 73 species of plant materials. They have also identified nine types of fruits and vegetation suitable for baiting hooks (Baird and Phylavanh, 1999a). Plant diversity is certainly important to maintain fish diversity, which is critical for the livelihoods of local people.

Dolphins

The Irrawaddy dolphin, *Orcaella brevirostris*, or *"pa kha"* in Lao, is the only species of marine mammal found in upper basin of the Mekong River, and in the Siphandone Wetlands (Baird and Mounsouphom, 1994; 1997). According to folk taxonomy, the species is considered a fish *(pa)* instead of a mammal *(sat)* (Baird *et al.*, 1999a). Listed as "data deficient" in IUCN's Red List of Threatened Animals (IUCN, 1996), the species is included in appendix II of the Convention on the International Trade in Endangered Species (CITES) (Baird and Mounsoumphom, 1994, 1997; Baird *et al.*, 1999a). The Khone Falls act as a biogeographical barrier to its movements, and the over 2.5 m greyish and snub-nosed dolphin only occurs as far north in the Mekong River as just downstream the Khone Falls, along the border with Thalaboriwath District, Stung Treng Province, north-east Cambodia. The Irrawaddy dolphin is not exclusively a freshwater dweller, and is found in estuarine and coastal environments throughout Southeast Asia. However, the Mekong population is believed to be isolated from populations in the sea, and is of particular conservation importance (Baird and Mounsouphom, 1994; 1997).

Local people have traditionally respected dolphins, and Laotians only very rarely ever harm them or consume their meat (Baird and Mounsouphom, 1997; 1994; Baird *et al.*, 1999a). Nevertheless, mortality caused by explosives fishing and especially unintentional entanglement in large-meshed gillnets has reduced populations along the Lao PDR/Cambodia border to critically low levels. The future of the dolphins seems precarious, as there are believed to be less than 10 animals inhabiting this section of the Mekong River (Borsani, 1999; and herewith), compared to at least twice that many five years ago (Baird and Mounsouphom, 1994; 1997; Baird *et al.*, 1999a; Duckworth *et al.*, 1999).

Other aquatic biodiversity values

The Siphandone Wetlands support a wide variety of bivalve *(kouang* and *ki)* and gastropod *(hoi)* molluscs, although no sistematic study of shellfish has been carried in this site and in southern Laos. Therefore it is not possible to determine the number of species occurring in the area, although general observations point out that local people collect and eat a number of species. Many small species, not consumed by local people, may well occurr. At least one snail, *Tricula aperta*, acts as the vector for the parasite *Schistosoma mekongi*, which can infect humans, and over a long time period can kill (Kitikoon, 1981). There are a number of edible bivalves and gastropods in Siphandone, including at least two species of freshwater oysters *(kouang* and *ki)*, which inhabit deep-water pools in the mainstream Mekong. The collection of shellfish appears to supplement the diet and income of local people, with a seasonal pattern to be investigated. This suggests that molluscs are not nearly as economically significant as fish, but they are nevertheless important to local people (Baird *et al.*, 1998).

There are a number of species of crustaceans found in the Siphandone Wetlands, including many kinds of shrimps *(koung)* and crabs *(kapou)*. However, detailed taxonomic investigations have not yet been conducted locally. Shrimps may not appear to be an important source of food, although during the rainy season scoop nets are commonly used to catch shrimp in the Mekong River for family consumption. The largest crustacean in Siphandone is a highly migratory *Macrobrachium* shrimp, which migrates upstream from the Mekong Delta in Viet Nam. In Siphandone, this bluish green species with long claws used to be relatively common, but now it is only rarely encountered. Only a few are seen at Hang Khone Village each year, and they are generally caught in gillnets, or occasionally on hooks (Baird, 1998; Baird *et al.*, 1999a; Baird *et al.*, 2000b). They are called *"koung gnai"* in Lao.

The presence of freshwater jellyfishes in the Mekong basin was only confirmed in March 1999. Then, a number of specimens were collected from non-flowing pools in the mainstream Mekong River below the Khone Falls near Hang Khone Village. Since then, locals have reported their occurrence in other parts of Siphandone Wetlands above the Khone Falls. Little is known about the Mekong jellyfish, and it is not known why locals only observe it during the lowest water level months of the dry season. Villagers claim that the thumb-sized clear white jellyfishes cause itching to those who touch them in the water. There is at least one species of freshwater jellyfish, called *"meng gnoum hat"* in Lao, and found in the Siphandone Wetlands. Although the confused state of freshwater jellyfish taxonomy in Asia has so far prevented the identification of this jellyfish to species level, it is a Hydrozoa in Anthoathecatae, and belongs to the family Moerisiidae, and the genus *Moerisia*. Since hydra can encyst, some freshwater hydroids/medusae have been carried as cysts in the stomachs of dabbling ducks, and hence are very widely transported and distributed. However, there is no evidence relating to whether Siphandone jellyfishes have ever been transported to or from the Mekong basin by ducks or any other creatures (*pers. comm.,* Dr. Paul Cornelius, Natural History Museum, London, 1999).

Wetland habitats in Siphandone support varieties of water snakes, aquatic or semi-aquatic turtles, and frogs and toads. Although there have not been any detailed aquatic reptile and amphibian biodiversity surveys conducted specifically in the Siphandone Wetlands, Stuart (1999) reported on amphibian and reptile surveys he did in parts of Mounlapamok District, Champasak Province, on the west side of the Mekong River adjacent to Siphandone Wetlands, as well as other places in southern Laos. He also compiled records from the Xe Pian National Biodiversity Conservation Area (NBCA) on the east side of the Mekong.

Although it is still uncertain what amphibian species are found in Siphandone, Stuart (1999) lists two species of true toad (Bufonidae), two species of tree frog (Rhacophoridae), nine species of narrow mouth frog (Microhylidae) and eight species of typical frogs (Ranidae) as occurring in lowland parts of southern Laos. The tiger frog, *Hoplobatrachus rugulosa (kop),* is one of the species local people in Khong District are actively trying to protect and sustainably manage (see Stuart, 1999; Baird, 1999). The species is listed in appendix II of CITES. Khong District is probably the only local administration in Laos that bans the export of this species, although smuggling is still common in some parts of the district (Baird, 1999). Frogs have been found to be good indicators of environmental health, and are an important part of the biological diversity of Siphandone (Kottelat and Whitten, 1996).

There are two species of Trionychidae soft-shelled turtles found in the Siphandone Wetlands: *Amyda cartilaginea* and *Pelochelys cantori* (Stuart, 1999). The first *(pa fa ong)* is smaller than the second one *(pa phou lou).* According to Lao folk taxonomy, these species are considered fish *(pa)* rather than turtles *(tao)* (Baird *et al.,* 1999a). Both are classified as globally threatened, and as vulnerable species considered potentially at risk in Laos (Stuart, 1999). The latter is largely limited to large rivers, and the southern part of the Siphandone Wetlands may represent important habitat for the species. Locals report that the presence of both has dramatically declined in the Siphandone area in recent years, probably due to over harvesting for local consumption and trade, and habitat disturbance (Baird *et al.*, 1999a).

Three species of water snakes (Colubridae) are known from lowland parts of southern Laos (Stuart, 1999). The puff-faced water snake *Homalopsis buccata* has been collected just below the Khone Falls at Hang Khone Village. The other two species, the striped water snake *Enhydris jagori* and the plumbeous water snake *Enhydris plumbea* have not yet been confirmed from Siphandone. However, the first was collected in Mounlapamok District, on the west side of the Mekong, near Siphandone, and the second was collected in Xe Pian NBCA (Stuart, 1999).

There are certainly more organisms that are dependent on riverine habitats in the Siphandone wetlands area. For example, mole crickets (Gryllotalpidae) *(meng khi nai)* are not strictly aquatic, but are highly dependent on Mekong River sand banks for nest building and breeding. Many other insects are equally dependent on the Mekong. Even earthworms rely on the banks of the Mekong for moisture. Moreover, numerous species of birds and mammals rely on aquatic biodiversity in Siphandone for their survival, although neither group (except for dolphins) is considered in this chapter.

The Khone Falls and aquatic biodiversity

The Khone Falls are the only major waterfalls on the mainstream of the Mekong River south of China. Well-known as especially important fishing grounds, the Khone Falls actually include tens of channels, rapids and waterfalls, and support a great deal of biological diversity. They are a natural wonder unique to Southeast Asia (Roberts, 1993a; Hill and Hill, 1994; Roberts and Warren, 1994; Roberts and Baird, 1995; Baird, 1996).

The Khone Falls acts as a biogeographical barrier for some aquatic organisms that are found below the waterfalls but not above them. The Irrawaddy dolphin *Orcaella brevirostris (pa kha)* is obstructed from parts of the Mekong River above the Khone Falls (Roberts, 1993a; Baird and Mounsouphom, 1994; 1997; Baird *et al.,* 1999a). Many other species of fish are also found only below the Khone Falls. They include the anchovy *Lycothrissa crocodiles (pa mak chan),* the silurid catfish *Ompok sp. (pa pik kai),* the pangasid catfish *Pangasius polyuranodon (pa gnone hang hian),* the ariid catfishes *Arius stormi (pa khat ok)* and *Hemipimelodus borneensis (pa khat ok),* the glassperch *Parambassis apogonoides (pa khap khong),* the goby *Glossogobius giuris (pa bou khao),* the threadfin *Polynemus longipectoralis (pa chin),* the freshwater sole *Synaptera cf. panoides (pa pan gnai),* and the tonguesole *Cynoglossue microlepis (pa lin ma)* (Roberts, 1993a). It is possible that the sawfish *Pristis microdon (pa salam)* and the scombrid fish *Scomberomorus sinensis (pa thou gnai)* (not yet confirmed to occur up to the Khone Falls) previously occurred up to, but not above the Khone Falls (Roberts, 1993a; Baird *et al.,* 1999a).

Kottelat and Whitten (1996) have listed the Khone Falls area as being a "freshwater site of exceptional biodiversity interest". Hill and Hill (1994:90) stated that,

"[The] Khone Falls is an ecologically unique area that is essentially a microcosm of the entire lower Mekong River. It is a remarkable natural laboratory that would allow researchers to focus on one small area of the river, yet be able to describe much of the ecology of the fisheries throughout the entire river. Such a site is so rare in nature that every effort should be made to preserve all of the Khone Falls from any development".

The paucity of data on the distribution of many Mekong fish species and the possible occurrence of still unknown fish species, or species still awaiting a confirmed identification, limit the present capacity to fully assess Khone Falls biodiversity values, including endemism. Nevertheless, while fish species richness is high in the Khone Falls area, as is typical for large lowland rivers in Southeast Asia, the species found there are generally widely distributed. However, there are possible exceptions. One or two species of Balitoridae in the genera *Hemimyzon (pa tit hin)* (see Baird *et al.,* 1999a) have so far not been reported from anywhere but the Khone Falls (see Baird *et al.,* 1999a). It is possible that they represent true endemics, limited to the Khone Falls by the non-availability of suitable waterfall habitat elsewhere in the mainstream Mekong River. These *Hemimyzon* use suckers to attach themselves to rocks in shallow and fast flowing areas, where they probably feed on plankton.

Likewise, Khone Falls may represent an important habitat for species of possible limited distribution within the basin. Fish species that require further taxonomic clarification include, inter alia, four species of small loaches in the genera *Schistura* and *Nemacheilus* and the family Cobitidae and a number of species of catfishes in the genus *Glyptothorax* and the family Sisoridae (see Baird *et al.,* 1999a).

AQUATIC BIODIVERSITY AND HUMAN LIVELIHOODS IN THE SIPHANDONE WETLANDS

The Mekong River in southern Laos is a rich resource, and the life of the people living near her are invariably linked with natural cycles, including those of wild fish. When it comes to food and animal protein intake, nothing is more important to southern Lao people than fish (Baird, 1996; Claridge *et al.,* 1997; Baird *et al.,* 1998; Baird *et al.,* 1999a).

Although virtually all the people living near the Mekong River and her tributaries in southern Laos rely heavily on wild fish for food and income, nowhere in Laos is rural livelihood more dependent on wild capture fisheries than in Khong District (Baird, 1996; Baird *et al.*, 1998). Most of the over 65,000 people who populate the district live on numerous islands in the middle of the Mekong, or along the banks of the river, and are highly dependent on wild-capture fisheries as sources of food and income (Baird *et al.,* 1998). Based on a rapid survey carried out in 14 villages of Khong District, Baird *et al.*, (1998) reported that 94% of the families in Khong are involved in at least subsistence fishing, and that the average family in Khong District caught 355 kg of fish over a year in 1996/1997, or 62 kg per person. Fish products represent the most important source of animal protein during approximately 80% of the meals of people living in the Siphandone area. The total fish catch was estimated to be around 4,000 metric tonnes, of which the small migratory cyprinid *Henicorhynchus lobatus* is the most abundant by weight (Baird *et al.,* 1998). We estimated that over US$ 1 million of fish products originating from Khong were sold to local and distant markets, and the average family generated the equivalent of US$ 100 from selling fish they caught themselves in 1996/1997 (Baird *et al.,* 1998). Aquaculture is almost non-existent in Khong (Baird *et al.*, 1998).

Fishing occurs all year round in Khong District, but is especially important in the dry season, when Mekong River levels drop. Approximately 91% of fish catches in Khong come from the mainstream Mekong River, with 5% coming from inundated rice paddy fields and natural depressions, and 4% from seasonal streams (Baird *et al.*, 1998). The people of the Siphandone Wetlands in Khong District employ a wide variety of fishing methods using a vast array of fishing gears (Claridge *et al.*, 1997; Baird *et al.*, 1998). Baird *et al.* (1998) recorded 87 different fishing gears, including gillnets with varying mesh sizes, and hooks baited differently. If one considers the different ways each gear is used, depending on local conditions and the season, the number of fishing methods utilised throughout Khong must certainly be well over 100. From investigations conducted over many years, it has also become increasingly evident that the fishing methods and gears vary considerably from community to community. These differences are based on both habitat and social factors. However, gillnets, castnets and hooks and lines are the most popular fishing gears used throughout the district (Baird *et al.*, 1998).

A fishing year below the Khone Falls

For most villagers in southern Laos, including those at the Khone Falls, the fishing year begins at the end of the monsoon season in late September or October. As streams, swamps and rice paddy fields begin to dry out, many species of fish, including “black fish”, such as *Channa striata (pa kho), Clarias spp. (pa douk), Rasbora spp. (pa sieu)* and *Esomus metallicus (pa sieu)* migrate from these areas to perennial water bodies like the Mekong River (Baird, 1996). Villagers use various traditional fishing gears to target these short distance migrators (see Claridge *et al.,* 1997). Some families make the staple fish sauce *(pa dek)* during this season, especially those in villages situated away from the Mekong mainstream river (Baird *et al.*, 1998).

By the end of October, fish begin migrating up the Mekong River from Cambodia. Just below the Khone Falls, villagers use gillnets to target these mainly medium and large-sized species (Roberts and Baird, 1995; Baird, 1998). Between November and early January, three spawning species are especially abundant in catches. They are *Hypsibarbus malcolmi (pa pak nouat),* *Probarbus labeamajor (pa eun khao)* and the CITES appendix I, and IUCN red listed species *Probarbus jullieni (pa eun ta deng)* (Baird, 1994; 1998; Nash, 1997). While the first of the three is mainly caught in falling door traps *(chan),* the latter two are targeted by large-meshed set gillnets *(mong gnai).* Baird and Phylavanh (1999b) found that *Hypsirbarbus malcolmi* vocalise at the end of October to mid-November near Hang Khone Village, just below the Khone Falls. Vocalisation tends to occur during hot afternoons, when temperatures are high. Spawning activities and vocalisations are probably closely linked.

Between 1993 and 1998, the large-meshed gillnet fishery at Hang Khone Village was monitored. *Probarbus jullieni* made up over 65% of the catch over the six seasons, with *Probarbus labeamajor* representing almost 13% of landings. The large carp *Cosmocheilus harmandi (pa mak ban)* was third most common with just over 6%, and the sisorid catfish *Bagarius yarrelli (pa khe)* was the fourth most abundant. The freshwater croaker *Boesemania microlepis (pa kouang)* was the fifth most landed species by weight. Thirty species of large fishes were landed in the fishery. Most *Probarbus* are sold fresh to traders who resell them in larger towns such as Pakse, or to Thailand (Baird, 1994; 1998; Nash, 1997).

By mid-December, as the Mekong River's water levels continue to drop, the first of the long distance migratory small cyprinid fish, *Henicorhynchus lobatus (pa soi houa lem)* begin arriving at the Khone Falls from Cambodia. Villagers use bamboo and wood traps *(tone)* placed in various channels around the Khone Falls to catch these fish, although larger runs of this and other species that arrive later are more heavily targeted (Roberts and Baird, 1995; Baird *et al.,* 1999a; Baird *et al.,* 2000a).

Shortly after the first small cyprinids arrive, other medium-sized migrating cyprinids move up to the Khone Falls. These species support an important fishery for local people, who target them using set and drift gillnets, and traps in the rapids, both above and below the Khone Falls (Roberts and Warren, 1994; Roberts and Baird, 1995; Baird, 1996; 1998; Warren *et al.,* 1998; Baird *et al.,* 1999a).

Between 1993/1994 and 1998/1999, the gillnet fishery targeting the medium-sized cyprinids was monitored at Hang Khone Village. *Scaphognathops bandanensis (pa pian)* made up over 30% of the catch for the six seasons, *Mekongina erythrospila (pa sa-ee)* constituted almost 27% of the landings, *Labeo erythropterus (pa va souang)* made up 4%, *Gyrinocheilus pennocki (pa ko)* represented over 3%, *and Hypsibarbus malcolmi* made up over 2% of catches. 101 fish species were recorded from the fishery, and much of the catch was smoked and sold (Baird, 1996; Baird *et al.,* 1998). All of the fish species listed above, along with some others, are believed to migrate up the Mekong River in Laos from the Se Kong, Se San and Sre Pok Rivers in northeast Cambodia (Roberts and Baird, 1995; Baird, 1996; 1998; Baird *et al.,* 1999a).

By late January or early February, important schools of small cyprinids begin arriving at the Khone Falls from Cambodia. Their arrival corresponds with the new moon, and their movements are closely associated with lunar cycles (Baird *et al.,* 2000a). These large schools of fish include, in order of total abundance, *Henicorhynchus lobatus (pa soi houa lem), Paralaubuca typus (pa tep), Henicorhynchus siamensis (pa soi houa po), Labiobarbus leptocheilus (pa lang khon), Botia modesta (pa mou man), Crossocheilus reticulatus (pa toke thoi), Cirrhinus microlepis (pa phone mak kok), Thynnichthys thynnoides (pa koum), Lobocheilus melanotaenia (pa khiang)* and many others. The first two species make up almost 80% of the catch, although the second species has a considerably higher market value than the first (Baird *et al.,* 2000a).

Between 1995 and 1999, a single fence-filter trap *(tone)* situated in the Khone Falls was able to catch at least 92 fish species. Approximately 32 of those, including all the species listed above, are believed to migrate from flooded forests and wetlands in Cambodia, including the Tonle Sap River and the Great Lake (Baird *et al.,* 2000a). Together these fish constitute an extremely important fishery in the Khone Falls area and other parts of Siphandone and southern Laos, north of the Khone Falls. Traps placed in the rapids are used extensively to target these fish until around March, when the migrations generally end (Roberts and Baird, 1995; Baird, 1996; 1998; Baird *et al.*, 2000a). Villagers living on islands in Khong District often make fish sauce *(pa dek)* for subsistence use and sale using small cyprinids caught in the dry season, and large quantities of sun-dried and smoked fish are also consumed and sold by villagers during this season. Most families consume between one and three jars of fish sauce a year (about 22 kg of salted fish per jar), with an average of about 40 kg of *"pa dek"* consumed per family each year (Baird *et al.*, 1998).

As water levels in the Mekong River drop to their annual lows, local people living just below the Khone Falls sometimes use large-meshed gillnets to target the freshwater small-scale croaker *Boesemania microlepis (pa kouang),* which are found in particular deep-water pools in the mainstream Mekong River in the Siphandone Wetlands. While most members of the family Sciaenidae are marine dwelling, this species is unusual in that it spends all its life in freshwaters, reaching at least 18 kg in weight and over a metre in length (Baird *et al.,* 1999c). Like *Hypsibarbus malcolmi,* this species vocalises during its spawning season, which is at the end of the dry season. Baird *et al.,* (1999c) identified seven different deep-water areas in Khong District where small-scale croakers are known to vocalise, and it is believed that those areas are the primary spawning grounds for the croakers in Khong District. All these areas have pools at least 20 m deep in the dry season (Baird *et al.,* 1999c).

By April, the first schools of small migratory catfish arrive at the Khone Falls from Cambodia. The species *Pangasius macronema (pa gnone siap)* is caught in large quantities as it migrates up the Mekong past the waterfalls (Roberts and Baird, 1995; Baird, 1996; Baird *et al.,* 1999d). Catches of this economically important species are particularly high in the Hou Sahong Channel of the Khone Falls, which lies between the islands of Done Sadam and Done Sahong (see map of Khong District). Hou Sahong is the only channel that migratory fish can effectively use in the lowest-water season to get past the Khone Falls, and Hou Sahong is well known to locals for being by far the most important channel for upriver migratory fish in all seasons. Most of the other channels that make up the Khone Falls have large waterfalls on them which migratory fish cannot get past, especially in the dry season. The Hou Sahong channel, on the other hand, has no natural barriers along its approximately 7 km length, making it easily passable by migratory fish that move up the Mekong River from Cambodia (Roberts and Baird, 1995; Baird, 1996; Baird *et al.,* 1999d).

Although many villagers now target migratory fish in the Hou Sahong, the Lao Government has long considered the channel to be of critical importance for maintaining populations of migratory fish. At various times in the 1960s, 1970s and 1980s the State specifically banned fishing in Hou Sahong because of its well-known function as a pathway for migratory fish (Roberts and Baird, 1995; Rainboth, 1996; Baird, 1996). Villagers living upstream from Hou Sahong often point out that if fish could not get up that channel, all the people living from Khong District to the north of Vientiane would not have enough fish to eat because migratory fish cannot easily get up other channels in the Khone Falls in large numbers (Baird, 1996). Local people living near the Hou Sahong and other channels in the Khone Falls area have developed specialised tenure systems for managing trap-based fisheries targeting migratory fishes. These systems prevent the total blocking of channels that fish pass (Roberts and Baird, 1995; Baird *et al.,* 1999d). Considering the importance of the Hou Sahong to dozens of species of highly migratory fish species, and the dependence of large numbers of people on these migratory fish, plans to build a large hydroelectric dam on the Hou Sahong will have to be carefully considered. The blocking of the Hou Sahong could devastate much of the most important fisheries in the Mekong River (Roberts and Baird, 1995; Baird, 1996; Baird *et al.,* 1999d).

By May, when the monsoon rains begin to fall and the Mekong River rises dramatically over a very short period of time, large numbers of fish, including many species of pangasid catfishes and other large cyprinids move up the Mekong River from Cambodia and arrive at the Khone Falls. Carps encountered include *Hypsibarbus spp. (pa pak), Cosmocheilus harmandi (pa mak* *ban), Labeo erythropterus (pa va souang), Morulius spp. (pa phia) and Cyclocheilichthys enoplos (pa chok).* While some may only be travelling short distances, others probably move farther. At the Khone Falls, they are heavily targeted using large-meshed gillnets. Much of the catch is sold fresh and transported to distant markets on ice. This is certainly one of the most important fishing seasons for villagers (Roberts, 1993a; Baird, 1996; 1998; Baird *et al.,* 2000b).

A number of species of pangasid catfishes are caught in large quantities at the beginning of the monsoon season using large immovable wooden and bamboo wing traps *(li)* (see Claridge *et al.*, 1997). Species caught include *Pangasius conchophilus (pa pho/pa ke), Pangasius krempfi (pa souay hang leuang), Pangasius bocourti (pa houa mouam/pa yang), Pangasianodon hyphophthalmus (pa souay kheo)* and Pangas*ius larnaudii (pa peung).* Of the 106 species of fish and one species of large crustacean recorded from a pair of wing traps in the Khone Falls monitored over a four year period (1994, 1995, 1998 and 1999), *P. conchophilus* was the most abundant, making up over 40% of the catch. *Henicorhynchus spp. (pa soi),* believed to be caught as they move downstream (see Roberts and Baird, 1995), were the second most abundant at over 12%. The carp *Scaphognathops bandanensis (pa pian)* was the third most abundant at 7%, and “miscellaneous fish” were fourth in terms of abundance. *Pangasius krempfi* was the fifth, *Pangasius bocourti* the sixth, *Cosmochilus harmandi* the seventh, and *Pangasius larnaudii* was the eighth most important in landings. *Pangasianodon hypophthalmus* was only abundant during one of the four years (1995), and was virtually absent from catches during other years (Baird *et al.,* 2000b).

The most intense fishing period for *Pangasius conchophilus* generally takes place over just a few days when water levels begin to rise. While catfish are mainly caught during the night, the cyprinids are generally landed during the day (Roberts, 1993a; Roberts and Baird, 1995; Baird, 1996; 1998; Baird *et al.*, 2000b). These migrations may be triggered by rising water levels at the beginning of the monsoon season (Roberts, 1993a; Roberts and Baird, 1995; Baird *et al.*, 2000b).

One of the most interesting migratory species caught in large-meshed gillnets, as well as wing traps, is *Pangasius krempfi*, a large catfish reaching 15 to 20 kg in weight and over a metre in length. This economically important species constitutes over 70 per cent of the volume of fish caught in the May to July large-meshed gillnet fishery just below the Khone Falls, and almost 5% of the wing trap *(li)* fishery (Baird, 1998; Baird *et al.,* 2000b). As mentioned earlier, the species is believed to migrate all the way from the Mekong Delta in Viet Nam and the South China Sea. Only adults over about 1 to 1.5 kg are caught near the Khone Falls (Roberts and Baird, 1995; Baird, 1998; Baird *et al.*, 1999a; Baird *et al.,* 2000b). During the fishing season for this species at Khone, all the *Pangasius krempfi* are nearing spawning condition (Roberts and Baird, 1995; Baird and Phylavanh, 1999a). It is not known exactly where these fish spawn, but they are only found in the Khone Falls area between May and late October or early November. After, they all disappear and are believed to travel back down the Mekong River to the Mekong Delta in Viet Nam. Fishers in the Mekong Delta have reported that they mainly encounter the catfish between December and April, indicating that the entire adult population may take part in this long distance migration up to the Khone Falls and back (Roberts and Baird, 1995; Baird, 1996; 1998).

In May and June villagers living just above the Khone Falls use narrow bamboo funnel traps *(kasone)* (see Claridge *et al.,* 1997) to target schools of *Hemibagrus nemurus (pa kot leuang),* which are migrating south to Cambodia, where they are believed to enter tributaries of the Mekong (Roberts and Baird, 1995; Baird, 1996).

Between June and July, many small and medium-sized cyprinids, including the ecologically dominant species *Henicorhynchus lobatus (pa soi houa lem),* swim downstream from Laos to Cambodia where they spawn, and enter various streams and wetlands, including the Great Lake. Before moving south, local people living just below the Khone Falls use bundle-basket bamboo traps *(kha)* to target them (Roberts and Baird, 1995; Baird, 1996; 1998).

By July, when water levels have increased to high levels, wing traps in the Khone Falls are either covered by water or are swept away by the strong current. Gillnets also become largely unusable. At that time, villagers begin using funnel traps *(lawp)*, falling-door bamboo traps *(chan)*, long lines *(bet phiak)*, and other hook and line gear to catch mainly non-migratory fishes. Most of the catch is used for subsistence purposes.

It is difficult to know exactly what the migratory patterns of fish are in the Khone Falls area during the height of the monsoon season, due to the inability of villagers to catch many fish then. However, locals believe that many species of cyprinids and others migrate downstream to Cambodia before entering tributaries of the Mekong, including the Se Kong, Se San, Sre Pok and Tonle Sap Rivers (Roberts and Baird, 1995; Baird, 1996; 1998; Baird *et al.,* 1999a).

Other important fisheries in the Siphandone Wetlands

There are certainly many important fisheries in the Siphandone Wetlands apart from those described from the Khone Falls (see Roberts and Warren, 1994; Warren *et al.,* 1998; Baird *et al.,* 1998). However, there are far too many to try to describe here! While some villages, like those below the Khone Falls, rely heavily on highly migratory fish species, other communities situated away from major migration routes rely much more on sedentary or only slightly or moderately migratory fish species (Baird *et al.,* 1999b). One important species caught throughout Khong District year round, and in various mainstream Mekong habitats, is *Morulius spp. (pa phia).* Baird *et al.,* (1999b) found it to be the most abundant species in many fisheries throughout Khong District. Vannaren (1999) also reported that the species is the second most abundant in catches in Stung Treng Province, northeast Cambodia, which is situated just downstream from the Khone Falls. Another important group of species caught throughout the Siphandone Wetlands is *Hypsibarbus spp./Barbodes sp. (pa pak)*, which Vannaren (1999) reported to be the most abundant in catches in Stung Treng Province. *Chitala blanci (pa tong kai)*, *Boesemania microlepis (pa kouang)* and *Pristolepis fasciata (pa ka)* are just a few of the economically important fish species that are not believed to be highly migratory (Baird *et al.,* 1999b).

Although the above accounts of some of the fish migrations and related fisheries in the Khone Falls area are incomplete, they should at least help to indicate how fish biodiversity in the Siphandone Wetlands supports a rich variety of important small-scale fisheries at various times of the year.

THREATS TO AQUATIC BIODIVERSITY IN THE SIPHANDONE WETLANDS

Large-scale hydroelectric development probably represents the single most-important threat to aquatic biodiversity in the Mekong River basin, including the Siphandone Wetlands. Large dams built anywhere on the middle or lower parts of the Mekong mainstream would certainly be devastating to local fish and fisheries, and would especially be destructive to highly migratory fish species that move up and down and in and out of the mainstream. Dams built on tributaries of the Mekong also pose a serious threat to biodiversity, especially when they are built on large tributaries (Roberts, 1993b; Kottelat and Whitten, 1996). Apart from blocking migratory routes, dams generally alter hydrological patterns, silt deposition patterns, water temperature, and water quality, leading to massive impacts to aquatic life. Unfortunately, those who have planned and promoted large dams have rarely ever conducted in depth investigations regarding the impacts on aquatic life (Roberts, 1993b; Kottelat and Whitten, 1996; World Bank, 1998).

Other schemes designed to divert water and alter river flows, such as small and large irrigation projects of various types, pose a serious threat to aquatic biodiversity, and the aquatic systems that local people depend upon for their livelihoods. Natural flood regimes are an important part of aquatic ecosystems, and whenever they are altered, it can be expected that serious impacts to aquatic life will ensue (Roberts, 1993b; Kottelat and Whitten, 1996). Changes in water flows can seriously alter water chemistry, leading to various impacts (Kottelat and Whitten, 1996).

Zakaria-Ismail (1994) has illustrated that land development poses another serious threat to freshwater biodiversity in Southeast Asia. Through intensive sampling of the Gombak River in Peninsular Malaysia in 1969, 1985 and 1990, he determined that 41% of the freshwater fish species that occurred in 1969 had disappeared by 1990. Land development resulting in habitat loss is believed to be the main cause of habitat destruction, which led to the loss of species.

Closely linked to the impacts of land development are the impacts of deforestation and forest degradation, which can seriously affect aquatic resources. Although the maintenance of forests throughout a watershed or basin are critical for protecting the aquatic systems, the degradation of seasonally inundated forests, as well as terrestrial forests adjacent to water bodies, has the potential to cause the most serious damage (Rainboth, 1996; Baird *et al.*, 1999a; Baird and Phylavanh, 1999a). Baird and Phylavanh (1999a) have demonstrated that forest fruits, leaves, flowers, bark and roots are important food items for various species of fish of economic importance, especially during the rainy season. Inundated forests create important habitat for spawning and nursing fish, and provide refuges that enable fish to escape predators. Trees hanging over streams and rivers create shady habitat critical for fish, and help increase the amount of insects that fall into the water from the canopy. The maintenance of forest habitat is critical for ensuring healthy aquatic systems (Roberts, 1993a; Rainboth, 1996; Kottelat and Whitten, 1996; Baird *et al.*, 1999a).

Changes in sediment loads caused by deforestation, agriculture, mining and road construction can seriously affect aquatic biodiversity. Increased silt deposition can transform heterogeneous substrate with rocks and deep-water pools into homogeneous sandy substrates, where certain species cannot survive. Silt can also clog up the gills of fish, suffocate freshly laid eggs, and affect nursery grounds for juveniles. Furthermore, increased turbidity reduces light penetration and plant survival, thus lowering primary productivity (Kottelat and Whitten, 1996).

The intentional and unintentional introduction of non-native organisms into the aquatic systems represents an important long-term threat to biodiversity. Vidthayanon *et al.*, (1998) reported the occurrence of 15 introduced fish species in Thailand's inland waters, and Welcomme and Vidthayanon (2000) reported that 17 non-native fish species had been introduced and had become established in the wild in the Lower Mekong River basin. In addition, eight other small fishes known from headwaters in northern parts of Laos may or may not be introduced, and five more may possibly be introduced soon, as they are in current use in adjacent basins (Welcomme and Vidthayanon, 2000).

In Siphandone, five non-native fish species have so far been recorded from the mainstream Mekong River (see Appendix 3). However, only the common carp *Carpio cyprinus (pa nai)* has become well established in the Siphandone area (Roberts and Baird, 1995; Baird, 1998; Baird *et al.*, 1999a). Unfortunately, this species has a history of being particularly destructive to indigenous fish species and their habitats (Fernando, 1991; Costa-Pierce *et al.*, 1993; de Moor, 1996; Baird *et al.*, 1999a).

Welcomme and Vidthayanon (2000) reported that six non-fish aquatic animals have also been introduced and have become established in the Lower Mekong basin. The golden apple snail is one of those, and is so far the only one of the six found in Siphandone. Originally introduced for aquaculture purposes, the mollusc has caused enormous damage to rice crops in the Vientiane area, as well as in Viet Nam. Over the last few years it has expanded its distribution, and in mid-1999 it was found in Khong District, on the east side of the Mekong River just north of the Khone Falls *(pers. obs.)*.

Due to the dangers posed by introduced species the world over, no more non-native aquatic species should be deliberately introduced into the wild. It should be recognised that the history of aquaculture shows that when non-native species are imported for use in aquaculture, they often end up escaping, and becoming established in the wild (Fernando, 1991).

Over fishing and destructive fishing can certainly affect aquatic biodiversity, and in the Mekong basin, there is a considerable amount of evidence suggesting that fishing has had an impact on aquatic biodiversity in particular areas (Roberts, 1993a; Claridge, 1996; Kottelat and Whitten, 1996; Claridge et al., 1997; Kottelat, 1998; Baird *et al.,* 1999a). Illegal and destructive practices, such as fishing with explosives, chemicals, electricity and water pumps in wetlands, are the best-known destructive methods in the Mekong (Claridge, 1996; Claridge *et al.,* 1997). Although none are commonly used in the Siphandone area (Baird, 1999), problems persist in adjacent parts of Cambodia (Baird and Mounsouphom, 1994; 1997; Baird, 1999). Still, even the use of gillnets, castnets and other small-scale gears can affect aquatic biodiversity, although there is only a limited amount of information regarding the impacts of small-scale fishing on inland aquatic life in the region (Kottelat and Whitten, 1996). Kottelat and Whitten (1996) have noted that there are no published data to indicate that over fishing or destructive fishing has been responsible for the biological extinction of any fish species in Asia, although fishing has certainly resulted in declines in certain fish stocks, and sometimes in the declines in whole aquatic communities.

Because the threats to freshwater biodiversity in the Mekong basin and Siphandone are so serious and varied, cumulative impacts are likely to result from the occurrence of more than one impact (Roberts, 1993b; Kottelat and Whitte, 1996; World Bank, 1998). However, there is still only limited knowledge regarding how combinations of human-induced impacts affect aquatic life. In any case, scientists have a considerable amount of information about the impacts of individual threats, and there are adequate grounds to be very concerned about the future state of aquatic resources in the Mekong basin, including the Siphandone Wetlands (Roberts, 1993b; Kottelat and Whitten, 1996; World Bank, 1998; Baird *et al.,* 1999a).

Sustainable management of aquatic resources in the Siphandone wetlands

Aquatic biodiversity is certainly a critical part of the Mekong River basin, supplying people with massive amounts of protein and income (Kottelat and Whitten, 1996; Ahmed *et al.,* 1998; Baird *et al.,* 1998). It is therefore necessary that greater efforts be made to sustainably manage and conserve aquatic organisms and the habitats that they depend upon. Loss of biodiversity can reduce future options for sustainable natural resource management.

Community-based aquatic resources co-management represents one approach that can lead to the improved management of fish and other aquatic organisms (see Baird, 1999 and Chapter 8). Apart from promoting community-based approaches to biodiversity conservation and sustainable natural resource management, there is a great need for regional cooperation geared toward educating government officials and local people regarding the importance of protecting natural freshwater resources (Baird *et al.,* 1999a). Regional cooperation is necessary in order to prevent and reduce impacts caused by various developments in different countries in the same watershed area.

Biodiversity conservation needs to be addressed at all levels, from the grassroots to the highest places in Government. Aquatic biodiversity in the Siphandone Wetlands is not only important for the health of our planet, and the Nation, but has inherent value and is of immense socio-economic importance to those who harvest aquatic resources from the mainstream Mekong River, seasonal streams, rice paddy fields, and natural ponds (Baird *et al.,* 1998). Everybody needs to make an effort to protect the natural aquatic resources of the Siphandone Wetlands, and the Mekong River basin as a whole. To ensure the maintenance of aquatic biodiversity, we need a balanced combination of good science, appropriate natural resource management policies and practices, and effective public awareness extension.

Chapter 7

A people-centred fishery: socio-economic perspectives on the Siphandone wetlands [10]

Richard Friend

Although often overlooked in biological models, the place of people in freshwater fisheries is central, as it is through the resource users rather than the fishery resource itself that policy and management aim to work. As issues of sustainability, equitable economic development and local level participation become more prominent policy and management objectives, there is a need to take a fresh look at the diverse and dynamic livelihood strategies of people who utilise freshwater fisheries. The case of the Siphandone wetlands provides valuable insight into the human significance of freshwater fisheries, and the central role of people in fisheries ecology and management. This chapter presents a model of a people-centred fishery ecology (cf. McCay, 1978, Friend, 1997), placing household livelihood strategies of which fishing is one component, at the centre of a wider dynamic, natural and socio-economic environment. It draws primarily on socio-economic survey work carried out by the Siphandone Wetlands Project (see Friend, 1999)[11].

PEOPLE-CENTRED ECOLOGY AND ADAPTING STRATEGIES

There are specific characteristics of how people utilise freshwater fisheries. Most people who fish do so in an irregular and varied manner, utilising a range of gears and habitats. Fishing is rarely undertaken as the primary economic activity, but is a component of wider household resource portfolios involving all members, moving in and out of different activities. In the Siphandone fishing is an integral component of most households livelihoods, with fish and other aquatic resources constituting the main source of animal protein in local diets (Baird, 1998). Most households are involved in some combination of rice, livestock, collection of forest products, cultivation of vegetables and fruit, migration, as well as fishing. Although there are

[10] This paper could not have been completed without the valuable insights and critical comments of Ian Baird, Vixay Inthaphaisy and Giuseppe Daconto. The original socio-economic survey had been carried out under the coordination of Renato Novelli.

[11] The methodological issues of conducting the survey, including the reliability of certain statistics are also addressed in Friend 1999.

similarities in household livelihood strategies there is also significant variation between villages, and also within villages.

As in other wetland and freshwater fisheries in the region, a central characteristic of livelihood strategies in the Siphandone is the need to juggle between different activities using available natural, material, human and socio-economic resources. No household relies on any one economic activity, although some households with limited resources portfolios might be more dependent on one, or a limited number of activities. Economic security is most closely related to households' capacity to spread their resource portfolio, including activities that generate cash income. Economic vulnerability on the other hand would appear to be most closely associated with limited access to this type of diversity of economic activity, and lack of access to income generating activities that can offset specific economic pressures such as crop failure or ill-health.

Household livelihood strategies depend on access to material and natural resources. But access to non-material resources is also highly significant, if less immediately apparent. Not only does this include labour and capital, but also social networks including kin, and such issues as status and influence. These may be of even greater importance in rural economies with limited market activity. This type of approach to rural livelihoods has a long history (see for example, Sen, 1981, Lewis and McGregor, 1993, Chambers and Conway, 1992, Friend, 1997) but is now widely referred to as a Sustainable Livelihoods approach. It is an approach that is highly relevant to freshwater fishery economies. In this approach (see Carney, et al., 1998) household livelihoods are based on five sets of resources:

- Human (labour, knowledge, skill)
- Natural/material (natural resources, land, livestock)
- Financial (cash, capital)
- Social (kinship and social networks, influence, status)
- Physical (including access to roads etc).

The full significance of fishing cannot be understood out of this wider socio-economic context. In order to assess the importance of fishing in local livelihoods, it is essential to determine the processes by which households adapt their livelihood strategies, and convert stocks of resources and assets into livelihood outcomes (cf. Carney, 1998). This requires an understanding of how households combine resource activities and how these patterns change, and the processes by which resources can be converted into benefits. The natural and socio-economic environments in which households operate are rarely constant between seasons and years. Livelihood strategies are constantly adapting to external change, and generating change themselves. These processes of change are intensifying in the Siphandone with greater market penetration, and more direct external intervention in local livelihoods through development and conservation.

This ‘people-centred’ approach to fisheries ecology has far reaching implications for fisheries assessment and management. Fisheries assessment is based on notions of catch and effort, in turn based on an assumption of some degree of uniformity and regularity in people’s involvement in fishing. Yet for the majority of small-scale freshwater fisheries rarely display such elements. People move in and out of the fishery with irregular catch and effort, partly due to the dynamism and uncertainty of the resource itself, but also due to the way in which households manage their livelihood strategies. This adaptive feature of livelihood strategies needs to be integrated into management strategies (cf. Hoggarth, 1999) in order to deal with the inherent uncertainty and dynamism of freshwater fisheries. However in order for management strategies to be appropriately adaptive, there is a need for established processes of assessment and planning, based upon appropriate indicators of change.

BACKGROUND TO THE SURVEY VILLAGES

The discussion that follows is based on the Siphandone Wetlands Project baseline socio-economic survey (for a detailed summary see Friend, 1999). This was conducted in two stages. In the first stage a village-level questionnaire was conducted in 38 sample villages. In the second stage six villages were selected for further more detailed household study. Methodological difficulties prohibit detailed statistical analysis, but illustrate important issues concerning the variety and dynamics of livelihoods. The experience of conducting a baseline socio-economic survey in the Siphandone also raises questions as to the most appropriate methods to assess local livelihoods (see Friend, 1999).

The discussion that follows draws from both sets of Siphandone Wetlands Project survey data, but with greater emphasis on the six sample villages. These six villages were selected on the basis of location, with three villages on the islands and three villages located on the mainland. In order to assess the significance of the establishment of conservation zones, three villages were also selected with already established norms and regulations for management of such zones, while the remaining three villages were yet to have established such co-management regimes. The six villages are summarised below (see appendix 1 for location):

- Ban Senhom: mainland village without fisheries co-management regime
- Ban Done Chome: island village with fisheries co-management regime
- Ban Done Thantavanoke: island village without fisheries co-management regime
- Ban Lomphat: mainland village without fisheries co-management regime
- Ban Dong: large island village
- Ban Houayhai: mainland village

To varying degrees the villages of the Siphandone share similar problems and livelihoods constraints. The economies are largely subsistence facing significant environmental and socio-economic change as a result of external development. They are also confronted with limited land resources and increasing population pressures. Land pressures are exacerbated to some degree by previous land frontiers increasingly being claimed by the state, denying access to local villagers. In the study area this is illustrated by the establishment of the Xe Pian National Biodiversity Conservation Area (NBCA). As conservation issues become more prominent in national development planning this is a trend that can reasonably be expected to continue. Environmental degradation, including deforestation, loss of forest fauna, and river bank erosion (cf. Elliott, 1998) is also increasingly becoming an issue in the area.

As in other parts of rural Lao PDR health conditions are extremely poor (cf. Council for Medical Sciences, 1996). There are numerous costs associated with poor health in general (although not specifically for the project villages), including:

- Low life expectancy
- Direct costs of medical treatment
- Loss of household labour
- Uncertainty and inability to engage in certain types of investment
- Child developmental problems

Vulnerability to illness and disease constitutes a serious economic risk, particularly since labour is one of the most important household resources, and the costs of medical treatment can be extremely high for households with little or no income.

There is only limited access to education, although the highest registration of all ten districts in the province (I. Baird pers. comm., 1999). Road communications are poor although there are well-established waterway communications.

HOUSEHOLD LIVELIHOOD STRATEGIES

Household livelihood strategies can be characterised as being based on the use of multiple resources, adapting to uncertainty and change. Despite a common range of resources in the project area there is significant variation between household resource bases and the ways in which these are utilised. This is an important issue for fisheries management to address.

The following section discusses the main economic activities in the Siphandone wetlands. Most people in the Siphandone wetlands area tend to refer to themselves as rice farmers, when asked about their ‘occupation’. This is typical of rural SE Asia. However, all households are involved in a number of activities. The full economic significance of different activities within the household is not always apparent at first. Often these activities, for instance when irregular or carried out by women or children, are not considered by locals themselves as economic activities. Terminology is often crucial in socio-economic investigation of these issues. The tendency of surveys to refer to ‘occupations’ (*asiip*) and thus elicit a narrow identification of main economic activities may easily fail to capture the complex economic reality, as is discussed below.

Rice

Throughout Southeast Asia rural peoples tend to define themselves as 'rice farmers' irrespective of the size of their land holdings or level of production. Rice is widely regarded as the staple, and as such the economic activity that takes priority. It is therefore not surprising that 2834 households of a total of 3159 surveys, or 90%, record rice farming as the main ‘occupation’ (cf. Baird 2000 in press). In many villages the figure is 100% although some villages present a much lower figure. For example, B. Phon Pho records 56% of households, and B. Phondeng 58% (see Friend, 1999).

Land Holdings and Production

As a rice-fish economy access to land is clearly of great importance. Average land holdings are similar to other villages in Champasak (see the Council of Medical Sciences, 1996 p. 10). However, landholdings vary significantly within and between villages and are not solely determined by location on island or mainland as might be expected. It would appear that the island villages of B. Done Chome and B. Thantavanoke are confronted with the greatest land pressures, with both the upper and lower ranges for these villages recorded as being the smallest. The village of B. Dong is perhaps less representative of other island communities as it lies on the largest island in the area. On the other hand, although situated on the mainland B. Lomphat is confronted with limited rice land, and displays the narrowest range of landholdings.

The percentage of households that are landless lies within a narrow range (ca. 11-13%), except for the village of Ban Senhom, with 20 % (cf Elliott, 1998). There are two possible explanations for this; (a) the arrival of new households to the village, (b) inheritance whereby because of limited land resources and matrilocal marriage patterns, land is passed on to elder daughters and sons inherit movable resources such as buffalo (Vixay Inthaphaisy pers. comm.). While landholdings vary sale of rice land is rare with extended families being involved in any such discussions, as well as matters of inheritance (Vixay Inthaphaisy and I. Baird pers. comm.). There is limited evidence concerning access to land rather than merely ownership. It is possible that households have access to land outside the village through kin connections and other social networks. This may be an important factor for those villages in which land is prone to flooding.

Table 11. Rice land holdings.

	B. Dong	B. Senhom	B. Houayhai	B. Thantavanoke	B. Lomphat	B. Done Chome
Total area (ha)	28	13.18	18.2	11.46	12.19	13.84
# landless households	2	2	2	1	1	1
% landless	11%	20%	13%	10%	11%	10%
Largest area (ha)	5.48	4.06	5.48	2.78	2.0	2.63
Smallest area (ha)	1.0	1.25	1.0	0.5	1.0	0.35
Average of those w land (ha)*	1.75	1.725	1.4	1.27	1.52	1.54
Average overall (ha)**	1.56	1.318	1.21	1.146	1.35	1.384

* This refers to the average landholdings of those households with land

** This refers to the average landholdings for all households, including those with no land..

Quality of land, rather than simply area, is also an important factor in production. Village headmen are responsible for collecting annual production figures for the village. These records provide the data for this section. While area of land holdings is highly significant, the site of the land (particularly vulnerability to flooding), and productivity of the soils are also important. Rice land in Lao PDR is classified by the government according to three categories (classes 1, 2 and 3) based on production. By far the majority of land in the project area, 71% is classified as grade 3, with 9% as grade 2, and only 7% as grade 1. The most significant change in terms of rice production has been the promotion of the irrigated second crop of rice (*naxeng*). Although this had only just begun at the time of the survey (October 1997), approximately 38% of the total area of paddy had been converted to *naxeng*. The figure is probably now closer to 50%. However, not all rice land is suitable for *naxeng* either due to the lie of the land, or proximity to irrigation facilities.

Production rates vary enormously between the six villages with B. Lomphat the lowest by a considerable margin. In many instances rice is sold to meet immediate household cash requirements, even if production is insufficient to meet subsistence needs. As is discussed later, rice deficits, if they cannot be offset by other economic activities tend to be one of the main reasons for economic deficit, and place a considerable burden on households.

The ratio of labour to dependants in the household can be a highly significant variable. Households with a large number of dependants may record production levels a third that of other households, even on the same area of land.

The uneven take-up of the second rice crop has the potential to generate further economic differentiation in the villages, although there is no evidence at present to indicate any strong correlation between the households selling rice from the first crop, and involvement in the production of the second crop. The quality and suitability of land, access to irrigation, as well as the access to labour are likely to be influential factors in levels of uptake. It is reported that families that have land suitable for *naxeng* but who do not wish to produce themselves, must rent their land at below market rates.

Table 12. Landholdings and production.

	B. Dong	B. Senhom	B. Houayhai	B. Thantavanoke	B. Lomphat	B. Done Chome
Total Production (T)	22.7	18.6	12.38	17.52	6.98	20.4
Average Production (T)	1.621	2.325	1.255	1.947	0.977	2.267
Total Expenses (kip)	256 000	270 000	31 000	247 000	0	243 000
Average Expenses (kip)	32 000	54 000	15 500	82 333	0	60 900
Total bought (T)	6.79	5.1	11.51	2.74	6.2	3.6
Average bought (T)	0.377	0.850	0.959	0.685	0.689	1.2
Total bought (kip)	1 373 000	798 000	2 790 000	840 000	1 656 000	570 000
Average bought (kip)	105 615	133 000	232 500	210 000	184 000	190 000
Total Income (kip)	564 000	1 829 000	0	287 280	150 000	700 000
Average Income (kip)	282 000	365 000	0	287 280	150 000	175 000

N.B. The exchange value of the Lao kip has changed dramatically since the time of the survey. At the time of the survey the exchange rate was approximately 2 500 kip to the dollar.

Livestock

Livestock constitute an important resource in rural Lao, as in other parts of SE Asia. Buffaloes are used as draft animals, without which ploughing rice fields is not possible. For many households livestock are the most important source of cash income. However they are not generally sold on a regular basis (e.g. in a set number per year) but when cash income is required, particularly in times of hardship (e.g. in the case of a crop failure, or a death in the household). The ability to sell livestock is an extremely important means of dealing with adversity. Without this option households are extremely vulnerable. Both buffaloes and cattle are also important sources and stores of income. Ownership arrangements may include the sharing of an animal, the sale price of the offspring being divided among the owners (I. Baird pers. comm.). Poultry are a more regular source of food, as well as cash income. There is no evidence of any intensive production. Raising pigs is also an important source of income for some households, but again is not done on an intensive scale. Limited availability of land constitutes the main constraint to rearing livestock.

Most villages have a similar percentage of households raising a similar average number of buffalo. B. Thantavanoke, an island village, has the highest percentage of households raising buffalo, as well as the highest average number of head of buffalo per household. In contrast, B. Senhom a mainland village has the lowest percentage of households owning buffalo. The number of households raising cattle is significantly lower, particularly in B. Done Chome and B. Dong, both island villages. B. Lomphat has by a considerable margin the highest number of households raising cattle (approximately the same number as raises other livestock). Percentages of households and numbers of pigs per household are also similar in all villages. Nearly all households in all villages raise poultry, with B. Thantavanoke once again raising the highest number. (NB. Numbers of poultry are often most difficult to estimate as they fluctuate). B. Lomphat reports the highest average income from livestock by a significant margin (despite having the lowest percentage of poultry ownership), followed by B. Senhom. B. Senhom also reports the highest percentage of households deriving no income from livestock (20%), the same figure as the percentage of households that are landless

Table 13. Livestock in survey villages.

	B. Dong	B. Senhom	B. Houayhai	B. Than Tavanoke	B. Lomphat	B. Done Chome
% households owning buffalo	72%	60%	73%	80%	78%	70%
Avge # buffalo	2.6	2.7	1.8	4.25	2.5	2.9
% households owning cattle	6%	10%	33%	10%	67%	0%
Avge # cattle	1	30	4	2	5.6	0
% households owning pigs	67%	80%	73%	50%	67%	70%
Avge # pigs	1.8	NA	1.3	1.6	NA	1.3
% households owning poultry	100%	100%	93%	100%	78%	90%
Avge # poultry	22	NA	12	54	22	NA
% (#) households reporting no income	0%	20%	6.7%	10%	0%	10%
		(2)	(1)	(1)		(1)
Total income (kip)	2 564 200	2 521 000	1 814 500	943 000	2 927 000	801 000
Average income (kip)	142 456	315 125	129 607	104 778	325 222	89 000

Fruit and vegetables

Orchard produce on households' own land is an important source of food, as well as a possible source of income. If on an appropriate scale, orchard produce can be one of the main sources of income and one of the main factors in determining economic security. However, average incomes derived from orchard produce are reported as being low, except for B. Thantavanoke, and to a lesser extent B. Dong. Even in these two villages economic benefit is not evenly distributed. Income for B. Thantavanoke is high due to production of '*mak tan*' (sugar palm) by 7 households. This is not a major source of income in any of the other villages and accounts for a total of 3 788 000 kip (91%) of the total income from orchards for B. Thantavanoke[12]. Income is high for B. Dong due to one household's income from bananas, and one other household's production of '*mak phong*' which accounts for 50% of the total income for the village.

Survey statistics are somewhat unreliable concerning garden production. The area of land is often very small and based around the homestead and in some cases on river banks, and income erratic as production is largely for consumption. However, most households grow at least small amounts of vegetables. The most common vegetables cultivated are chilli and mint, most of which is consumed within the household.

It is not clear which member(s) of the household is involved in gardening. It would seem that for some activities it tends to be women, but not exclusively so. District project counterparts suggest that watering of vegetable crops on the river banks may be carried out by gill-net fishers, in between removing their nets (Vixay Inthaphaisy pers. comm.).

Collecting from the forest

As with fishing, forest resources constitute an important source of food and income, as well as a range of traditional medicines, firewood and timber. Reliance on these resources varies from village to village. According to the village survey data only 16 of the total 38 villages are involved in collecting forest resources for consumption, and only 6 villages (or 15%) derive cash income from these resources. Further validation fieldwork would suggest that this is a significant underestimation of the value of forest resources in local livelihood strategies. It is

[12] The name of the village B. Thantavanoke is derived from the sugar palm, *dton than*.

also not clear to what extent forest resources are of greater significance for poorer households, but this is clearly an issue that should be addressed. As a commons resource requiring limited capital investment, it would seem likely that forest resources may be of greater significance in the livelihood strategies of poorer households.

The main forest products that are utilised are : mushrooms; bamboo shoots; *Mak Naeng* (cardamom); *Khixi* (*shorea sp* resin); *Nam Man Yang* (dipterocarp resin); *Dok Kheeng/ Dok Kachiao*; *Phaksamek*; *Mak Chong* (malva nuts); and *Mak Yang Pa*. Firewood, mushrooms and bamboo shoots are collected throughout the villages. The quantity of both mushrooms and bamboo shoots collected is probably significantly underestimated (and for many households no quantities are recorded at all) but nevertheless, the data does suggest that these are important resources.

Given the way in which forest resources are utilised there are limitations to quantifying forest products collected, simply by using survey methodology. Since much of the forest products are collected for domestic consumption it is difficult for villagers to quantify in kilos the amount gathered over a whole year. Often forest products are collected in a rather ad hoc manner by different members of the household, influenced by seasonal availability and the ability to combine with other economic commitments. Forest products may also be collected during other activities. For some villages and some households forest products are obviously of great importance, although this has not been fully revealed in the survey. Interviews in B. Lomphat (field notes May 1999) suggest that a great deal of effort goes into collection of forest products, and that mushrooms in particular are an important source of income, often being sold to passing vehicles on the nearby main road. Villagers in the neighbouring village of B. Kokpadek report that villagers from B. Lomphat are permitted to enter forests of B. Kokpadek to collect forest products. These are not considered to be important resources for B. Kokpadek and there is therefore no competition. Incomes from these forest products also appear to be under-reported. This may also be true for other poor villagers with access to productive forests.

Migration – hired labour

Selling labour is often the highest source of income and the main basis for economic differentiation, or the ability to offset deficiencies in other resources. With increasing market involvement and the potential for a growing demand for labour, the ability of households to sell labour can be predicted to become of growing importance. Hired labour within the villages is reported as less prevalent, although selling of labour is reported to occur in 72% of the villages, but only by a small number of individuals. There are limited markets for hired labour in the village whereas exchanges of labour tend to occur on a reciprocal basis, often between kin, or from landless or land-short households. Methods of payment vary and do not always involve cash, but often a share of the crop. More detailed analysis of the selling of labour within the villages would provide valuable insight into the distribution of wealth, and factors in differentiation.

The most commonly reported activity for selling labour outside the village is in the coffee plantations of Pakxong. This is a highly seasonal activity, occurring in the dry season, a period of relative quiet in the villages. This type of labour is reported as being poorly paid and unreliable, often involving a high degree of investment - taking the family a long way from home, costs of living and in the case of the highland coffee growing areas, risks of disease associated with the unfamiliar climate. In some cases the cost of medical care may consume all wages earned. Thailand and Pakse are also recorded as important labour markets. Although there is no evidence on how the economic downturn in Thailand has affected these labour markets, it should be noted that casual labour markets are extremely volatile. Discussions with District Project counterparts indicate that kin connections influence patterns of labour migration, with households migrating with kin, or to places where kin are already established (Vixay Inthaphaisy pers. comm.).

Fishing

Fishing activity is primarily for subsistence needs with fish and aquatic resources constituting the main source of animal protein in people's diets. For most households fish are sold in periods when productivity is high, and subsistence needs have already been met. However, fish are often a highly important source of cash income. In discussions with villagers regarding the Fish Conservation Zones, it was suggested that the increased productivity derived from the FCZs had ameliorated the effects of the loss of *naxeng* in B. Kokpadek and B. Chan (field notes May 1999). This would suggest that with increased production, fishing has the potential of being a more important source of income. This is an important point to note. There are limited opportunities for increases in agricultural production and cash income without high levels of investment. Although evidence is inconclusive at the moment, if production from the fishery can increase significantly through the implementation of appropriate management strategies (such as the establishment of Fish Conservation Zones) there would be considerable potential for generating cash income. This would of course be of great value for poor households, less able to invest in other activities.

Involvement in fishing for market is not solely influenced by seasonality and productivity, but also by the relative viability of other economic activities. Fishing appears to be reasonably accessible for most households, and with improved market connections, more easily traded as a source of cash income. There are also indications that there has been an increase in the number of local people in some villages who are involved in market trading. There are several possible explanations for this trend; increased availability of ice and ice receptacles, increased access to markets, increased production, increased demand, wider availability of credit that allows for investment (and related risk) in trading activities. Much of the fish traded goes to markets out of the district, with the majority going to Pakse. Fish that are sold tend to be higher-value species, whereas fish consumed tend to be those species with a lower market value.

Fishing activity is influenced by a number of factors, the most obvious of which are habitat and seasonality. Due to the life-cycles of fish and aquatic resources, and the seasonal change of environmental conditions, the level of intensity of fishing activity varies throughout the year. The main period of fishing activity is between December and June, however, some fishing is carried out throughout the year. There are four main fishing habitats: the Mekong River, streams, ponds and rice fields; although these can be further subdivided according to particular characteristics. Deep water areas and rapids are important fishing grounds on the Mekong (see Baird, 1999 in progress). Not surprisingly the Mekong River is recorded as being the most widely used habitat as it is accessible and productive throughout the year. The three remaining habitats types offered in the surveys are more strongly influenced by seasonality. Of these habitats, rice field fishing is the most intensively utilised (in August, September and October). Streams are less intensively used but for a while longer; from June until November. Ponds are most heavily used October through to January. The explanations for the seasonal variation are based on changing levels of water, and compatibility of fishing activity with other economic activities. It is also important to bear in mind that since fishing in non-river habitats is considered to be subsidiary fishing, it is less likely to be recorded as accurately.

Choice of Gears

There are numerous fishing gears used in the project area and many of the categories of fishing gear can be subdivided with more detail than in the Family Surveys (see Baird et al., 1998). The most frequently used gear is the cast net (*he*), followed by the gill net (*mong*). These gears could be broken down further according to type and size, although this was not done for the surveys (for a more detailed discussion of fishing gears see Claridge, et al., 1997). Both these types of gear have to be bought, although the *he* can be made by villagers made from bought lengths of nylon. Whereas the typical life-span of the *mong* is only three years or less[13], that for the *he* is

[13] Ian Baird (pers. comm. 2000) notes that gill nets often last less than 3 years. For example small cyprinid gill nets with a mesh size of 2.5 cm need to be replaced every one or two years.

closer to ten years. The *he* can be used in river environments throughout the year. Although it is more widely used, the yield of the cast net is lower than that of the gill net (*mong*) with the majority of fish caught being caught in gill nets (Baird, et al., 1998). This clearly is significant if choice of gear is largely determined by cost.

The *mong* tends to be used with more intensity for fewer months in the year. Two main types of *mong* are used; the floating gill-net and the fixed gill-net. Both of these are available with varying mesh sizes, typically between 2.5cm to 25cm, but more commonly 2.5cm to 12cm. From August to November *mong* are recorded as not being used at all. Along with *he*, hooks and lines are used throughout the year. For those who fish regularly the level of intensity remains more or less constant throughout the year. For those who fish less regularly the level of intensity peaks around March till June, and then again in September to October.

Both *mong* and *he* are the two gear types that are most widely appropriate to the conditions of the Mekong. Use of *he* and *mong* as most frequent gear varies according to the village. In B. Dong, B. Lomphat and B. Houayhai the *mong* is most frequently used, whereas in B. Senhom and B. Done Chome the *he* is most frequently used. In B. Thantavanoke both *mong* and *he* are most frequently used. Both these villages have rapid areas and deep water near the villages (I. Baird pers. comm.).

A number of other gears are also used related to the particular habitats accessible to the villages. The *kha* is used intensively for two periods in the year, from November to December, and from June to July. However, it is only used by a small number of households, in conjunction with several other gears. Its use is specialised, based on the area below the falls (see Baird, 1998). The *kha* is most widely used in Ban Dong, but on only by six households. In the six survey villages, B. Done Chome and B. Thantavanoke record two households as using *kha*, and in B. Houayhai only one household. There are no households using *kha* in B. Lomphat and B. Senhom.

It is also significant that most households employ a range of gears. For those households that do not use a range of gears, the gear of choice is either the cast net (*he*) or gill nets (*mong*). Households that do not have either *mong* or *he* use hooks and lines (*bet*) as their main gear. Cost is a major factor as hooks and lines are significantly cheaper than other gears and the data reveals that one poorer household only uses *bet*. It is notable that B. Lomphat and B. Houayhai in nearly every category appear to be the poorest villages, and also record the lowest number of average gears, and the highest number of 'no gears'.[14] B. Done Chome clearly has the highest average number of gears per household, as it also has the most range of fishing habitats. The ability to utilise a number of fishing gears suggests greater capacity of a household to utilise a range of fishing habitats in different seasons, and also suggests greater yield.

Sources of economic differentiation

In considering the diversity of local livelihoods it is important to consider the extent and causes of economic differentiation. If targeting poverty is to be an objective of fisheries policy it is necessary to assess distributional impact of policy. Again with an increasing pace of economic change and market penetration it is important to assess the likely impact on poorer households, and to devise strategies to alleviate these pressures.

There are many overlapping causes of economic differentiation. By considering the factors that local people consider determine economic status, it is clear that economic status is not simply an

[14] District project counterparts questioned whether any households actually do not own any gear at all. The data indicates that the households in B. Houayhai that do not own any fishing gear are households comprised of old people, or households with no male member of suitable age. For B. Senhom and B. Lomphat household of older people for whom fisheries data may be incomplete. One other household in B. Lomphat appears not to be engaged in fishing, and records fish as an expense.

issue of access to material resources. The three main economic categories that local people discuss are presented below:

Upper (*somboun*):
- Enough productive land
- Enough land, few household members
- Enough rice production
- Ownership of buffalo
- High ratio of labour to dependants within the household
- Access to several economic activities (and ability to move from one to the other)
- Access to income (cash) generating activities
- Access to remittances from relatives
- Ownership of motorised boats

Middle (*pan kang*):
- Enough land and rice production for the number of people in the household
- Able to raise livestock - particularly chickens and ducks, and also able to sell pigs
- Do not have to rely on other people (kin)

Lower (*thok gnak*):
- Little or no land
- A large number of people in the household
- High ratio of dependants to labour in the household (female-headed households, or households with large number of old and young)
- No buffalo
- No kin in the area
- Need to work outside the village
- Ill health

The discussion of household income and expenditure that follows is most significant for its discussion of trends, rather than fixed values.

The main income by a significant margin is from wages/labour (see Friend, 1999). This is then followed by livestock which constitutes approximately 60% of the income from wages/labour. Both wages/labour and livestock are significantly higher than the next highest sources of income: fish/aquatic resources and fruit trees. Both these latter categories are more or less equal. The next source of income is from petty trading. These are then followed by remittances and forest products, with vegetable gardens as the final source of income. It is highly significant to note that income from rice is offset by the expenses of production, and is in fact a negative value, roughly equal to the gross income from rice.

The main sources of income require significant inputs, and human, natural and social resources. In the case of wages/labour, households require able-bodied members, to a large degree although not exclusively men, in order to be able to gain benefit. Livestock also requires significant investments in land (particularly for buffalo and cattle), capital as well as labour. Most of the labour markets are outside the village and requires living for extended periods away from the household. There are significant costs associated with labour outside the village. The very fact that a male member is away from the village means that there is a significant opportunity cost of their labour that could otherwise have been engaged in one or more activities in the village. If only one male member is able to engage in selling his labour, a greater strain is placed on the household members that remain in the village, with less economic opportunities. Unsurprisingly income from labour appears to be higher in those households in which there is more than one male member; at least one of whom can remain behind and carry on other economic activities.

Economic activity varies considerably from village to village. In the case of B. Dong those households that record income greater than expenses have access to a combination of wage labour, livestock and remittances. One activity on its own is insufficient, although wage labour appears to offer the greatest returns. Significantly, households that record income as being greater than expenses tend to be those that record fishing and rice as expenses. This would suggest that rice and fishing only meet subsistence needs in B. Dong with limited potential for increases in production, and that access to other more productive activities can offset deficits in subsistence.

The case of B. Senhom also suggests the importance of a range of economic activities, and the potential for wage labour, livestock, and fishing to counter deficits in rice production. However without these options a deficit in rice production is highly significant. Poorer households tend to be those that incur greater expenses and are less able to be involved in wage labour and livestock. It is significant to note that in the case of B. Senhom poorer households tend to be those with less access to income generating activities, but also those that incur expenses related to household maintenance and medicines, as well as rice. This implies a high degree of vulnerability. Not only are poorer households less able to benefit from the more lucrative activities, but they are also the households that have less resources to cope with adversity. In this sense, such households are less able to move out of poverty, and more susceptible to slipping back into poverty. It is also significant to note that B. Senhom is the village with the highest level of landlessness at 20% and the highest percentage of households deriving income from rice production.

Most households in B. Thantavanoke derive income from a range of resources and livelihood strategies. In comparison with the other villages, these appear to based within the village, rather than wage labour. The most significant activities include forest products, livestock and fruit. For 2 households that record income to be greater than expenses, the main source of income is fishing, in conjunction with other activities. Of the 9 households in B. Lomphat, 7 households report livestock to be the main source of income, and the remaining 2 households derive a small income from livestock. 5 households also record income from wage labour, although this is very much a supplementary income.

Fishing is recorded as being the main source of income in B. Done Chome. For the 2 households that record income greater than expenses, 1 household derives income from fishing and rice, while the other from fishing and wage labour, with rice as an expense. For the majority of households the main expenses are household supplies and maintenance, medicine and production.

Although many activities do not appear at first sight to have a major income value, their real value to the household economy should be placed in context. As has been said earlier, no households are able to rely on one single economic activity. Although fishing may not always appear as a source of income in the survey it is on the whole a subsistence resource, and indeed the main source of animal protein. Without being able to meet subsistence needs in fish, a household is in a very precarious situation. Clearly this situation is exacerbated if the household also faces a rice deficit, or any vulnerability in another areas. Simple costing of individual activities out of context of wider household resource profiles is inadequate. This raises methodological issues for the project wanting to carry out monitoring of socio-economic situations, and the distributional effects of development change and management interventions (including the establishment of Fish Conservation Zones).

It is important not to underestimate the significance of non-material resources (cf. Carney, 1998). The survey provides limited evidence of the role of social resources, but there are strong indications that kinship connections are of considerable importance, for example in times of trouble, sources of labour or credit, access to markets or political favours. These types of resources become even more important in livelihood strategies as households attempt to adapt to rapid change, periods of uncertainty or natural disasters.

FISHING IN CONTEXT: IMPLICATIONS FOR MANAGEMENT

From the above discussion it can be seen that the full significance of fishing becomes apparent when placed in the context of wider household livelihood strategies. This itself requires an understanding of how households combine different activities, and how they respond to change.

While it is necessary to build an understanding of local resource use based on the household, this must then be placed in context of the wider socio-economic arenas in which households operate. The communities of the Siphandone generally are well established, with seemingly relatively equitable norms and regulations governing resource use, production and exchange within the village. However, there is reason to assume that increasingly these communities will be faced with internal differentiation, and come under external pressures. Assessing how these communities deal with this changing environment and how disputes are negotiated and settled will be an important means of monitoring the progress of co-management regimes.

Increasingly rural communities in Lao are coming under the influence of market forces, and implementation of state policy. Market influences are becoming stronger in Siphandone, influencing fish sold (large, high value species) but also the economic viability of alternative activities. This can be anticipated to become increasingly significant with greater market penetration of the area. Although the state's influence has not been strong historically, growing influence is evidenced in increased development activities including the extension of the second rice crop, as well as in implementation of conservation policy, such as the establishment of the Xe Pian National Biodiversity Conservation Area (NBCA). The implementation of 'development policy' is itself further manifestation of the state's influence at village level.

In establishing community level management regimes it is essential to assess the distributional effects of such regimes on different status households. Village norms and institutions in Siphandone, as in other parts of Lao (see Ireson, 1996) are argued to be highly equitable. However, the success in conserving aquatic resources may in itself generate greater competition over the resource. In some cases community management regimes are established in what had previously been commons resources, often the domain of the poor. In such cases it is often the poor who carry a disproportionate burden losing access to a resource that was exclusively theirs, but unable to access alternative resources (cf. Garaway, 1997). There is no evidence to suggest that this has been the case in Siphandone; however it is clearly an issue that needs to be addressed as other sources of economic differentiation intensify. Useful lessons could also be derived from how community level management regimes in the FCZs ensure equitable access and distribution.

Modelling fisheries

A 'people-centred' model of fisheries economies as outlined in this discussion has further implications for how fisheries are assessed in terms of catch and effort, their local economic value, and also in terms of monitoring and assessment.

First of all the value of traditional socio-economic surveys is extremely limited, and in many situations counterproductive to long-term management objectives. A survey is incapable of revealing the dynamic aspect of relative value and importance of household livelihood strategies, or how households make decisions and act in response to change. Surveys assume a level of uniformity and regularity that is rarely in evidence in such rural economies. At best surveys can present a snapshot of stocks of resources at one point in time. If repeated often enough, this may provide valuable information and the basis for further investigation. However the type of information that is generally provided is of limited value for management purposes. Management attempts to generate change and to influence patterns of resource use. Without an understanding of the dynamics and diversity of local livelihood strategies and how stocks of resources are converted this is not possible. This is particularly important in these types of fishery. Fishing is one component of diverse and dynamic livelihood strategies, in which patterns of fishing activity are irregular and subject to a range of variables.

There is widespread talk of the importance of participation and the use of participatory methodologies in contemporary development. However, these concepts and their application are often poorly understood, and consequently have been reduced to the level of jargon. The essential characteristic of participatory methods (such as PRA) is that they do not impose a limited, narrow line of questioning but elicit ideas and opinions in people's own terms. As such they are most appropriate to allow fishers to reveal how they understand their own livelihoods, how they make decisions and deal with change, and what factors influence these decisions and actions. In terms of management, greater participation of local fishers is an essential means of establishing legitimate, equitable and sustainable practices. Participation does not merely mean a greater contribution of fishers in the gathering of socio-economic data. Participation of fishers should extend to analysers of data, monitoring and evaluation of the condition of the fishery, co-managers of the fishery resource, and a more prominent role in the policy-making process.

Monitoring and assessing

In the same way that local livelihood strategies need to be adaptive, management of freshwater fisheries must also be adaptive (cf. Hoggarth, et al., 1999). This has implications for the types of assessment and monitoring activities that are undertaken, and the ways in which these are carried out. The dynamism and diversity of fisheries requires regular monitoring and assessment that cannot be achieved in a one-off survey.

While there is clearly a role for the application of fisheries biology modelling techniques there are serious constraints. It is also beyond the capability of under-funded, undermanned fisheries departments. Fishers have the capabilities to undertake detailed and sophisticated monitoring and evaluation. This has already begun in the Siphandone Wetlands Project (see Baird 2000 in press) with fishers maintaining detailed records of catch and effort, including species composition, size, gear used, fishing grounds used and amount of time spent catching fish. This provides important empirical data on the conservation zones. It is also institutionally sustainable allowing for continued input from fishers over the years thereby presenting a more reliable, and empirically rigorous assessment of the fishery than could be achieved by a one-off survey.

Perhaps even more importantly it enhances the role of fishers as managers of their resource base, providing them with the tools of biological assessment that allow them to argue their case more effectively with government officials. While local knowledge is often discussed, it tends to be extracted and translated into scientific knowledge by outside experts. It is rare for local knowledge to be strengthened by supplementing local knowledge with scientific methodologies. It is essential for sustainable, equitable management purposes to have local institutions that are responsive to local needs and conditions.

Fisher participation – an end and a means

Ultimately no fishery can be assessed, monitored or managed without a high degree of participation of local fishers. It is therefore appropriate that all assessments of the fishery whether biological or socio-economic, aim to enhance this participation not merely as a means for extracting information but by building local assessment capacity as a management objective in itself. Although there is clearly a need for a rigorous biological assessment of fisheries, no such assessment could be carried out without the input of local fishers. The starting point for effective assessment and management should therefore be strengthening the capacity and participation of local fishers, establishing responsive local government institutions, and the development of economic activities that take into account the diversity of local livelihood strategies.

Chapter 8

Towards sustainable co-management of Mekong River aquatic resources: the experience in Siphandone wetlands

Ian G. Baird

Natural resource "co-management" can be defined as, "the collaborative and participatory process of regulatory decision-making among representatives of user-groups, government agencies and research institutes." (Jentoft et al., 1998:423). In terms of fisheries, co-management has been heralded as a tool for doing away with the distant, impersonal and insensitive bureaucratic approaches to management, which have dominated aquatic resource management systems in recent history. Co-management supports the decentralisation of management responsibilities to resource user groups, providing them with a certain level of autonomy within an overall institutional and government accepted framework. It provides opportunities for developing cooperative and interactive governance through the direct participation of users in decision-making processes involving natural resources, or through user representation at levels that transcend community boundaries (Jentoft et al., 1998).

Most of the aquatic resource co-management programmes cited in the literature relate to coastal salt or brackish water environments (Kuperan and Abdullah, 1994; Davis and Bailey, 1996; Symes, 1996; Pomeroy, 1998; Finlay, 1998). Institutionalised co-management programmes for inland fisheries are apparently much rarer, and when they do exist, they often relate to natural and man-made lacustrine habitats rather than free flowing streams and rivers (Petr, 1985; Ali, 1996; Donda, 1998). The community-based aquatic resource co-management programme in Khong District, Champasak Province, in the southern part of Lao People's Democratic Republic (Lao PDR or Laos), addresses issues related to natural inland riverine water bodies and associated wetlands. Aquatic resources managed in Khong are largely sourced from the mainstream Mekong River and its immediate tributaries (Baird, 1994b; Baird, 1996; Baird *et al.*, 1998a).

Between December 1993 and August 1998 a total of 63 villages in Khong District established sets of regulations to conserve and sustainably manage aquatic resources in the mainstream Mekong River, swamps, streams, and paddy fields. Wild-capture fisheries management has been the main focus. Like many other countries in the world, Laos is beginning to embrace the concept of natural resource co-management (Baird, 1994b; Baird, 1996; Noraseng, 1998; Phanvilay, 1998; Baird *et al.*, 1998b).

This chapter provides an overview of the aquatic resource co-management system in Khong District, its evolution, and the reasons for its apparent success. The paper presents lessons regarding aquatic resource co-management and considers how applicable they are for other parts of Laos and Southeast Asia.

AQUATIC RESOURCES MANAGEMENT AND RESOURCE TENURE IN KHONG DISTRICT

Traditional aquatic resource management and resource tenure in Khong District

Up until the 1950s and early 1960s fisheries practices in Khong were largely traditional. Fishing was conducted almost entirely for subsistence purposes, with the exception of a small amount of barter trade for certain high quality preserved fish like *"som pa eun"* and *"pa chao"* (see Baird, 1994a; Baird *et al.* 1998a). The human population of Khong was significantly lower than it is now, and virtually all types of fishing gears were small-scale and made of local materials. As a result, fish and other aquatic animals were extremely abundant.

The inland fisheries of Khong District have long been identified and managed as commons resources. The people of Khong have traditionally recognised access to fisheries and other aquatic resources as a fundamental right, but it would be a mistake to characterise the fisheries as entirely "open access". Most of the limits on fishing and other aquatic resource harvesting activities historically imposed by people in Khong were related to reducing personal or societal risk from dangerous spirits *("phi")* or creatures like crocodiles *("khe")*, large sting-rays *("pa fa lai")* or even serpents *("gneuak")*. For example, certain deep-water parts of the Mekong River were traditionally off limits for fishing due to the fear of danger from mysterious creatures and other unknown entities. There was no need for villagers to fish those areas, since it was easy to catch fish in shallow water close to shore. Only in certain cases, such as with the management of large wood fixed Mekong River wing and basket filter traps *("li"* and *"tone")* in the Khone Falls area in southern Khong District (see Roberts and Baird, 1995 for details) have complex individual and family tenure systems been developed to help divide up limited number of good trap setting sites (Roberts and Baird, 1995).

Changes in traditional aquatic resource management and resource tenure in Khong District

Over the last few decades there have been many changes in aquatic resource management patterns in Khong District, and Laos as a whole. The human population of Khong has increased rapidly. Lines and nets made of nylon, including mono and multi-filament gillnets, have become extremely common. In fact, gillnets are now the most important type of fishing gear in Khong. Baird *et al.* (1998a) found that approximately 71% of the families in Khong owned one or more nylon gillnets in 1996. Nylon castnets were also owned by 67% of the families (Baird *et al.*, 1998a). Nets made of natural fibers are no longer in use anywhere in Khong.

In recent years there have also been significant changes in Khong with regards to fish marketing and consumption patterns. Whereas fish had a low economic value in the past, they now fetch relatively high prices (see Baird, 1994a). In the not so distant past, villagers caught fish almost exclusively to feed their families, but economic considerations now have a much greater influence over fish harvesting and marketing practices. Villagers have also begun to desire more cash to buy consumer goods, which have become more visible due to the expansion of market activities.

The rapid increase in the use of motorised boats over the last decade has significantly increased the mobility of both fishers and fish traders, and has resulted in the increased need to generate cash income in order to cover engine, fuel and maintenance costs. Transportation links between Khong and the commercial centre of Pakse have also changed. Whereas it was extremely difficult to transport fish to market ten years ago, it is now relatively easy to move fish to buyers via passenger buses that run between Pakse and Khong on a daily basis. Finally, widespread access to block ice for storing fresh fish has greatly influenced fish marketing dynamics. Until about a decade ago, ice was virtually non-existent in Khong, but now most fish traders now have coolers, which makes it possible for them to buy fresh fish and transport them on ice to markets in Pakse and Thailand (Baird, 1994a).

The fisheries management situation in Khong District was in great flux in the early 1990s when co-management organising began. Human population had risen, gillnet use had increased, and fish trading was up. Villagers were reporting sharp declines in fish catches. Some species had become very rare and locally extirpated. Changes were occurring rapidly, and while most villagers were becoming aware of the over harvesting problems facing their fisheries, only limited action had been taken to reverse the perceived downward trend in aquatic animal populations.

The aquatic resources co-management programme in Khong District

The Lao Community Fisheries and Dolphin Protection Project (LCFDPP) was established as a small, NGO supported, government project in Khong District in January 1993. Between December 1993 and June 1997 a total of 59 villages requested and received assistance in devising their own unique sets of co-management regulations (Baird *et al.*, 1998a).

In July 1997 the Environment Protection and Community Development in Siphandone Wetland Project (SWP) took over the responsibilities of the LCFDPP. Between July 1997 and August 1998 an additional four villages established co-management plans and associated regulations, bringing the total to 63 villages with functioning co-management systems for stewarding natural aquatic resources.

The development of the aquatic resource co-management system in Khong District

Unlike conventionally science-based approaches to fisheries management, one of the hallmarks of co-management systems are that they recognise that fisheries management is as much a people-management problem as a biological or economic one (Clay and McGoodwin, 1995). Over the last six and-a-half years the aquatic resource co-management programme in Khong has grown and evolved. After almost a year of initial research into aquatic resource management issues in the southern part of Khong District, the first district government recognised village aquatic resource co-management plan was created in Khong for Ban Hang Khone village. Before long the LCFDPP was receiving requests from numerous village leaders in Khong who were interested in establishing their own village-based aquatic resource co-management systems. The motivation of villagers was mainly based on the recognition that fisheries resources were in decline and that something needed to be done to stabilise and eventually reverse the trend.

In 1994 the LCFDPP cooperated with Agriculture and Forestry Office (AFO) of Khong District and the Agriculture and Forestry Division of Champasak Province (AFDC) to determine how to respond to the great interest shown by villagers in co-management. A process for extending the work of the project was agreed upon.

The aquatic resource co-management system establishment process in Khong District

Initiating the process

The system for working with villages to establish co-management plans is based on the principle that villages should not be forced or pressured into establishing aquatic resource co-management regulations. Instead, villages should only be assisted in establishing co-management strategies after they have requested assistance in doing so.

The process for establishing aquatic resource co-management systems in villages always begins with the village and its leaders. Communities generally learn about opportunities for establishing co-management systems from neighbouring villages, friends and relatives, and government officials who visit their communities. If community leaders are interested in establishing a aquatic resource co-management plan, they are required by Khong District and Champasak Province to write a short letter to the Khong District AFO in order to request permission to establish regulations recognised by government.

Preparing for the establishment of aquatic resource co-management regulations

Once requests have been received by the district, the AFO compiles them and prepares a letter to the AFDC in order to request official permission for the aquatic resource co-management process to proceed. The district chief and the AFDC approve the request. Up until 1996 Champasak Province required that the provincial governor also authorise documents related to fisheries co-management, but the province has since decided that it is no longer necessary. This indicates that they have become more comfortable with the process.

During the period in which government permission is being sought, extension workers from the LCFDPP or the SWP make contact with the village leadership. It is important that communities are provided with advice regarding the process for establishing co-management systems. An early start helps ensure that villagers have adequate time to make preparations. Information needs to be collected regarding what village leaders expect to achieve by establishing aquatic resource co-management regulations. Extension workers also need to determine what steps have already been taken at the community level. It is preferable if the whole community is asked to decide on whether co-management regulations should be established prior to a village request for assistance being submitted. However, village headmen sometimes make the decision before the whole community has been consulted.

One role of the extension workers is to encourage community leaders who have not consulted with their constituents to do so promptly. Another role is to explain to village leaders what kinds of regulations have previously been established in other villages in Khong, and how the implementation and enforcement of those regulations has developed. The leaders are advised to meet with fellow villagers to draft a list of co-management regulations that the community favours. Advance discussions are important, because villagers feel more comfortable if regulations are discussed and debated within the community before any outsiders become involved. Villagers also need ample time to carefully consider the implications of establishing particular regulations. Co-management is not as much about the regulations established as it is about the communicative and collaborative process through which regulations are formed (Jentoft *et al.,* 1998).

Village aquatic resource co-management workshops

Usually about a month or more is allowed after the extension workers visit a village before a formal aquatic resource co-management workshop is organised in a community. These one-day workshops represent the most important official step in establishing government recognised co-management regulations.

All the adult members of the community are requested by the headman and his assistants to attend formal aquatic resource co-management workshops. However, it is usually not possible for everyone to attend, and it is standard practice for one or two members of each family to participate. Apart from villagers, SWP staff and AFO officials also attend. The district chief or his designated representative and AFDC provincial officials sometimes attend. It is extremely important that village leaders formally invite the village headmen from neighbouring communities to participate, because the success of a village's co-management plan is often predicated on how well the community is able to coordinate and communicate with its neighbours.

Workers from the LCFDPP or the SWP and AFO officials generally arrive at villages organising co-management workshops the day before they are scheduled to take place. Because community leaders have never organised co-management workshops, they generally appreciate advice and it takes a number of hours to make all the necessary arrangements.

Since villages initiate the co-management process, the government of Khong feels strongly that communities should control workshop proceedings. Government and project guests are required to act mainly as observers and facilitators and not as active participants. Officials are concerned that problems could arise if villages become overly dependent on government support, leading to a lack of village initiative. They want villagers to own the process.

Village headmen chair co-management workshops. A village headman generally opens the proceedings by explaining the main objectives of the workshop. He then explains how the workshop will be organised. AFO officials and LCFDPP or SWP workers make short presentations regarding the reasoning behind establishing co-management regulations for aquatic resources, and the experiences of other villages in Khong.

The village headman then presents the draft of the co-management regulations developed by the community prior to the workshop. After presenting the draft to the workshop, the community is divided up into two separate gender groups for open and informal discussions regarding the draft regulations. Apart from considering what regulations to endorse, the groups are required to consider what level of punishment should be mandated for those who break the regulations. Villagers are free to make recommendations regarding management strategies, but they are not allowed to advocate regulations that either conflict with already established national laws, result in increased degradation to natural resources, or cause serious conflicts between or within communities. The Khong AFO acts as watchdog to ensure such problems do not arise.

There is no definite time limit for how long villagers have to discuss the proposed regulations, but discussions generally last between one and two hours, depending on how much preparation has been conducted prior to the workshop, and the level of internal controversy regarding the management strategies being considered. Government officials or other guests do not attend the discussions (the officials sit away from the groups until they are ready to present the results of their discussions). The discussions are generally spirited and lively, and broad villager participation is the norm.

Most villagers in Khong possess a great deal of traditional ecological knowledge (TEK) regarding aquatic natural resources. This makes it possible for villager discussions to deal with quite detailed and specific aspects of management. It is difficult for individual villagers to mislead others regarding certain aspects of management because most know enough to easily recognise when somebody is not being truthful. As Pomeroy and Carlos (1997) have noted, community members can play an important role in supporting the co-management process due to their indigenous knowledge of local conditions.

When group discussions have ended, the men and women rejoin government officials and other guests in the main meeting area, which is generally the village’s school or the main hall of the village’s temple. Representatives of each of the two discussion groups present their respective conclusions, including recommendations regarding management regulations proposed by the village, and additional regulations not considered in the original draft of the management plan. Men generally concentrate their regulation-making efforts on large bodies of water and large and valuable fish species. Women tend to focus on issues related to small water bodies and aquatic-life in streams, ponds and rice paddy fields. These differences in special interests help balance and broaden the final contents of management plans.

Next, the participants debate which regulations to adopt. If the recommendations of the women differ from those of the men, or if one or both groups have ideas that conflict with those of the original proposal, discussions continue until consensus is reached. While Lao villages are not without conflict, they are typically governed by consensus (Ireson, 1995). If disagreements cannot be resolved, the AFO representative generally recommends that the issue be deferred until later, so as to allow time for resolving any differences that remain. Interestingly, nobody has ever suggested that a vote be taken to determine whether a regulation is adopted. This may be because villagers do not want to cause rifts within the community by emphasising differences. Consensus, on the other hand, helps maintains village solidarity.

Government officials and LCFDPP or SWP representatives sometimes comment on various aspects of particular regulations during the final workshop discussions. They usually provide examples of how other villages have approached management issues. This input helps broaden the perspective of villagers. However, outside guests are generally mindful not to impose their viewpoint on the community, or to give the appearance of interfering excessively with the process.

Once a community has agreed upon a set of regulations, the host village headman asks village headmen from neighbouring villages to comment on the appropriateness of individual regulations. Although guest village chiefs rarely object to the decisions of the host community, they sometimes suggest improvements to certain regulations by providing new perspectives. They also occasionally request that certain regulations be altered or scrapped. If a neighbouring village headman is able to justify a particular position, the host village will generally try to adjust its regulations in order to maintain good relations with its neighbours, which is an important cultural norm. However, if a request from a neighbouring village headman is considered unreasonable, or is not based on socially accepted TEK, villagers from the host community generally have no qualms about refuting the idea. The AFO sometimes acts as mediator.

After a final set of regulations has been agreed upon and recorded by villagers, the regulations are read back to all the participants one last time to ensure that documented information is representative of the decisions made by the workshop participants. Any errors in recording particular regulations are corrected as they are read out.

Before the village headman closes the workshop, the district chief generally states that the district endorses the decisions of the community, and supports all village initiatives to improve the management of aquatic resources for the benefit of local people and the nation. Government support for community-based management is important to villagers, and is certainly a major factor in successful co-management (Jentoft *et al.*, 1998). Support from government both makes it clear to villagers that they are authorised to manage resources, and helps reduce villager conflict because government support can be cited to justify villager actions and make it clear to other villagers that such actions are not based on personal conflicts or revenge.

Once all members of the village administration and the district have signed the aquatic resource management plan document, it is officially recognised as "village law" (see next section). Four copies of each plan are made. One copy remains with the village, one is filed by the AFO, one is given to the AFDC, and the LCFDPP or the SWP keeps one.

Because formalised aquatic resource co-management planning is unfamiliar to villagers, it is generally necessary for adjustments to be made to regulations after they have been tried out. Changing and adapting regulations is an acceptable and important part of adaptive management (Walters, 1986; Jentoft *et al.*, 1998), and it is important that villages develop the capacity to make well-reasoned changes. Lessons are invariably learned as time passes, and experiences generally indicate whether regulations should be softened or hardened. Village headmen have the right to change regulations, but they are supposed to organise village meetings to get prior approval from the community before alterations are made. Village headmen are also supposed to notify the AFO of Khong when changes are made. Experience indicates that while village headmen almost always seek a mandate from their fellow villagers before instituting changes, they rarely inform the AFO. However, they apparently have no intent to keep the changes from the district, and when officials visit, village leaders generally have no apprehensions about informing officials about regulation changes.

Ireson (1995) claims that in general, lowland Lao regulations related to natural resources are directed toward claiming a geographically defined portion of the resource for exclusive use by one's own village, while not limiting the extraction rates of village households. Although villagers in Khong sometimes want to claim resources for their own community's exclusive use, the AFO has shown considerable wisdom by ensuring that villages do not establish regulations that only discriminate against other villages. Khong District’s policy is that villages are not allowed to restrict outsider-fishing activities unless they are willing to enforce the same restrictions on themselves. However, if a village bans a fishing method in their area of jurisdiction, outsiders are expected to abide by the ban in the same way as local fishers. This "non-discriminatory regulation" principle helps maintain good relationships between villages. It also helps the co-management programme retain a good reputation amongst villagers. Outsiders are much more willing to abide by the regulations of host villages when they realise that local villagers are abiding by the same regulations. In contrast, Isaac and Ruffino (1998) reported that conflict between fishers in the Amazon has increased as a result of communities of fishers dividing up the rights to use resources amongst themselves, and then excluding disadvantaged outsiders.

Village law in the Lao context

It is important to understand the legal context in which the aquatic resource co-management system in Khong District has been incorporated. From the beginnings of the programme, it was recognised that co-management had more chance of succeeding and being sustainable if it was incorporated into the existing Lao village administrative structure. No attempts were made to establish new levels of bureaucracy at the village level, although certain villages have established their own informal or ad hoc working groups to deal with particular issues. Regulation implementation and enforcement is left up to the community.

From a legal perspective, Khong District administrators consider that the aquatic resource co-management regulations of villages fit well into what is known as "village law", or *"kot labiap ban"* in Lao. The legal system of Lao PDR allows villages to make certain regulations regarding local issues, provided that they do not conflict with national laws or the constitution. However, village regulations have rarely been utilised to deal with natural resource management issues. Instead, "village law" has generally been used for designating regulations related to security issues, or the tying up or releasing of water buffaloes. However, Khong District officials believe that the system accommodates the aquatic resource co-management system well. There is undoubtedly a great deal of unrealised potential for utilising "village law" for dealing with natural resource management issues in Laos.

The issue of boundaries of management jurisdiction between villages is critical (Seixas and Begossi, 1998). Surprisingly, over the last five years there have been no major conflicts between villages with regards to village boundaries for aquatic resources. In fact, villagers appear to have a clear sense of aquatic resource territoriality. Territories are known to help manage conflict and conserve resources (Seixas and Begossi, 1998), and the ease in which the concept of human-territoriality is grasped by the Lao indicates that past management has not been simply "open-access".

Community structure

In Laos, social organisation must be understood first and foremost from the village level. Village structure has long been the foundation of ethnic lowland Lao society. Villages in Laos, perhaps more than any other region in Southeast Asia, can be characterised as self-sustaining communities relatively unconnected with larger political and social units (Ireson, 1996). Lowland Lao rural communities have very limited social and economic stratification (Ireson, 1995). The sense of social equality and unity between villagers is generally strong. Shared understandings and the social expectations of neighbours circumscribe the actions and decisions of villagers. High levels of cooperation and mutual dependence between villagers are characteristic of rural communities (Ireson, 1996). The historical remoteness of rural Lao villages, and the lack of strong central control throughout history, probably indicates why village structure continues to be such an important factor in Laos.

Although conditions are relatively constant within single communities, disparities in wealth and power within villages are growing. These shifts in economic circumstances are greatly influencing the structure of Lao society. Nevertheless, even now concepts related to village identity and solidarity are strongly adhered to by villagers (Ireson, 1996). McCay and Jentoft (1996) have pointed out that one of the keys to successful fisheries co-management programmes is the ability for villagers to speak with one voice. This condition is generally met in Khong where locals strongly identify themselves as belonging to particular villages, or, when villages are separated geographically, people sometimes associate themselves with certain parts of the village. Villagers generally identify with elected or "natural" leaders in their communities whom they rely on to represent them when dealing with outsiders.

Olomola (1998) has stressed the importance of the cohesiveness of social, kinship, linguistic and cultural interconnections in determining the success of fisheries co-management programmes. Ireson (1996) has pointed out that the social norm of taking care of each other can be significantly jeopardised by factionalism and conflict among cliques in villages. These points help explain why villagers in Laos tend to avoid excessive conflict. It is useful to consider Ireson's (1996) assertion that there are three interlocked and mutually reinforcing elements required to maintain Lao village cooperation and solidarity, being, (1) a village ideology of mutuality, (2) successful events of cooperation, and (3) shallow socio-economic stratification.

AQUATIC RESOURCE CO-MANAGEMENT PLANS: THE CO-MANAGEMENT REGULATIONS IN DETAIL

Sixty-three villages in Khong District have established regulations designed to conserve and sustainably manage aquatic resources. The main regulations that have been adopted are outlined below. See Claridge *et al.* (1997) for detailed descriptions and illustrations of Lao fishing gears.

Fish conservation zones

The most significant co-management initiatives for villagers and local government officials in Khong has been the establishment of Fish Conservation Zones (FCZs) in parts of the mainstream Mekong River. FCZs are basically year round or part year "no-fishing zones".

Between December 1993 and August 1998, 60 villages established a total of 68 FCZs. All are in operation today. Single villages established some, while others were the result of joint cooperation between two or three communities. The largest FCZ is 18 ha, the smallest is 0.25

ha, and the mean size is 3.52 ha. The deepest FCZ is approximately 50 metres in the dry season, the shallowest is about 2.5 metres, and the mean depth is about 19.5 metres. Villagers have widely reported that the establishment of FCZs has resulted in increases in the stocks of over 50 fish species. Fish catches have also reportedly increased. Interestingly, the fish species that benefit from independent FCZs appear to differ depending on the type of riverine habitat protected within an FCZ. It is also possible that series of FCZs provide accumulated and synergistic benefits for certain migratory fish species (Baird *et al.*, 1998b).

Villager logic for establishing FCZs is based on TEK, which is accumulated through generations of fishing experience and the personal observations of fishers. Fishers believe that large numbers of individual fish species, and especially large ones, congregate in deep parts of the Mekong River at the height of the low-water season. Since the dry season is the main fishing season for most people in Khong (Baird *et al.*, 1998b), and since water discharge is reduced 30 fold and many metres in the dry season as compared to the wet season (Cunningham, 1998b), it is the time of year when many fish species are the most vulnerable to harvesting pressures. Villagers believe that fish harvesting impacts can be reduced through banning or significantly limiting fishing activities in key deep-water areas. They claim that these areas serve as dry season refuges, and sometimes spawning grounds for fish.

Bans on stream blocking

One of the most popular regulations adopted by the vast majority of villages in Khong relates to the blocking of small seasonal tributaries of the Mekong River at the beginning of the rainy season *("tan houay tan hong")*. Every year in June or July small streams and channels come to life with the arrival of torrential rains, and many fish species migrate up them and enter inundated wetlands and rice paddy fields to spawn. Historically, the people of Khong did not obstruct fish migrating from the Mekong River into seasonally inundated areas, but in recent decades the use of basket traps *("lop" and "say")* and other fishing gears to block streams has increased. Because these fishing gears catch a large percentage of the fish trying to move into seasonal wetlands, a reduction in the recruitment of many fish species has been identified as a problem.

Villagers believe that when streams are not blocked at the beginning of the rainy season, there are more fish for catching at the end of rainy season when wetlands and rice fields begin to dry out and fish migrate back to the Mekong River. They also appreciate the convenience of being able to catch more fish when working in their rice fields. Although most villagers believe that channels should not be blocked when fish are migrating upstream, they approve of the setting of traps in small streams when fish are migrating out of wetlands at the end of rainy season. This is based on observations that more fish can escape from traps when they are moving downstream, compared to when they are moving upstream. Moreover, fish are not in spawning condition when they are caught at the end of the rainy season. At the end of the rainy season villagers believe that fish are big enough to harvest. It is crucial to recognise that most villagers consider early wet season stream blocking not to be a traditional activity.

Bans on 'water banging' fishing

Another regulation that is commonly adopted by villages in Khong relates to the use of 2.5 and 2.8 cm meshed mono-filament gillnets *("mong soi")* to catch small cyprinids in the dry season, including the ubiquitous species, *Henicorhynchus lobatus ("pa soi houa lem")*. In recent years some villagers have begun setting small-meshed gillnets in shallow waters and using various kinds of long poles with metal end pieces *("tho lek")* to bang the water and riverbed near the nets in order to chase fish into them.

The main reason many communities have banned this practice is because those who set small-meshed gillnets but do not bang the water are unfairly disadvantaged by the minority of people who bang the water. Villagers believe that banging the water scares fish away from the general area, resulting in smaller catches for everyone.

Bans on spear fishing with lights

The dry season use of single and triple pronged spears *("lem")* and powerful battery operated lights *("mo fai")* to locate and stab fish at night in the Mekong River is another heavily criticised fishing method in Khong District. However, those who use it can catch large amounts of fish. The use of spears and lights to catch fish was introduced in Khong in recent years, and there are various reasons why it is unpopular. To begin with, only a very small percentage of villagers use the method, and older people almost never fish in this way. Secondly, some people believe the method is too effective in catching large fish that move into shallow waters during the night. Villagers believe the problem is especially significant for species that spawn in the dry season, such as *Chitala blanci ("pa tong kai")* and *Channa marulius ("pa kouan").*

Probably the most important reason villagers oppose this fishing method is that those who engage in the fishery are often responsible for stealing chickens, ducks, live fish tied under water, and fishing gears when they pass villages at night. The desire to not have outsiders passing through their villages at night has motivated many communities to ban this method. Villagers in Khong do not seem to have any objections to the daytime use of spears to stab fish hiding amongst submerged vegetation during the rainy season, which they consider to be a traditional activity. Moreover, subsistence oriented rainy season night fish stabbing with lights in rice fields is generally acceptable to villagers, providing that rice plants are not trampled on.

Juvenile fish conservation

Another popular regulation established by many villages relates to the management of snakehead fish *Channa striata ("pa kho")*. While few people catch and eat the juvenile snakeheads within the approximately two week period after they are born, some use fine-meshed scoop nets *("saving")* and wedge-shaped basket scoops *("sanang")* to catch them for food. Until many villages established regulations banning this practice, juvenile fish harvesting was apparently on the rise due to declines in other fisheries. Many villagers are now well aware that the harvesting of juvenile snakeheads is wasteful because whole schools are easily caught when they are very young. However, once juvenile snakeheads have dispersed and are no longer travelling in schools, villages are allowed to catch them using hooks and lines *("pet pak")*, castnets *("he")* and other fishing gears.

Frog conservation and sustainable management

Khong District has been traditionally blessed with abundant populations of amphibians, including various frog species *(Rana spp.)*. Up until just a few decades ago most people in Khong did not eat frogs *("kop")*, or if they did, it was only on rare occasions. This differs from many other parts of Laos where frogs have long been a staple food. Nevertheless, as fish stocks have declined and human populations have increased, more people in Khong have begun to make frogs a part of their diet. There is also increased demand for frogs in local and distant markets in Pakse and even Thailand. Frog populations have been depleted throughout many parts of mainland Southeast Asia, and some villagers who now live in Khong moved there from northeast Thailand decades ago, largely because fish and frogs populations were already depleted around their former villages decades ago.

Whereas frogs had little or no value in Khong only a decade ago, they are now bought by the kilogram, and market prices are relatively high (5,000 kip = US$ 0.60/kg wholesale in Khong). The price of medium-sized and large fish is still higher per kg than for frogs, but the gap appears to be narrowing. In north-east Thailand frogs are now more expensive per kg than most common fish species (*pers. comm.*, Ian Craig). Traders are willing to buy frogs regardless of size, which further encourages the harvesting of juveniles. Rising frog prices has certainly led to more harvesting. Moreover, the ability of villagers to harvest large quantities of frogs has significantly increased due to the introduction of new technologies, the most important being high-powered battery charged lights *("mo fai")*. Only a decade or so ago resin torches and charcoal lamps limited opportunities for finding frogs at night.

Some villagers favour allowing frog harvesting for subsistence food supply, and banning the selling of frogs year round. Others advocate regulating frog harvesting and allowing the selling of frogs during certain seasons. Generally, villagers believe that the most destructive time of the year to harvest frogs is during their spawning season, which is triggered by the first big rains of the monsoon season. Frogs generally spawn for about a week, and the amphibians are very vulnerable to capture because they leave their hiding holes and croak loudly. If they are caught before they are able to spawn, reproduction potential for the species is reduced. Therefore, harvesting is often banned during this period.

Frog harvesting is usually allowed during the middle and especially the end of the rainy season when frogs have already spawned and juveniles have had time to grow. Villagers generally favour frog catching at the end of the rainy season because at that time of year it is sometimes difficult to catch fish in the Mekong River, and it is easier for villagers to catch frogs from the rice fields after long hours of harvesting rice. Frogs are also said to be fatter and tastier at the end of the rainy season.

Many villages ban dry season night light frog catching along the edge of the Mekong River. During this season rice fields have dried up and most frogs have retreated to the banks of the river. Villagers believe that it is easy to over harvest frogs during the dry season. Furthermore, like night spear fishing for fish in the Mekong, the method is sometimes linked to thievery.

Many villages ban certain frog catching gears such as frog basket traps *("say kop")* and frog hooks and lines *("bet kop")*, because these gears are often used to intensively catch frogs. Some villagers also complain that rice plants are commonly damaged by *"bet kop"*. When a frog gets caught on a hook, it sometimes twists the line around clumps of rice stems, damaging the plants.

Some villages regulate frog catching by area, with varying restrictions according to designated harvesting zones. For example, the village of Ban Oupaxa bans frog harvesting for selling (only subsistence catching allowed) east of highway 13, but allows commercial harvesting on the west side of the road, where there are no agriculture areas.

Many villages have regulations regarding the harvesting of tadpoles *("houak")*. As with regulations banning the harvesting of juvenile *Channa striata* snakeheads, the logic behind this is that they are very vulnerable to over exploitation. Moreover, a large number of tadpoles need to be caught to provide enough food for a meal. However, if tadpoles are allowed to grow into frogs their end weight in harvested protein is likely to increase, even when considering natural mortality. Fortunately, most people in Khong do not eat tadpoles, finding them repulsive, unlike other parts of Laos. In areas where people commonly consume tadpoles, aquatic resources are generally less available, or population pressure is high. Different ethnic groups also have different preferences for tadpoles.

A few villages ban the digging of deep holes or pits used to attract amphibians at the end of the rainy season. These pits, called *"khoum khiat"* in Lao, are capable of concentrating large numbers of frogs *("khiat")* into confined zones when surrounding areas dry out. This makes the frogs very vulnerable to over harvesting. *"Khoum khiat"* are also unpopular because water buffaloes and cattle sometimes accidentally fall into them and die. They are therefore considered a menace to the community. One village has banned the harvesting of juvenile frogs for baiting longlines *("phiak")* due to the belief that too many were being harvested for that purpose. Apart from wanting to conserve frogs in order to have an easily accessible source of food and income in times of need, villagers commonly express their desire to have frogs in their rice fields to help regulate insect and crab populations. When there are no frogs, damage caused to crops by crabs and insect pests is believed to increase. Therefore, frog harvest zoning by villagers is often based on the particular objective of protecting frogs in rice paddy fields. The regulations adopted by different villages with regards to frog harvesting vary more than for any of the other aquatic resource in Khong.

Management of aquatic animal harvesting in rice paddy fields

Some villages regulate the harvesting of fish and frogs in rice paddy fields *("na")*. This is not only done to protect the animals, but also to reduce the damage done to rice plants by people who trample them while trying to harvest aquatic animals. Many villages specify that harvesters not be allowed to enter other villagers' rice paddy fields until they have received permission from the owners of the fields. The harvesting of frogs and fish in commons areas outside of family owned rice fields are generally not restricted. The harvesting of frogs and fish in paddy fields is also generally not restricted after rice harvesting.

Fishing in other village aquatic resource management areas

Villagers are generally allowed to fish in the resource management territories of other villages. In fact, most lowland Lao people believe that fishing areas should be open to all Lao people. However, most villagers believe that outsiders should be restricted to the scale and types of fishing activities that they are allowed to participate in when visiting other villages. Villagers living close by are seen to have more resource-use rights than those from far away. Kinship links and social status also influence how resource extraction by outsiders is viewed.

Visitors are supposed to follow the management regulations established by host villages. They are required to harvest aquatic animals in a manner that is in keeping with host village practices. They are also supposed to report their arrival and departure from the host village. Some villages do not allow outsiders to sleep on islands out of view of their village because visitors are often accused of stealing agricultural products cultivated on the islands. Therefore, visitors are sometimes asked to sleep in the host village or another place agreeable to the host community. Guests are generally not allowed to spend many days in host village areas if they are fishing for commercial purposes. It is common to allow guests to catch enough fish to fill two or three jars of fish paste *("pa dek")*, which is considered to be a subsistence right of all Lao people.

Pond management regulations

Villagers in Khong have long managed the harvesting of aquatic animals in natural depressions or ponds *("nong")*. Some *"nong"* occur in rice paddy fields and others are found in non-agricultural commons areas. The most common traditional practice related to the management of ponds is called *"pha nong"*. This tradition restricts aquatic animal harvesting in natural ponds at the beginning and middle of the rainy season. In most cases, harvesting is restricted until near the time when the pond is going to naturally dry out, which varies depending on the pond and year. Each year, the village headman, a village elder, or an individual owner or guardian of a particular pond announces a day, based on the lunar calendar, when everybody in the village, and sometimes people from neighbouring villages, are allowed to communally harvest fish from the area. *"Pha nong"* systems are often related to spirits and Animist rituals. For example, in Ban Hat Khi Khouay, elders responsible for Animist ceremonies in the community manage a large natural pond.

In some cases village leaders, elders and pond owners are given a share of other people's catches as a kind of resource rent. However, individual fishers are generally allowed to take home most of their catch. Following the designated day for harvesting, everybody is allowed to fish the pond until it dries out.

Nevertheless, there is significant variation in how *"pha nong"* is implemented in different villages in Laos. In some cases absolutely no harvesting is allowed before the designated day. In other cases limited harvesting is allowed. For example, putting hooks and lines *("pet pak")* along the outer perimeter of ponds is often permitted, provided that the centre of the pond is not disturbed. In some cases trap fishing and cast-netting are permitted around the perimeter as well.

The practice of *"pha nong"* has declined in Khong over the last few decades, and many villages have discontinued the practice altogether. In many cases ponds, which were previously managed under the common property *"pha nong"* system, are now managed by individual families or have become open-access areas. This is unfortunate, as the practice of *"pha nong"* can help build village solidarity, protect fish brood stock, and allow juvenile fish a few months to grow before they are harvested.

Despite the advantages of adopting the *"pha nong"* system, it is interesting that only a few villages in Khong have incorporated *"pha nong"* related regulations into their aquatic resource co-management plans. However, some villages, like Ban Done Chome, have designated particular ponds for year round or seasonal protection from harvesting, without referring to the term *"pha nong"*. Many villagers appear to feel that the practice of *"pha nong"* is old-fashioned or too closely linked to Animist practices to warrant reviving. It appears that after 1975 the Government discouraged the practice.

Sometimes ponds near Buddhist temples are protected by monks who encourage villagers to rescue fish from them and return them alive to the Mekong River before the ponds completely dry out at the end of the dry season. A good example of this practice exists at Ban Done Det Tavan Oke.

Despite the rich traditions of common property pond management in Khong, there is a general trend towards greater private ownership of ponds in which other villagers are never allowed to harvest aquatic animals. This is probably largely related to the trend in increased social and economic stratification, and associated changes in marketing and consumption patterns. It may also be associated with land and resource pressures.

One interesting example of how private ownership of ponds has intensified relates to villager interest in freshwater finfish aquaculture. In Ban Oupaxa one pond was actually fenced off to prevent other members of the community from using it after it had been stocked with non-indigenous fish fingerlings. The act of stocking a small water body with fish fingerlings apparently often results in strong private ownership of all aquatic resources in and around the pond. However, finfish aquaculture is still very rare in Khong, and there are no examples of sustainable aquaculture in the district.

Other restrictions with regard to fish harvesting also exist in relation to other pond uses. For example, many ponds cannot be fished during the early part of the rainy season because their "owners" have planted lotus flowers in them, and do not want anybody to disturb their crops before they are harvested. However, fishing is not restricted after the lotus seeds have been harvested.

Bans on explosives, chemical and electricity fishing

The government of Lao PDR has banned the use of explosives, chemicals and electricity for fishing since 1975. Although these methods are not used in Khong District, they are still commonly used in bordering parts of Cambodia (Casey, 1993; Baird, 1998a) and other parts of Laos (Baird, 1997; Baird, 1998b). Explosives fishing and insecticide poison fishing were common in Laos prior to 1975 (Fraser, 1974). Many Lao villagers are extremely critical of these fishing practices and believe that they have greatly contributed to declines in fish stocks. Therefore, a number of villages in Khong have reaffirmed their desire to ensure that these destructive methods are totally banned by including a clause in their management regulations reinforcing the government ban on their use.

Miscellaneous regulations

There have been various other regulations established in individual or small groups of villages in Khong. No two villages have ever adopted the exact same set of co-management regulations. The ability for the system to adapt regulations to meet specific circumstances is one of its greatest strengths. Examples of unique regulations adopted by villages in Khong include the limiting of bamboo shoot harvesting for sale in Ban Senhom; the creation of a seasonally protected man-made pond in Ban Khinak; the limiting of the number of gillnets that can be used per family per day in Ban Tha Kham; and the banning of flooded forest tree cutting on sand islands near Ban Done Det Tavan Tok. Many villagers have adopted regulations designed to protect riverine forests, which they recognise as being important aquatic habitat.

IMPLEMENTATION OF AQUATIC RESOURCE CO-MANAGEMENT SYSTEMS

Different villages in Khong District rely on different strategies for implementing their respective aquatic resource co-management systems. Considering the relative remoteness of many communities, and a long tradition of only limited central or regional government influence over village affairs in Laos (Ireson, 1996), variations between villages are not surprising. However, the overall framework under which all villages in Khong operate is basically the same. The methods used by individual villages depending largely on villager values and personalities, the ecological conditions near villages, and the views of village headmen and other community leaders. Factors related to the customary practices and the social norms of individual communities are important. Some villagers are accustomed to strict interpretations of regulations, while others have a more relaxed attitude to regulation enforcement. They tend to put more emphasis on raising the awareness of villagers. Local realities and pragmatism are important factors influencing the implementation of village aquatic resource co-management strategies.

It is generally up to the village headmen to organise regulation implementation. Most communities rely on a mixed strategy that includes enforcement of regulations and raising awareness. It appears that both factors are equally important. Villagers are generally critical of leaders whom they believe have not been stringent enough enforcing regulations. However, villages that enforce regulations effectively but fail to emphasise raising awareness tend to have problems maintaining systems over a long period of time. If villagers are not convinced that having regulations are beneficial, they are unlikely to abide by the regulations when enforcement becomes lax.

Yet regulation enforcement is generally only emphasised by villages at initial stages of implementation. The pattern in Khong has often been that a few warnings and fines are handed out in the first year of regulation implementation in order to let everybody know that the village is serious about implementing the regulations. By the second year much less regulation enforcement is required. By then locals are usually familiar with the regulations, and have come to clearly understand why they have been adopted. But villagers are still often effective enforcers of regulations when necessary. In Ban Kokpadek and Ban Chan, the villages' FCZ has so many fish in it that there is now a great deal of incentive for people to illegally fish there. It is possible to make large amounts of money by gillnetting in the area for just a short period of time. Therefore, both villages have organised patrols to watch over the FCZ during the dry season. In Kokpadek seven groups of four or five people have been organised by the village without any outside support. Each of the groups is responsible for watching over the FCZ for one day a week, resulting in 24 hr protection. In Ban Done Tholati villagers were smart enough to recognise that poachers might be setting gillnets and longlines in their FCZ without using floats, in order to avoid detection. Every few days an anchor is dragged through the FCZ (at mid-water level). Any unmarked fishing gears are snagged and confiscated. Other villages have also learnt from Ban Tholati and adopted similar methods. In Ban Tha Kham, villagers have tied clumps of twigs and thorns onto stone weights and set them at mid-water level in their FCZ to discourage poachers from fishing in the area.

Villagers are pragmatic people. They tend to feel more positive about co-management regulations if they begin to see positive results. Fortunately, villagers often report increases in fish stocks and catches outside of FCZs even after just a year of implementation, as well as positive results from other regulations. If regulations are not working, villagers tend to alter or abandon them. It is encouraging that the system is still dynamic and running strong after over five years. Many villages claim that they will continue implementing their co-management systems into the future, regardless of whether there is a project supporting their work or not. This is certainly a very positive sign, and indicates that the regulatory framework is likely to be sustainable over the long-term. Yet some villages probably continue to require support because they are still learning how to effectively implement their plans. However, many villages and sub-districts in Khong have developed inventive processes for addressing problems and resolving conflicts within and between villages. Regular community discussions about co-management have been identified as a key factor in reducing conflict and improving management conditions.

Punishment for regulation violators

In Khong District the system for punishing regulation violators requires that first time violators receive a warning at the sub-village level. Second time violators receive a warning at the village level and also must sign a document in which they agree not to break the regulations again. Third time violators are fined 5,000 kip and/or have their fishing gear confiscated. Fourth time violators are sent to the district so that legal charges can be laid against them.

There is, however, more to punishing violators than meets the eye. The Khong AFO recommends that the first person to violate a particular regulation be considered to be the only first time offender. The logic is that if every person is not fined until he or she has been caught violating a regulation three times, hundreds of individuals in a village could theoretically violate a regulation and only receive warnings, and by the time fines started being given out the resource would already be depleted.

Most villages have adopted the four-stage system, but village leaders tend to adapt the system to meet local conditions. For example, 5,000 kip was worth about US$ 7 in 1993 and 1994, but the value of the Lao kip has declined dramatically in recent years. Today 5,000 kip is worth just US$ 0.60. Therefore, many villages have raised their fines. For example, Ban Phiman Phon recently decided that fines of 5,000 kip should be increased to 50,000 kip. Other villages have done the same, and more adjustments are expected in the near future.

It is interesting that villagers often advocate heavier fines than headmen or district officials. It appears that most villagers feel strongly that those who violate regulations and damage the interests of the whole community should not be let off lightly. However, most village headmen are hesitant about issuing large fines or imposing heavy punishment. Handing out punishment as community work is an option that is sometimes utilised. Enforcing regulations is especially difficult for headmen when relatives are involved. In some cases deputy headmen have had to enforce regulations with regards to the relatives of chief headmen.

Apart from fines, most villages confiscate any aquatic animals illegally harvested by regulation violators. Although only small amounts of money are normally generated from collecting fines from violators, it is important that whatever is collected becomes the property of the whole community and is used for communal activities, agreed upon in village meetings in which all families are represented. However, it is often quite acceptable to communities for funds to be used to buy gasoline for those who are responsible for patrolling FCZs. Villager satisfaction is generally based on the communicative ability of the village headman.

In some cases, those responsible for catching violators are given a portion of the fine money collected as an incentive to help enforce regulations. Many villages have altered their co-management plans so that confiscated fishing gear is given to those who are responsible for catching offenders. While rewarding enforcement could potentially be abused, there have been no reports of problems in Khong so far. Instead, most villagers think the system works well.

Village leaders are almost always extremely reluctant to invoke the fourth stage of the punishment measures recommended by the government. Headmen generally do not want to send violators to the district as long as they are able to control the situation themselves, which is virtually always the case. Therefore, village headmen have always opted for continually repeating stage three of the punishments (fines and confiscation) rather than moving on to stage four. Nevertheless, stage four remains a final option for village leaders in case all other strategies fail. Village headmen generally have no qualms about using their discretion when deciding how to punish regulation violators. The severity of punishment generally depends on the will of individual village administrations and the overall opinion of the community.

Regulations are often enforced more leniently with regard to outsiders than they are when it comes to host villagers. It is generally assumed that residents are more aware of village regulations than outsiders, and therefore have less reason for breaking them. If villagers who violate regulations are from far away, they are initially assumed to be ignorant of the regulations of the host village. Therefore, they are generally let off lightly and warned at least once before being fined.

Village chiefs sometimes send word to outside violators' home villages when they break regulations. Maintaining good inter-village relations is important, because rivalries and bad feelings between villages can lead to conflicts and social problems damaging to communities. Experience in Khong has demonstrated that the punishment of outside violators creates less conflict when headmen from the home villages of the violators enforce the regulations. If the host village headman imposes a punishment, there is a risk that the punished outsiders, and others from their villages, will resent the host village enforcing the regulations. Village to village conflicts arising from the enforcement of co-management regulations are extremely undesirable in the Lao context, but this indigenous conflict resolution method seems to be efficient in reducing them.

Some villages virtually never resort to fining violators, but are glad to have that option available. Most would rather solve their problems through exerting social pressure on those who do not respect the will of the community. Fortunately, powerful social mechanisms act as strong disincentives to those who might be inclined to violate village regulations in Khong. Therefore, the overall use of fines as a primary deterrent is low.

MONITORING AND EVALUATION

Monitoring and evaluation are important aspects of any natural resource management programme. One of the roles of the LCFDPP and later the SWP has been to assist in monitoring and evaluating village aquatic resource co-management systems in Khong District. This includes assessing increases in aquatic animal stocks in cooperation with villages, and assessing whether regulations have been effectively, equitably and fairly enforced by villagers. Khong District officials also play an important role in monitoring and evaluation.

Informal monitoring

The LCFDPP and SWP have approached the monitoring and evaluation process for aquatic resource co-management systems from various directions. Informal monitoring has certainly been the most important tool utilised. This kind of monitoring has been effective because both projects have had community development components. Although some of the community development activities supported have been seemingly unrelated to aquatic resource management issues, their implementation has provided important opportunities for conducting monitoring activities in relation to aquatic resource management issues. Rural development activities have included community school and well construction, small-scale agricultural credit programmes, women's activities, sustainable agricultural training, and other social and economic capacity building activities. Since the same project officers who participate in aquatic resource management activities in villages are responsible for various aspects of other community development activities, they have many opportunities to informally monitor aquatic resource management activities when they visit the villages to work on different community development activities. Sometimes villagers approach them to discuss problems or successes related to co-management, and project officers often make inquiries about aquatic resource management issues when visiting villages for other reasons.

It must be recognised that all the Lao people working in the field for the SWP reside with their families in villages in Khong District with aquatic resource co-management regulations. Most were born in Khong and have a good understanding of local conditions and practices. The projects have relied on other informal sources for monitoring, such as information received from villagers, and from government officials in other offices. Creating good communicative relations with a large number of people is important.

Formal monitoring and evaluation

The LCFDPP and the SWP have also relied on formal monitoring and evaluation processes. For example, in July 1997 the LCFDPP invited two independent monitors to spend two weeks each in Khong District to evaluate the aquatic resource co-management programme there. The evaluators worked with project officials, district government officials and villagers from 21 randomly selected communities with government sanctioned aquatic resource co-management regulations. A wide range of people from each of the communities visited were randomly selected and interviewed by the evaluators.

This was followed up by discussions between the evaluators, project officials, and village leaders regarding community comments encountered by the evaluators. Village leaders were asked to self-evaluate their own co-management experience, and to consider ways in which lessons learnt could be used to improve management practices in the future. Village leaders reported that the exercise was useful in facilitating communities in self-evaluating themselves and finding ways of improve the implementation of aquatic co-management systems. Khong District government and the project also benefited from the evaluators' participation. The exercise provided project and local government officials with an opportunity to hear an external opinion regarding the village co-management programme.

As a result of the success of the first external evaluation conducted in July 1997, the SWP and Khong District decided that it would be useful to conduct a second round of evaluations with the remaining 38 villages with aquatic co-management regulations. This phase took place between September 1997 and March 1998. It was conducted entirely by project officials.

The second evaluation phase was successful in strengthening local co-management systems. It provided the project and local government with valuable information about the status of village co-management systems. Most village leaders reported that it would be ideal if the project conducted evaluations for each village at least twice a year. However, the project has encouraged village leaders to not rely on project officials too much for monitoring and evaluation. Villagers have been encouraged to initiate self-evaluation activities on their own. Project officers have had many discussions with the district regarding their role in monitoring and evaluation, and the need for local government to take an independent role in order to avoid over dependence on project support. District officials understand that they have the long-term responsibility for maintaining an effective monitoring system.

Monitoring by Government

The Khong District government has conducted it's own informal monitoring activities of co-management systems, and while little documentation of this monitoring is available, senior district officials often have up-to-date information on the status of aquatic resource co-management systems in villages. The government relies on the project for information, but also takes advantage of other sources of information from villages. Khong District also occasionally sends out notices to all the villages in Khong in order to inform, or re-inform, villagers regarding the importance of respecting village aquatic resource co-management regulations, especially those related to FCZs.

The district has made various resource management decisions based on information they have received through monitoring co-management activities. For example, Khong District was one of the first districts in Lao PDR to ban the export of frogs to markets outside of the district. The district made this decision without consulting the project. The decision was based on the attendance of district officials at meetings with villagers where frog depletion in Khong was discussed in detail. In many cases, this frog-export ban has helped to support village co-management regulations, since many villages had already banned frog selling prior to the district directive being issued.

Fish conservation zone monitoring

Another of the formal forms of monitoring and evaluation that the project has participated in relates to ecological and biological factors affecting the establishment and implementation of "Fish Conservation Zones" (FCZs). Studies have been conducted to look at the relationship between habitat protected by FCZs and the fish species that appear to be benefiting from FCZs. This process began when project officials and the external evaluators visited the 21 villages in Khong in July 1997. At that time they noticed that there were differences between villages with regards to the species of fish believed to have benefited as a direct result of the establishment of certain FCZs. Further investigations revealed that there is at least some association between the type of aquatic habitat protected by FCZs and the species of fish reported to have benefited by villagers. During the second phase of evaluating the remaining 38 villages, additional effort was put into collecting detailed information regarding the species of fish believed to be benefiting from individual FCZs, and the habitat contained in individual FCZs. Some of the previous 21 villages included in the first stage of the evaluation were revisited during the second phase so that a full set of data regarding all the FCZs in Khong could be compiled and statistically analysed. Villagers from the 59 communities surveyed reported that a total of between 53 and 61 fish species had benefited from FCZs. The species most commonly reported as having benefited from FCZs included *Morulius spp. ("pa phia"), Chitala blanci ("pa tong kai"), Chitala ornata ("pa tong khouay"), Micronema micronema ("pa nang"), Hemisilurus mekongensis ("pa nang deng"), Belodontichthys dinema ("pa khop"), Boesemania microlepis ("pa kouang"), Pangasius pleurotaenia ("pa gnone thong khom"), Hemibagrus wyckioides ("pa kheung"), Cosmochilus harmandi ("pa mak ban"), Pangasius conchophilus ("pa pho/pa ke")* and *Probarbus jullieni ("pa eun deng")* (Baird *et al.*, 1998b).

This data was validated between May and September, 1998, and resulted in some revisions to the original data, based on recommendations by villagers. More detailed data regarding the habitat contained in FCZs was also collected. Although this data validation process did not result in any major changes in the fish species villagers reported as benefiting from FCZs, or the types of habitat originally reported as occurring in FCZ areas, it did help to refine the data and clarify some previously reported inconsistencies.

After the fish species lists and FCZ habitat parameters had been revised, various tests were conducted on the data to determine the level of correlation between the occurrence of certain habitat types and the fish species that are likely to benefit if that type of habitat is protected. Although some significant correlations have been noted, the complex ecological and biological conditions of the Mekong River has made it quite difficult to isolate relationships between habitat and fish species believed by villagers to be benefiting from FCZs. The results of running a logistic model on the data have been marginal. However, most correlations, while weak, appear to be in the expected direction, based on the known biology of the species.

Village self-monitoring and evaluation

The SWP has also supported a pilot FCZ monitoring process in eight villages in Khong District, including Ban Done Tholati, Ban Done Xang, Ban Tha Phao, Ban Nang Khouat, Ban Done Houat, Ban Kokpadek, Ban Chan, and Ban Oupaxa. All of the villages have reasonably efficient systems for managing their FCZs, and have reported increased fish catches in areas surrounding their FCZs. The villages are also spread geographically throughout the district, making the group more representative of the whole district, except for inland villages away from the mainstream Mekong River, which were not represented in the exercise.

The SWP has worked with each of the eight villages to set up specific monitoring programmes appropriate for each community. The villagers, project and local government agreed that it would be useful to try to quantify the progress and success of the FCZs in the villages through collecting data regarding the fish species and quantities caught. A catch-per-unit-effort (CPUE) methodology was adopted. The goal of the research was multi-fold. The villagers wanted more data to validate the successes of their FCZs. Secondly, the project and district government wanted to get more data regarding FCZs for planning and evaluation purposes. Thirdly, it was recognised that provincial and central government agencies required some sort of quantitative data in order to confirm to them the value of the fish conservation work already implemented.

Since no quantitative data regarding fishing activities and fish catches was collected in any of the villages in Khong prior to the establishment of FCZs, the project realised that there was not enough quantitative data to back up villager claims that fish catches outside of FCZs had increased since the establishment of FCZs. However, it was felt that fish catch data from the present period could be collected and compared with pre-FCZ period anecdotal data. Moreover, it was recognised that data could be collected and compared with present catch data if the same methodology is used again at the same locations in the future. Finally, fish catch data could help indicate which fish species are the most important for the specific communities and habitats, and whether those species are likely to be ones that would benefit from FCZs. This data could indicate whether the fish species that have reportedly increased are actually being caught in large numbers.

The first stage of the exercise involved project officers sitting down with groups of experienced fishers in each of the communities in order to learn about which species villagers believed had benefited most from FCZs. After a list had been compiled, the villagers were asked to consider the following questions: What are the most important fish species to collect data about? What fishing gears should be used to catch the target fish species? What seasons would be the most suitable to collect data? For example, villagers from Ban Done Nang Khouat selected three groups of species. *Morulius spp. ("pa phia")* was selected by villagers as the most important species to monitor. It was decided that it would be best to collect data on the abundance of this species in the dry season using castnets. Another important species identified for monitoring was *Chitala blanci ("pa tong kai").* However, villagers felt that dry season castnetting was not a suitable method for monitoring the abundance of this species. Instead scoop netting in the rainy season was chosen for collecting data about this species. Finally, women in the village pointed out that *Pristolepis fasciata ("pa ka")* and other small species caught with hooks and lines near the shore had benefited from FCZs. Therefore hook and line catches were monitored.

Once village priorities for research had been identified, village leaders, and especially village headmen, recommended groups of five or six individuals from the village to collect fisheries data regarding each of the fisheries of interest. In some villages just one key fishery was researched. In other cases up to four or five were considered. The selection of village researchers was based on (1) the ability of the villager to skilfully use the fishing gear selected for monitoring, (2) the frequency of fishing by the villager, and (3) the level of interest and willingness of the individual to participate in the research.

The project then assisted the village researchers by providing them with training in data recording methods. Notebooks and pens were distributed to each of the village researchers, and they were taught to record individual fishing outings. Data recorded included: the date, the time period, the number of hours spent fishing, the gear used, the species caught, the number of individuals of each species caught, and the weight of the catch by species. The researchers were left to fish as they normally would, and data was recorded on a daily basis. This activity started at Ban Tha Phao and Ban Nang Khouat in mid-1997, and expanded to the other six villages in January 1998. The first phase of the work was completed by June 1998. During the data collecting period village leaders and project officers occasionally visited the data collectors, helping to clarify issues regarding data recording methods when there was confusion. In some cases, such as with women hook and line fishers from Ban Done Nang Khouat, the children and grandchildren of the data collectors actually recorded the data for the researchers since most of the women using hook and lines are illiterate. However, most of the researchers were men who had at least basic literacy skills and were able to record their own data.

Once the data had been collected, the project organised meetings in each of the eight villages so that the data could be reviewed before being formally compiled. All village researchers and headmen attended these meetings. Project officers reviewed each of the researchers' data sets, and tried to resolve problems related to incomplete or unclear data with individual fishers. While some methodological problems did emerge, most of the data was well collected and easy to compile. Since villagers are generally very familiar with fish species in the Mekong, identification was not a problem, although some species lumping was done at the genus level. Weights of individual fish were sometimes quite accurate, especially when they were weighed on scales before being sold to traders, but in many cases villagers had to estimate weights. Nevertheless, fishers are generally skilful at estimating fish weights because they often catch and sell fish by weight.

Once the raw data had been reviewed at the village level, the project transferred the logbook data onto spreadsheets to facilitate analysis. The project provided each informant with a mosquito net and blanket, as a token of appreciation for large amount of time the villagers had devoted to the work.

During the next stage, the villagers were presented with the compiled and summarised results for analysis. For example, on 16 March 1999 data collected by six castnet fishers from Ban Done Houat between 18 January 1998 and 30 June 1998 was reviewed at a village meeting. The fishers had recorded data regarding a total of 468 fishing trips and 1,073 hours of fishing. Most fishing took place during the daytime using 4-10 cm meshed castnets. A total of 1,688 kg of fish were caught, representing an average of 1.58 kg of fish per hour of castnetting. A total of 36 nominal species of fish (possibly up to 40 scientific species) were recorded in catches. *Morulius spp. ("pa phia")*, the most often reported beneficiary of FCZs in Khong District (Baird *et al.* 1998b), made up 67.8% of the total catch by weight. *Chitala blanci ("pa tong kai")*, another very commonly reported beneficiary of FCZs (Baird *et al.,* 1998b), was the second most abundant species in catches at 4.3%. Many other species commonly reported to be beneficiaries of FCZs were found to be prominent in catches. It is highly significant that nine of the ten most important species recorded in fish catches are believed by villagers to be either basically sedentary or only slightly or moderately migratory. This data has helped to support the claim by villagers that many of the species they rely on are not strongly migratory, and therefore have the potential to be beneficiaries of FCZs. Moreover, it has helped to show that in the case of Ban Done Houat the sedentary and slightly migratory species that are the most likely to benefit from FCZs are in fact the most abundant species in castnet catches in the Ban Done Houat area. However, the situation in Khong varies from village to village, and some communities rely more on migratory fishes than others. In any case, villagers from Ban Done Houat plan to conduct the same research again in the year 2000 so that they can compare the data they have collected already with new data.

The data collection and monitoring exercise has proven to be very useful in raising awareness amongst villagers regarding the importance of FCZs. In many ways the exercise has strengthened the ability of villagers to analyse fisheries management issues, and make appropriate management decisions. It has helped strengthen TEK. It has also provided the project and government agencies with useful quantitative data. It has an important role to play in helping to develop the capacity of villagers to sustainably manage fisheries in cooperation with government. Monitoring needs to be based on local conditions, and directed towards answering specific questions of local interest. Moreover, research needs to be done in the context of adaptive management. This is the kind of action research that really interests villagers and government officials. It is not advisable to simply conduct a lot of research without indicating the practical value of data collected.

PROMOTING THE CONSERVATION AND SUSTAINABLE USE OF NATURAL RESOURCES

It is useful if natural resource co-management programmes are complimented by non-formal education activities at the village and the local government levels. The LCFDPP and the SWP have supported a number of environment-oriented awareness raising activities over the years. A number of calendars, posters, cartoon books, handbooks, brochures and videos promoting the conservation and sustainable use of natural resources have been produced and distributed in Khong. The projects have worked closely with teachers and students to support various environmentally oriented education activities (see Baird *et al.*, 1997). The importance of these activities in terms of strengthening co-management systems should not be underestimated.

DISCUSSION

The ability of villagers to effectively use and adapt TEK has been one of the main reasons communities in Khong have been relatively successful in managing aquatic resources (Cunningham, 1998a and 1998b). Because TEK is a dynamic rather than a static system, villagers are able to integrate new information with already existing TEK to improve their capacity for managing resources.

It is interesting that community-based management strategies for tropical riverine fisheries tend to differ fundamentally from approaches adopted by their respective governments. While community initiated fisheries management in the Mekong River in southern Laos and northeast Cambodia, and the Amazon River in Brazil, emphasise restricting fishing effort during the low water season, when fish are most concentrated and vulnerable, government legislation in Brazil, Laos and Cambodia focuses on implementing seasonal closures during the spawning season, despite the natural protection afforded to fish by flooding (Isaac and Ruffino, 1998; van Zalinge *et al.*, 1998; Baird *et al.*, 1999).

The willingness and ability of villagers to adjust resource management strategies to meet local conditions has been another critical reason why the aquatic resource co-management programme in Khong has been a success in the eyes of villagers. Having the freedom and ability to be flexible with regards to management approaches is one of the main advantages of decentralised natural resource management systems. It encourages dynamic adaptive management and keeps regulations relevant.

Certainly, experiences in Khong have shown that it is at least as critical to understand kinship, religious, linguistic, social, economic, political and cultural factors that affect natural resource management practices than it is to understand ecological processes. Villagers generally have an integrated and holistic way of viewing nature, and therefore have a lot of natural potential to come up with good management ideas, provided they are given the support and encouragement they need. Social indicators from Khong are strong. Outside cultural influences have been relatively few, and the people of Khong almost all have the same first language. Most people consider themselves to be Buddhists, and kinship links in communities are often extensive and complicated. Khong also has relatively few problems related to community rifts arising from vast differences in occupation, class and wealth. Finally, almost the whole population of Khong comes from the same ethnic group. All the above factors certainly help to explain why co-management systems in Khong have largely been successful. However, relationships between communities in other parts of Laos are likely to be more complex and therefore require more consideration.

Interestingly, there appears to be an association between those villages that have well implemented aquatic resource management systems, and those that are relatively remote, and have a high level of community spirit and solidarity. It appears that activities and conditions that increase solidarity at the village level also indirectly benefit community-based natural resource management. When solidarity increases as a result of co-management, there are many spin-off benefits in terms of community development. These benefits are clear to the Khong District government. That is why the local government in Khong views co-management as being an integrated part of their "community development" strategy.

Another important factor linked to the success of the co-management system in Khong relates to the emphasis that has been put on developing close working relationships with district authorities. While it is true that central and provincial agencies have more authority over broad policy issues, daily management is basically the responsibility of district governments. Without their support, recognition at higher levels of government is unlikely to result in the successful implementation of management strategies. This is not to say that provincial and central government agencies do not have important roles to play, but their limitations need to be recognised.

Many natural resource managers have used the “tragedy of the commons” (Hardin, 1968), “the prisoner’s dilemma” (Dawes, 1973) and “the free rider” (Olson, 1965) models to justify centralised natural resource management structures (Ostrom, 1990). Natural resource management theory based on the assumption that individuals do not generally act for the good of the whole have resulted in a perceived need for impartial agents of authority with national or collective, rather than personal or local interests at heart. Unfortunately, these conclusions have often resulted in an underestimation of the capacity of local bodies to sustainably manage natural resources, especially at the village level. At the same time, the capacity of central authorities to effectively manage resources has generally been overestimated. In many cases the result has been the creation of costly and ineffective bureaucracies. Often the increased role of centralised authority in managing resources has resulted in the traditional local management authority losing influence over management decisions related to resources (Kuperan and Abdullah, 1994). It is now generally recognised that centralised management systems for natural resources, including fisheries, have failed more often than they have succeeded, and the three models above have come under heavy criticism (Ostrom, 1990; Kuperan and Abdullah, 1994; Jentoft *et al.*, 1998).

The central authority in Laos responsible for wild-capture fisheries management has historically been very weak or even non-existent in remote areas like Khong. This factor has certainly contributed to the relative ease in which fisheries co-management has been accepted in the district. In the eyes of local authorities, there was not really any competing centralised fisheries management system to obstruct the establishment of a co-management system, and therefore there was not much to lose by abandoning ideas of centralised management. Co-management is also attractive because it is much less costly to the state (Cunningham, 1998a and 1998b). This is important since Khong District generates almost no revenue from fisheries, except for licensing fees from traders. Khong considers fisheries to be a fundamentally important commons resource that all Lao people should have access to for subsistence purposes.

Another fundamentally important problem with "the tragedy of the commons", "the prisoner's dilemma" and the "free rider" models is that they all fail to consider institutional arrangements in terms of the "imbeddedness" perspective. Humans are not fully “rational” beings. Instead, human behaviour is embedded in social relations. People do not only make decisions with individual gain in mind, and even when they do, the perception of gain is defined by cultural and social forces rather than simply individual benefits. The role of people in social groups, communities and organisations fundamentally influences the decisions of individuals. Individuals often conceptualise choices that result in "we" decisions being taken rather than "I" decisions (Jentoft *et al.,* 1998). As is generally the case in Khong, individuals often identify themselves as an inseparable part of a community, which is symbolised by the village institution. Most villages in Khong have been established for a long time, and most people were either born in the villages they live in or have moved into them from nearby villages as a result of marriage. Therefore, most people consider village problems to be problems for themselves as individuals. As long as the feeling of community remains strong, collective decisions are likely to dominate.

CONCLUSIONS

In recent history Khong District has been faced with dramatic changes in fishing and fish marketing practices. Initially this has involved apparent declines in fish and frog stocks that were thought to be due to over harvesting and destructive resource-use patterns. However, experience in Khong has illustrated that common property regimes do not always break down when faced with crisis. People in Khong recognised that collective organisation was necessary to address increasingly important issues regarding the management of natural resources. They responded by strengthening their management systems to ensure that aquatic resources were managed more sustainably

The aquatic resource co-management programme in Khong has been successful in improving management strategies and practices related to aquatic animal harvesting. The main successes, as viewed by Khong District and villagers, have been (1) increased village solidarity, (2) increased natural resource management capacity at the government and village levels, and (3) observed and/or perceived increases in fish and frog stocks and catches.

Yet it is much less clear how useful the lessons from Khong are in terms of managing aquatic resources in other parts of Laos and the region. Certainly social conditions in Khong are quite amenable to supporting successful fisheries co-management. What about other parts of Laos where the history of community change has been more tumultuous and unstable, and where social, religious, kinship, ethnic and linguistic conditions are less homogenous? Certainly not all of the lessons from Khong are applicable to other parts of Laos or other countries in the region, but recent experiences in Khong at least indicate that co-management may be a viable option for at least some other parts of the country, and other countries in the Mekong River basin.

Provided that co-management systems remain flexible and can adapt to social and institutional circumstances unique to particular areas, they represent an important option for improving the management and equitable distribution of natural resources. Natural resource co-management systems that allow for the full participation of villagers and government should receive increased attention and support. The process of developing appropriate aquatic resource co-management systems in Lao PDR is off to a strong start, but is still evolving and much more work remains to be done.

Chapter 9

A visual-acoustic survey of the Irrawaddy dolphins (*Orcaella brevirostris*) at Siphandone wetlands

Junio Fabrizio Borsani

A number of Irrawaddy dolphins (*Orcaella brevirostris*, Gray 1866) are known to inhabit the lower Mekong River system. The natural upstream limit to their range is represented by the Khone Falls (Baird, et al., 1994a,1994b, 1997), a large complex of rapids and waterfalls which obstructs the navigation as well as the movements of cetaceans further upstream. The Khone Falls system is located in the wider area called Siphandone Wetlands, while the study site is located at a deep river pool called Boong Pa Gooang (13°56’ N, 105°56’E) - which literally means “the small-scale croaker site” - in front of the villages of Hang Khone and Hang Sadam and found immediately N of the border with Cambodia.

The presence of this small population of Irrawaddy dolphins represents a remarkable biodiversity value of the wetlands and should be considered as of major management and conservation concern. The dolphins also represent an important resource towards the development of an ecotourism industry, already established at a small scale by the villagers of Hang Khone and Hang Sadam. World-wide the whale-and dolphin-watching industry has by far overgrown the whaling industry (Hoyt, 1995) and set the basis for a modern economic understanding of sustainable use of cetaceans intended as a resource.

As part of the Siphandone Wetlands Project, CESVI invited the author to conduct a combined visual-acoustic survey of the population of Irrawaddy dolphins of the lower Siphandone Wetlands. This paper presents a summary of the study undertaken, whose detailed results were presented in a technical report (Borsani, 1999). This paper presents: background information on the Irrawaddy dolphin; objectives and methods of the survey; discussion of the results and suggestions for future action on conservation and management aspects; a brief case history on the Small-scale Croaker and the undertaken investigation on the vocalisations of this fish.

SCIENTIFIC-HISTORICAL BACKGROUND

Little is known about Irrawaddy dolphins in the wild. The species is listed as insufficiently known by the World Conservation Union (IUCN). To-date very little research has been conducted on the species (Perrin, et al.,1995) These dolphins are known from a few riverine and estuarine areas in tropical and subtropical locations from the Indo-West Pacific Region, between about 25° latitude North and South.

Wild animals are secretive and occur in comparably small groups (5-15 animals). Nothing is known about their social organisation, although it is most likely that groups that have colonised certain restricted areas form, at least functionally, family units. Irrawaddy dolphins seem to feed (Lloze 1993,unpublished thesis) on fishes and shrimp in the non-tidal regions of the Mekong River. It is reported there that dolphins also feed on fish eggs and fry. *Orcaella* appears thus to be a generalist feeder, taking food from the bottom and from within the water column.

The population of the area of Khone Falls has attracted attention a) because of its unique location so far upstream (approximately 700 km away from the sea), where some other tributaries of the lower Mekong (Sedon and Sekong Rivers, Baird, pers. comm.) carry occasionally individuals, and, b) because of its potentially important role in the economy of the bordering villages. Controlled and attentive eco-tourism activities are carried out to date by the villagers of Ban Hang Khone and Ban Hang Sadam; the overall income generated by the tourists that come to watch the dolphins is not negligible. CESVI has suggested that an accurate counting of the animals and a thorough assessment of problems and potential solutions to these be made with state-of-the-art research methods. This study, the first of its kind in Southeast Asia, combines visual and underwater acoustic techniques to assess both dolphin abundance and the acoustic environment within the study area.

OBJECTIVES OF THE STUDY

The study had the following objectives:

1. To provide accurate numerical estimates on the abundance of Irrawaddy dolphins in the area by means of state-of-the-art underwater acoustic research techniques.

2. To disseminate knowledge on cetacean acoustic field study techniques, instrumentation and literature among Lao staff of the Siphandone Wetlands project.

3. To evaluate the environmental acoustics conditions of the area, assess the quality of underwater acoustic components of anthropic origin and define potential mitigation actions.

4. To discuss the impact of other human activities within the area and evaluate their potential impact on the dolphin population.

METHODS AND ACTIVITIES

The study was carried out between 29 March and 8 April 1998. At this time the river water discharge is minimum and the dolphins are localised in the deep water pool. Two daily surveys of 2-3 hours each were conducted, one in the early morning hours and the second in the mid-afternoon hours, respectively. Tracks were logged by with help of a Garmin 45 GPS (Global Positioning Satellite) data-logger. While approaching the dolphin pool the water surface was scanned visually and a first location upstream near a surfacing rock was chosen where the engine would be stopped and underwater listening begun. The position and heading of the boat were recorded continuously so that the orientation of the array could be back-calculated and the locations of the dolphins (and the croaking fishes) mapped for each survey throughout its duration. The hydrophone array consisted of two HTI-94-SSQ hydrophones (frequency range: 2Hz-30 kHz at -168 dB re 1V/μPa) hung 1.5 deep into the water with a spacing of 2 m, made constant by use of a bamboo-pole cut exactly to provide this array-aperture. The hydrophones were connected to a Casio DA-P7 r-DAT (Digital Audio Tape) recorder set at a sampling rate of 48 kHz, (providing an effective frequency range 7-22KHz). The instrumentation was powered upon Pb-gel cells that were recharged in the evening with clean photovoltaic power provided by a Solarex Lite 10W photovoltaic panel.

By measuring time-of-arrival differences of the sounds at the hydrophones and accounting for the left-right bias (in this case a bow-aft bias), locations for the sound-sources were computed and hyperbolic localisation probability curves were calculated. These counts never provided more than 4 animals at a time. By combining visual observations with numerical acoustic counts from some 8 hours of recording a maximum estimate of 10 different animals present in the area was computed. More likely, however the actual number of animals present is lower.

A GIS (Geographical Information System) database was created with the collected data and sightings combined with acoustic detection were plotted each for the morning surveys and for the afternoon surveys respectively. Sightings occurred more often in the afternoon than in the morning and tended increasingly to occur downstream of Ban Hang Sadam in the later afternoon hours.

A staff from the Department of Forestry, Wetland Management Unit, was introduced to basic underwater acoustics and the basics of instrumentation handling and care. Instruments and their functioning and role were explained first on land and successively on the water with hands on demonstrations. The technical problems arising with the use of electronics on the water were considered into some detail and their correlation the quality of data obtained was demonstrated. Successively the attention was drawn to negative details (i.e. ground-loops, low power, nearness to magnetic sources) the prevention of whose is of primary importance for obtaining good quality recordings.

The importance of silence during data collection was emphasised and some of the known dolphin behaviour and animals' interactions with both fish and human activities were explained and demonstrated. The role of several sound sources, such as crustaceans, fishes, seismic activities and human activities were described into detail.

Sound of the Irrawaddy dolphin (*Orcaella brevirostris*, Gray 1866)

Kamminga *et al.*(1983) reported on the vocalisations of captive Irrawaddy dolphins that had been caught in the Makalam River of East Kalimantan. These animals emitted clicks of about 2-3 ms duration with a dominant frequency centred at 60 kHz with small deviations. The repetition rate of the pulse trains was almost constantly varying between 40-60 Hz. No whistles were heard in audible range.

I recorded a small number of sounds each time dolphins were near the hydrophones. Generally, it must be said that the dolphins were not highly vocal. It seems that the quiet and smooth river environment stimulates passive listening for prey and that swimming across the river needs limited or no navigating at all. Sounds recorded included single clicks, pulse trains with both rising as well as decreasing repetition rates. Modulated whistles were discovered and are briefly described (data presented in Borsani, 1999).

Whistles were usually modulated responding to the rise-fall-rise pattern. The initial frequency was usually around 3 kHz and the final one up to 8 kHz. All of the whistles recorded matched this scheme. This suggests that these whistles are signatures from individual dolphins and that the dolphins recorded belonged to a parental line. The low number of whistles encountered suggests a low social diversification and probably accounts for the limitations in reproductive access to other dolphins this remote population is subject to.

Sounds of the small-scale Croaker (*Boesemania microlepis,* Bleeker 1858-59)

With the mentioned equipment additional sounds produced by the scieaenid fish called the Small-scale Croaker (local name: Pa Gooang) *(Boesemania microlepis*, Bleeker 1858-59) were recorded during the survey. According to literature, this is the first study of the vocalisation of this species. Throughout the globe sciaenids are known for vocalising during their reproductive season. The small-scale Croaker is caught in the area in spawning conditions from beginning of February to the end of March (Roberts, *et al.*,1995). The sounds recorded were produced almost invariably during the mid to late afternoon hours, they were loud fast series of pulses that sound like the horn of a truck and are produced by the swimbladder. The sounds range up to approximately 6 kHz in frequency, with the main energy located at 0.5 kHz, and last up to 100 ms (Borsani, 1999). They are repeated for bouts several minutes long at a time. The sounds can be easily used to locate the fishes even from above the water surface.

It is relevant to mention that I observed a group of two dolphins closing in to a rock where a distinctive fish call was originating, and that after the dolphins suddenly dove near the rock and some splashing went on at the surface, no fish sounds coming from that direction could be heard any more. It is suggested that dolphins can use the fish sounds for locating the fishes passively and for capturing them. In addition the fish sounds can be used for estimating abundance of spawning pairs and calculating the resulting biomass. This could provide an invaluable tool while attempting this to prevent this species from being overfished, given that it is thought to have dramatically declined in recent years (Roberts, *et al.,*1995).

DISCUSSION

The conservation status of these dolphins world-wide is insufficiently known (Reeves, *et al.,*1994), while this local population is subject to intense anthropogenic pressure through fisheries practices. The assessment of the range and bearing of vocalisations and of the occurrence of sightings from other locations suggests a minimum abundance estimate of eight animals, a maximum estimate of ten and a best estimate of nine animals. Stacey (1996) reviews records of dolphin presence and abundance in Lao PDR and concludes that at least 17 animals were present in the study area at Hang Khone in May 1993. A nearly 50% population decrease in five years raises serious concern about the residual viability of this local population. It is suggested that immediate action be undertaken to preserve the remaining dolphins in the area.

The concurrent presence of spawning fish-aggregations, as emphasised by the dense number of sounds heard by the Small-scale Croaker, suggests that this area is particularly worth preserving, and that preservation could be eventually achieved by determining areas where fishing is banned (and where dolphins can find shelter from nets) during the spawning time, that is the time where the fishes are heard “singing”. It is clear that where harvest occurs in the presence of spawning aggregations there is going to be low offspring production, hence no future presence of the species in that area.

Suggestions for future action

It is strongly recommended that action is undertaken in order to a) stop blast-fishing on the Cambodian side of the river and, b) partially modify the make of fishing gear (in particular that of gill-nets) traditionally used by local fishermen.

Fishing practices that use several types of explosives are common on the Cambodian side of the dolphin pool, and have been described in some detail by Robert (1993). It is suggested that dolphins would strongly benefit blast-fishing to be discontinued, since explosions are a major cause of disorientation and physical damage to cetaceans (Ketten, 1995). A replacement for explosives as a fishing tool has to be encouraged bilaterally by the Lao and Cambodian Governments.

Several types of gill-nets are used in the area and most of them are made nowadays of nylon (Robert, *et.*,1995). Their variable mesh size, the fact that nylon is acoustically translucent and remains therefore undetected by the Irrawaddy dolphins' biosonar, and their intensive use in the area make them to a potentially the most dangerous obstacle for dolphins to swim around. Gill-nets are reportedly the major cause for entanglements and the thereof resulting drowning of several animals during the past 5 years (Baird, *et al.*,1997). It is suggested that a) involved fishermen be encouraged (through an *ad hoc* educational campaign) to attach preventively small objects that reflect sound to their nets, similar to those described in Goodson *et al.*,(1994) with the aim of reducing entanglement in nets; and, b) that regulations be implemented that ease a more sustainable fishing policy by reducing the number of nets set all across the dolphin area.

Reducing the number of nets allowed across the area would first benefit the fishermen by preventing overexploitation of the resource (fish) and, secondly, allow, both the fishing grounds to recover and the dolphins to survive by having to face a lower anthropic pressure.

Chapter 10

Avian fauna of Done Khone

Peter D. Cunningham

This paper presents a record of bird observations over a period of one year (January-December 1997) at the Siphandone wetlands Project field station in Done Khone. Over 150 species of bird were recorded, including a number of regionally threatened species. The long term viability of Khone Island avian fauna depends on the sustainable management of local habitats and the control of human pressure.

Khone Island (Done Khone) is one of several islands which straddle the line of the Great Waterfalls ('Khone' or 'Lee Pee' Falls) of the Mekong River in the southernmost sector of Siphandone (Appendix 1). Khone Island is 4km in length and about 6 km^2 in area. The villages of Khone Tai and Khone Neua are located in the northern part of the island and the village of Ban Hang Khone is located on its southern cost, facing Cambodia. The population of the island is about 1,300. Given the relative scarcity of arable land in this island, compared to other islands of Siphandone, the inhabitants of Done Khone rely to a larger extent on fishing and collection of natural products for their subsistence.

The island is at the centre of a region including remarkable wildlife resources. Recent wildlife reports from the nearby Houay Kaliang area of the Xe Pian National Biodiversity Conservation Area (NBCA) in eastern Khong district have included sightings of Giant Ibis *Pseudibis gigantea*, Green Peafowl *Pavo muticus*, and villagers' reports of Kouprey *Bos sauveli* (Baird, 1997; Timmins *et al*., 1993; Evans, 1996; Xe Pian NBCA officials, 1997). To the west of the Mekong in Mounlapamok district, reports of nesting birds such as Black-necked Storks *Ephippiorhynchus asiaticus*, Adjutants *Leptoptilos* spp., Giant Ibis *Pseudibis gigantea*, and Saurus Crane *Grus antigone*, have led to recommendations that the Dong Khanthung area should also be declared NBCA (Timmins and Vongkhamheng, 1996; Wolstencroft 1997). To the south, part of a large stretch of the Mekong River between the Cambodian border and Stung Treng has recently been proposed for RAMSAR status partly in recognition of the high diversity of bird species which live within the area (Ministry of Environment, Govt. of Cambodia, 1997). 'As the crow flies', Done Khone is within 50 km of all of these areas.

Khone island includes a range of habitats, from paddy field systems near the main villages in the north of the island, to tall secondary, semi-evergreen forest along some of the seasonal river channels in the south. Of special interest are the various wetland habitats which surround the island. River-scapes include many waterfalls, rocky channels, sandy river banks, muddy backwaters, and many seasonal islands. Mekong River run-off varies from a maximum of about 30 - 50,000 cumecs at the height of the flood season (August - September) to only 1 - 1,500 cumecs during the months of March and April (MRC, 1996). The associated vertical change in river level from August to March at Ban Hang Khone is of around 10 m.

Khone Falls are a major obstacle to fish migrating upstream. Only a few of the many channels over the line of waterfalls are passable to fish during the months of December - March when the largest shoals arrive. As fish struggle to find a way over the falls, many are knocked against rocks, or swept, exhausted, back downstream. This bottle-neck effect of the falls upon fish migrations has provided outstanding fishing opportunities for both man and wildlife over countless generations. The area is the scene of some of the world's most spectacular river fisheries (Chapter 6). However, following a period of fighting and political unrest in the 1970's, human activities are once again encroaching into areas where for many years wildlife and wild habitats have remained relatively undisturbed. In many local villages, population pressure has reached the point where traditional fisheries and rice farming systems are no longer sufficient to provide for even the most basic needs of some families. Local villagers say that much wildlife has disappeared over the last few decades and that many of the larger waterbirds are no longer seen in areas where they used to be common.

METHODS

Most species accounts are based on records from SWP Field Station at Ban Hang Khone (BHK). At least one bird survey walk was made each month of the year. Walks usually began at 06:00 hrs on Sunday mornings, and lasted between 3 and 6 hours. The author was the principal observer, equipped with 8 x 30 Russian binoculars and "Lekagul and Round, 1991". Other observers included Bounpheng Phylavanh and Ian Baird (both staff of SWP). Other records were submitted by ornithologist Peter Davidson (PD) following his visit to the area in May 1997. Attention tended to be focused on river side habitats, particularly around the seasonal island of Done Eeheu (south-west of Done Khone). Various small forest dwelling birds were probably under-recorded, or over-looked. Other information was gathered on visits to neighbouring parts of the project area, whilst undertaking other project related work, from conversations with local people who possess a great deal of historical knowledge of bird populations in the area.

SPECIES ACCOUNTS

The full list of species recorded on or from Done Khone, or seen or reported from nearby areas, is presented in Appendix 4. The list includes 187 species.

Of special interest were observations of various regionally threatened water birds (Adjutants, Woolly-necked Stork, River Tern, Oriental Darter, Greater Thick-knee), Grey-headed Fish-Eagle and three species of vulture (Red-headed Vulture, White-rumped Vulture and Long-billed Vulture). Table 13 lists the species of major conservation interest. Additional details on observations of species of particular interest were included in Cunningham, 1998.

BIRD HABITATS AND HUMAN IMPACTS

Bird habitats in and around Khone island

Waterfalls, Rapids and Rocky Channels

These areas provide some of the best fishing opportunities for both man and wildlife. Traditional fence filter fish traps (Claridge *et al.*, 1997) were constructed in every major channel around the island. The numbers of fish traps which operate mainly between January and July may have increased over the last ten years (Roberts, 1993). During the '*pa soi*' migration (January to March) fishing parties usually arrived at the trap site at dawn and left at dusk. From April to end July, many fish (especially catfish species) migrate nocturnally, and many fishermen camped out overnight. In less accessible areas, fishermen constructed temporary shelters and may live beside their traps for the duration of major fish migrations.

Table 14. Key bird species seen or reported from the Done Khone area in 1997

Species	*Threat category (*)*	*Local Occurrence in 1997*	*Local Status in 1997 (**)*
Oriental Darter	GNT	visitor (April - July)	Common
Little Cormorant	NHD	visitor (March - July)	Common
Grey Heron	RAR	visitor (Oct. - March)	uncommon
Purple Heron	RAR	market (October)	one record
Malayan Night-Heron	RAR	Uncertain	possibly heard only
Painted Stork	RAR ?	visitor (December)	one 1996 record
Woolly-necked Stork	RAR	visitor (all months)	uncommon
Greater Adjutant	GT	Visitor	rare
Lesser Adjutant	GT	Visitor	rare
Pelican sp.	RAR?	uncertain (not seen)	reported only
Giant Ibis	GT	uncertain (not seen)	reported only
White-shouldered Ibis	GT	uncertain (not seen)	reported only
Spot-billed Duck	NHD?	visitor (Nov. - July)	uncommon
Brahminy Kite	NHD	breeds locally	common
Grey-headed Fish Eagle	GNT	visitor (November)	one record
Red-headed Vulture	GT?	visitor (Jan.-Aug.)	uncommon
Long-billed Vulture	GNT	visitor (February)	one record
White-Rumped Vulture	GNT	visitor (all months)	rare
Peregrine Falcon	RAR?	poss. breeds locally	uncommon
River Lapwing	RAR	breeds locally	3 or 4 pairs
Small Pracintole	RAR	breeds locally	possibly >5 pairs
Great Thick-knee	RAR	breeds locally	uncommon
River Tern	GT	breeds locally	3 or 4 pairs
Green Imperial Pigeon	RAR	breeds locally	uncommon
Alexandrine Parakeet	RAR?	breeds locally	rare
Blossom-headed Parak.	RAR?	breeds locally	uncommon
Fish Owl sp.	NHD?	breeds locally	at least one pair
Pied Kingfisher	NHD	breeds locally	at least one pair
Wreathed Hornbill	RAR, LC1	visitor (Nov.-Dec.)	2 record
Black-head. Woodpecker.	RAR	breeds locally	at least one pair
Wire-tailed Swallow	RAR	prob. breeds locally	uncommon
Grey-faced Tit-Babbler	GNT	prob. breeds locally	reported by (PD)
Hill Myna	RAR, LC1	breeds locally	common

* <u>Threat category (following Timmins and Vongkhamheng, 1996):</u>
GT: Globally Threatened, GNT: Globally Near-Threatened (Collar et al.(1994))
RAR: Regionally at Risk (Treesucon and Round (1990)
NHD: National Historic Decline (Thewis et al 1996 or 97)

** <u>Status</u>:
common: usually seen; uncommon: seen on more than 5 occasions; rare: seen on less than 5 occasions

For these reasons, there were evidently few places or times where large waterbirds could descend to feed undisturbed when the fishing was at its best. Areas subject to less disturbance may have included the top of Hou Nokasoom and parts of the Somphamit waterfalls area. Storks were seen ascending from the former site on two occasions (January and February). A party of fishermen, camped out near the latter site, interviewed in August (each carrying a musket), talked of eating Pelican, adjutants and Painted Stork (though not necessarily all in 1997).

Seasonal (low water) wetland habitats

As water levels fall, large expanses of wetland habitat emerge around the island. Channels dry out leaving muddy puddles and cut-off pools which provide feeding opportunities for waders, large (storks) and small (sandpipers). Seasonal sandy or rocky islands emerge which provide securer nesting habitats for River Terns, River Lapwings, Small Pracintole and in past years, Great Thick-knee.

From February to April, many of the wetland areas around Khone Island were visited on an almost daily basis by villagers, often accompanied by dogs, foraging for shellfish (various snails mainly) and other edible matter. Several villagers reported finding nests with eggs. Traditional customs forbid the removal of eggs or young from nests. However, it appears that such customs are being strained by shortages of fish (relative to the numbers of human mouths to feed), and by new market opportunities. Nesting terns were also disturbed by buffalo grazing on the thick growths of filamentous algae. Villagers said that algal growths were thicker in 1997 than in previous years; this may be an indication of eutrophication relating to agricultural intensification (increasing use of N-P-K fertilisers for dry season rice crops) in upstream areas. Large-billed Crows frequented the area and may have taken unguarded eggs or young of terns or lapwings disturbed by human activities. Many smaller seasonal islands found around Khone island were also visited on a daily basis by fisher-people. Human activities included foraging for shell fish and filleting / sorting the fish catch. Explosives were detonated by a few Cambodian people in waters adjacent to many of these islands on an almost daily basis (January - April). Water levels rose for a brief period during early April, flooding many of the smaller islands. Several nests may have been submerged.

Seasonally flooded vegetation

A wide variety of seasonally flooded trees and shrubs grow around the island (see Chapter 4). At the height of the flood, the river is a vast, swiftly flowing, sediment-laden torrent, which carries downstream enormous quantities of floating debris: tree trunks, human garbage, etc. The force of this floating debris-laden flow is very great and determines the ‘cut off’ level of the mid-river tree tops. Below the waterfalls, trees of 8 metres in height are fully submerged during the flood season. Above the falls the seasonal change in river level is only of 4 or 5 m, and the mid-river trees tend to be cut off at shorter stature.

River-scapes are transformed as the water level drops and the trees, then the smaller bushes, emerge and burst into leaf in November and December. Many river plants also begin to flower, and small birds move in to feed on insects and other items. The water transparency increases from less than 10 cm (Secchi disk) in September, to in excess of 200 cm by March. Growth of river plants is prolific during much of the dry season.

As water levels begin to rise in April and May, many small fish move in to the freshly inundated areas. Kingfishers, cormorants, and Oriental Darters were seen feeding within areas of river trees. Many fishermen set gill nets in the same areas to target large schools of “*pa soi*” in the area. Nets were usually checked by fishermen during the early morning and late evening causing some disturbance of birds; though there were no reports of birds being targeted.

Some of the trees and bushes along the river banks are also fully submerged during the flood season, whilst others merely get their roots wet. These include various seed and fruit producing trees, including *Ficus* spp.. They provide feeding opportunities for hornbills, mynas, parakeets, pigeons, orioles, barbets, and bulbuls as well as various mainly insectivorous species.

Local people generally recognise the importance of river trees and bushes as habitats for fish, and also for the protection they give to river banks. However, bankside vegetation has been thinned considerably in several rocky areas surrounding fish trap sights (for trap construction materials and fuel wood to smoke - dry fish). Around many of the villages where banks tend to be of sediment (silts and sand), vegetation has been cleared and gardens were constructed for the cultivation of tobacco and various vegetables. (Around several of the islands where banks are steeply dipping, this practice is apparently accelerating rates of bankside erosion, as discussed in Chapters 3 and 5). An invasive, thorny, *Mimosa* species has colonised many parts of the riverbank, especially where the native flora has been disturbed.

Forests

Much of the southern part of Khone Island (south of the waterfalls 'line') is a 'mosaic' of various sorts of scrub and secondary forest. Deciduous trees are now dominant across most of the island, though in a few places, densities of evergreen species suggest that the natural forest cover may have once been of different composition (see Chapter 4). Vegetation varies according to local topography: the lower lying, damper areas tend to support thicker (greener) understorey growth than higher areas, where seasonal fires prevail.

The most common birds associated with woodland habitats include drongos, bulbuls, orioles (in the dry season) woodpeckers, and various small insectivorous birds. Here and there are large strangler fig trees *Ficus* sp. which fruit several times during the year. 'Bird waves' often congregate around fruiting trees to feed. However, there are few trees of suitable stature to provide nesting places for larger birds such as hornbills.

Forests are important foraging habitats for local people who posses a huge knowledge of the various edible (and poisonous), medicinal and timber tree species and other plants. Various fungi, plant parts (roots, stems, leaves, flowers, fruits and seeds) and various animals (insects, amphibians, reptiles, birds, bats, arboreal mammals, a few wild pigs) are taken and eaten. Villagers say that barking deer and monkeys were extirpated from the island within the past twenty years; gibbons (which were heard calling from the Cambodian forests across the river, now also subject to increasing levels of human encroachment) and 'tigers' were extirpated from the island somewhat earlier. Villagers say that large areas of the islands forests were cleared by the French Cambodian refugees during the 1970's. Most large trees of the better quality timber have been selectively removed for house or boat construction. Smaller trees are cut for firewood.

During the dry season of 1997, large areas of forest (possibly as much as 40 hectares) were slashed and burnt to clear areas for upland gardens. Wet season rice harvests in 1995 and 1996 were poor in the area, and rice shortages may have prompted this larger than usual clearance. Several local families moved from their villages to seasonal shelters beside their swidden gardens where they lived until their crops of rice and corn had been harvested. Many areas of secondary forest have recently been claimed / allocated to local people and several plantations of teak and kapok have been planted. Extensive areas of understorey vegetation were also burnt. This traditional practice probably dates back over hundreds of years in parts of Champassak province (Harmand 1879).

Scrub

Forests grade into scrub. Many such areas are former swidden gardens or poorer paddy fields which have been abandoned. The most extensive thickets of bamboo and thorn tree scrub form a belt of country running east-west across the middle of the island, separating more forested areas to the south from the main areas of paddy fields (above the level of the water falls) to the north. These areas provide habitats for a variety of birds, including Coucals, Junglefowl, Bulbuls, and Babblers. Some areas are virtually impenetrable, but for a few trails used by the many buffalo which are turned loose on the island after the rice has been harvested in December. Villagers collect fuelwood from these areas, and also bamboo (food and construction material).

Paddy fields

Paddy fields extend across much of the northern third of the island. Smaller strips of paddy land are located in valleys in the southern part of the island. Cultivated plots are usually very small. Within the fields are many scattered trees, palms and bamboo. There are also several small ponds with fringing bushes. Birdlife varies according to season. During the rainy, rice-growing season, the fields support many fish, frogs, and aquatic invertebrates. Resident kingfishers visit, and Brahminy Kites frequent the area. As the rice ripens, large flocks of Red-breasted Parakeets arrive and various ingenious bird scaring devises are deployed. Migrant pond-herons and egrets also visit before the fields dry out in October and November. Birds which were seen around the paddy field areas at many times of year include several species of myna, bulbuls, doves, Asian Palm-Swift and Collared Falconet. Myna birds were often seen feeding around buffalo.

Bird hunting, trapping and trade

Only a small minority of the island's villagers possess firearms. Until recently, there have been sufficient fish to meet subsistence needs, and wild birds have not been targeted to any great extent. However, during the year several villagers acquired firearms, and it appeared that hunting pressures were greater towards the end of the year[15]. Species shot on the island included Greater Coucal, Pied Hornbill. Eagle sp., Imperial Pigeon sp., Blue-winged Pitta and Scops Owl. Other reports from the district include the following: Large owl sp. (eaten by ADB 7 road engineer, Khinak); Green Peafowl : 2 shot (reported by Khinak resident in December); Adjutants, storks, Pelican (said to have been shot and eaten by fishermen on Done Saniat, see above).

Villagers living by their upland gardens set various noose traps in the surrounding forest for ground dwelling birds. Coucals and Junglefowl were targeted. Decoy traps were set for Spotted Doves by a Ban Khone villager; it is not known whether doves were being sold to traders from outside the area. 'Mist' nets were deployed around some of the upland gardens where parakeets and munias were the obvious targets. Nets set around BHK were said by one villager to be for catching bats. They also took various birds, including bulbuls and tailorbirds. Several reports were received of the use of bird 'lime'. The extent of this practice on the island is not known (local markets sell a very effective glue for catching mice).

Parakeets and myna birds (especially Hill Myna) are popular cage birds within the district. Villagers said that young birds are taken from their nests. However, the trade appeared to be mainly of a local nature, possibly due to the inaccessibility of Khong district relative to regional demand and other areas of supply (e.g. Salavan Province). In the Done Khone area populations of mynas and parakeet species appear to be still fairly healthy. Reports of caged vultures and large eagles being traded in Bangkok from southern Laos or Cambodia are cause for greater concern (PD pers. comm.). Local markets operate for a few hours each day in the early morning. Trade is usually brisk, and various items exchange hands before reaching the market place. Table 15 is a list of birds observed on visits during September - November. Many birds may have been traded before or after our visits.

Many of these birds were probably taken in and around the paddy fields. Several local people also reported the capture of migrant waders around the river banks and small seasonal islands. Several marketed birds had gunshot wounds, though the majority were probably trapped. Many other captured birds were probably not traded at markets.

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[15] Following a new government policy, a hunting gun handover programme was undertaken in Khong District in May-July 1999, with support from the Siphandone Wetlands Project (Baird, 1999). The programme's early implementation appeared quite effective and a large number of guns were collected throughout the District. The long term impact on hunting behaviour and pressure on local avian population is to be determined.

The recent upgrading of route 13 (Pakse to Khong) will facilitate market penetration. Several stalls selling wildlife parts have recently been opened in Pakse market. The increased accessibility of the area to wildlife traders from Pakse and NE Thailand may constitute the most profound impact of the new road for biodiversity conservation in Khong district.

Table 15. Observations of birds at markets in Khong District, 1997

Market	*Date*	*Observation*
Khong	23 Sept.	20 + snipe (probably Pintails)
Khong	24 Sept.	20 - 30 snipe. 4 checked: all Pintails; 1 Little Heron
Khong	25 Sept.	1 Purple Heron; 3 Chinese Pond Herons; 1 ?Green Sandpiper ; 8 Pintail Snipe; 1 Painted Snipe
Khinak	30 Sept.	Little Egrets; White-breasted Waterhen; Curlew or Whimbrel sp.
Khong	3 Oct.	20+ Pintail Snipe; 4 Chinese Pond-Heron; 1 Black-winged Stilt
Khong	4 Oct.	White-breasted Waterhen; 3 Chinese Pond herons; juv. Black-crowned Night Heron
Khinak	11Nov.	juv. Black-crowned Night Heron; Asian Barred Owlet
Khong	12 Nov.	no birds seen. (however, a tourist later reported Egrets)
Khong	19 Nov.	Spotted Dove; 2 juv. Japanese Sparrow Hawks; 30 - 40 Pipits (mainly Richard's)

CONSERVATION ISSUES

The context of social, economic and cultural issues relating to human ecology and bird conservation in and around Khone Island is complex and beyond the scope of this paper. Various problems relating to bird conservation in the area are outlined in Table 16. Here we point out the following evidence arising from our observations:

- the Khone Island area provides seasonal feeding or breeding habitats for many regionally rare birds (Table 14)
- numbers of most of these species appear to be very small, and are reported to have fallen rapidly in recent years most obviously as a result of hunting, trapping and human disturbance.

The area as a whole remains insufficiently well surveyed to be able to highlight areas of special conservation importance. The relatively inaccessible western Somphamit falls area, Done Saniat, Done Eeher and islands and surrounding seasonally flooded areas appear to be particularly rich, although Done Saniat has recently been settled by immigrants from villages in other parts of Khong district (Done Saniat children presently have no access to schools).

It may be unreasonable to expect local people to take a much greater interest in wildlife conservation, until they are able to take care of their own problems of food security, health and other basic needs. It is probably also unreasonable to expect local government authorities to direct their limited resources to the conservation of threatened wildlife unless they are able to derive some material benefit for local people by so doing. Thus, the primary responsibility for conserving regionally threatened wildlife may lie with the national and international community, at least in terms of resource (finance, man-power) provision, for the time being.

However, there are many ways for local schools, business people (including guest house owners and tour guides), Buddhist monks, village elders and other local people with concern for the future of the natural resources, to contribute through their combined efforts. Many villages are already taking measures to actively manage their natural resources. Over 60 village managed fish conservation areas have been designated by villages in Khong District since 1993, and villagers are already speaking of increasing numbers of some previously depleted fish species (AIT, 1997; Hogan, 1997). The SWP is promoting and supporting village initiatives to manage all their natural resources.

The Khone Island is becoming increasingly popular as a tourist destination. Around 1000 foreign tourists visited the island to see the waterfalls and / or the dolphins in 1997. Few knew where to look for birds. Plans for the area have included the development of a large (500 million Bath) resort complex (airport, casinos, golf courses, open zoo) occupying several neighbouring islands around the Phapheng waterfalls. Details have not been made available to local people. The area has considerable potential to be developed as an eco-tourism destination for both foreign visitors and Lao nationals. In addition to the rich natural heritage (waterfalls and wildlife), the traditional fisheries are of outstanding interest and value as cultural heritage. However, if over-hasty, poorly-planned developments which disregard the most basic rights and interests of local people are allowed to proceed, there is a risk of alienating the very people who could most usefully benefit and of destroying a large part of the area's tourist potential and value as "National Heritage".

With increasing competition in the regional market place for tourist business, great care needs to be exercised in developing tourism in the area. With careful planning and management, the Khone Falls area could be gradually developed as a 'National Park' (a special place primarily for the people of Lao PDR), or a 'Regional Park' which extends across the river into the forests of adjacent parts of Cambodia. If the unique traditional fisheries can be sustained and wildlife populations restored; the area might one day even merit designation as a 'World Heritage' site.

Table 16. Khone island problems which relate to bird conservation.

Problems	*Possible Solutions*
Human population rising to levels which the island's existing resources can not sustain	➢ Support efforts to extend family planning initiatives and other health education; ➢ Support efforts to establish alternative forms of employment on the island and elsewhere within the region;
Fisheries no longer adequate to meet subsistence needs of local people	➢ Support efforts to improve management systems for aquatic resources; ➢ Support efforts to control the illegal trade of fish through the island from Cambodia. Consider establishing a border police / protected areas office station on the island (e.g. at Ban Hang Khone) to monitor / police fishing activities and trade along the Cambodian border;
Levels of hunting and trapping increasing	➢ Support efforts to designate and enforce no - hunting areas. ➢ Support education systems. Until local people are able to selectively target only the more common species, the whole Khone Falls area might need to be designated no-hunting area;
Habitat degradation, especially slash and burn	➢ Support efforts to improve the productivity of existing gardens; ➢ Support efforts to improve the management of community forests; ➢ Support efforts to establish protected forest area.

Chapter 11

Siphandone wetlands: values and future challenges

Giuseppe Daconto

Freshwater wetlands are complex ecosystems, which provide a wide range of benefits to the local population and also play critical functions in the riverine ecology. This concluding chapter aims at introducing the broader context within which such resource management problems need to be assessed and addressed. It also summarises the main findings with respect to the management of artisanal fisheries and the improvement of our understanding of the broader values of this exceptional area. Finally, it discusses emerging challenges which need to be addressed to ensure the sustainable development of this wetland site and particularly to harness its vast potential for the growth of a sustainable tourist industry as a key development option for the area.

THE CONTEXT OF WETLAND ASSESSMENT AND MANAGEMENT

The activities of the Siphandone Wetlands Project should be reviewed within the broader context of riverine wetland assessment and management. While a thorough review of these issues is beyond the scope of this chapter, we wish to provide a brief introduction to the salient background points.

Wetlands[16] are complex ecosystems which provide a broad range of resources and services to people and play fundamental ecological roles. However, they are a frequently neglected type of ecosystem, and often bear the brunt of development pressure and are rapidly lost. The wetland literature classifies wetland values under *use values*, encompassing the benefits and resources which wetlands provide directly to people (e.g., agricultural land, fish catch, water supply, etc.); *non use values* (also called *attributes*) encompassing the characteristics of biological diversity, scenic beauty, wilderness, historical and cultural features which enhance the preservation value of a certain wetland site; and *indirect use values* (also called *functions*), which state the roles that wetlands play in the functioning of natural ecosystem (e.g. flood attenuation and control,

[16] Wetlands are defined by the Ramsar Convention as "areas of marsh, fen, peat-land or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine waters, the depth of which at low tides does not exceed six meters".

nutrient cycling, the provision of habitat for plants and aquatic fauna, etc.) (we will refer mainly to the value classification system of Roggeri, 1995).

Riverine lowland wetlands, like coastal wetlands, are subject to intense anthropogenic pressure, because of their accessibility, their wealth of natural resources and their potential for infrastructural and economic development. The combined effect of on-site developments, up-stream river basin developments (in the case of riverine wetlands) and land use changes which affect the river's natural hydrological regimen, often brings about the loss of wetland habitats and their ecological functions. These effects in turn undermine the traditional livelihood of local people, who rely on a range of natural resources provided by the wetland. Following the loss of habitats and natural resources, traditional management systems also break down. These phenomena have occurred along the course of all major rivers world-wide. In continental southeast Asia, major wetland sites are by and large situated in the lower basins and deltas of the major rivers: Chao Phraya, Mekong, Irrawaddy and Red River (Wetlands International & The World Bank, undated). In Thailand, rapid economic development and intense human population pressure have already led to the conversion of a large proportion of the Chao Phraya River floodplain into agricultural land, with the loss of extensive wetland habitats.

The lower Mekong River basin contains a large number of wetland habitats. An inventory of wetlands In Lao P. D. R. (Claridge, 1996) lists 30 wetland sites and estimates that the large majority of these are found within the Mekong river corridor. The Mekong floodplain is used to a large extent for traditional agricultural practices. Human pressure has been growing as a consequence of population growth, expanding land conversion and watershed degradation. Over the last decades the basin has experienced a dramatic level of deforestation through unsustainable logging, further compounded by unsustainable shifting cultivation practices: these factors cause increased sediment load and water run-off and are bound to affect profoundly the catchment area's hydrological features. At the same time, the riparian countries are considering the promotion of capital-intensive development projects and plans which will foster much-needed economic growth. These chiefly involve lowland developments, such as land reclamation for intensive agriculture (i.e., irrigated rice cultivation, which also requires higher chemical inputs for fertiliser and pesticides, which in turn may affect water quality); and hydropower development in the tributaries and main river course. A few such projects have already been implemented and are on-going; a larger number are at proposal stage.

Ensuring the sustainable harvesting of wetland resources while at the same time promoting their long-term preservation and the conservation of critical ecological functions is a daunting challenge[17]. Lack of an adequate information base is one of the most critical constraints: sound information is essential if we are to assess wetland values, identify potential trade-offs between development and loss of resources and thus appropriately inform policy formulation and development planning. It is commonly accepted that understanding and awareness of the complex Mekong basin ecology lag far behind ongoing manmade changes and proposed development plans. Of particular concern is the cumulative impact of even small interventions which are gradually altering the basin's natural hydrological and biological features: the long-

[17] The Ramsar Convention of Wetlands advocates a "*wise use*" concept for the management of wetlands; while this concept is identified for the management of wetland sites designated under the Convention, its broader sense provides a meaningful vision to sustainable management of wetlands in a general context. In its definition, the Ramsar Convention’s Guidelines recognise that "the wise use of wetlands is their sustainable utilization for the benefit of humankind in a way compatible with the maintenance of the natural properties of the ecosystem", where sustainable utilization is defined as "human use of a wetland so that it may yield the greatest continuous benefit to present generations while maintaining its potential to meet the needs and aspirations of future generations"; and where natural properties of the ecosystem are defined as "those physical, biological or chemical components, such as soil, water, plants, animals and nutrients, and the interactions between them" (Ramsar Convention on Wetlands, *Guidelines on Management Planning for Ramsar Sites and Other Wetlands*).

term consequences of these phenomena are potentially huge and at the same time very difficult to assess without sound and extensive baseline information on natural resources and processes.

The complexity faced in the management of wetland sites not only emphasises the need for an adequate information base, but also raises the question of the institutional and technical context: wetland management is ideally expected to bring a range of resource users and stakeholders into a unified framework. These stakeholders often have conflicting demands and requirements (e.g., fisheries versus hydropower development, land development versus ecotourism, etc.). At the same time wetland management institutions are expected to preserve critical ecological functions which are often very dynamic and affected by a broad range of natural factors and human pressures both on-site and external (e.g. climate, land use changes in the upper catchment, etc.). The management of major wetland sites cuts across many sectoral lines along which the public administration is often organised (e.g., water resources, hydropower, fisheries, agriculture, forestry, etc.) and requires a fairly sophisticated effort of coordination and consultation among stakeholders at various levels (central, regional, local), both within the administration and outside (private sector operators and investors, farmers, fisherfolk, etc.). All these actors typically pursue their own agendas in an uncoordinated manner, although each initiative taken individually may appear to address agreed-upon broad goals of economic development. Although this situation is not confined to Lao P.D.R., it is clear that this country has a pressing need to establish coordination of land use and development planning at central, provincial and district Government levels. The important parastatal development enterprises should also be involved, if prevailing resource development goals are to be pursued in a sustainable manner (Chape, 1996).

The development of effective institutional mechanisms for sustainable wetland management needs to be pursued at several levels (basin, national and local), through means appropriate to different but complementary goals and requirements at each level. The preservation of the ecological functions of riverine wetlands often cannot be meaningfully addressed at local level only, because their complex natural dynamics depend on basin-wide factors and characteristics. There is therefore a need for a conducive institutional framework at basin-level that will be able to ensure a coordination of policies and development plans aiming for sustainable river-basin development and management goals. In the case of the lower basin of the Mekong River, the Mekong Commission is uniquely placed to provide a platform for intergovernmental-level coordination of basin development policies. There is a strong argument in favour of appraising and reviewing the management of major riverine wetland sites within their basin-wide context: this process also requires a common framework which will allow us to identify and assess wetland values.

While acknowledging the regional perspective, it must also be stated that wetland management generally is first a national and local affair. The local level management is becoming increasingly important due to decentralisation policies and the weak capacities of the central administrations of countries such as Lao P.D.R. At national and local levels wetland-site management needs to build on the traditional sector-based management approach and develop it into a multi-disciplinary and area-based approach relying on inter-agency coordination. This often involves changes to entrenched practices and established jurisdiction within the public administration. Similarly, sound wetland management requires the employment of adequate technical and human capacity in the relevant agencies, which, in Lao P.D.R. and many other countries, often have very few resources and lack the multidisciplinary skills required to implement sustainable wetland management.

However, it must be noted that the development of a conducive institutional and legal framework and the improvement of the level of technical and human resources at the disposal of government agencies are not enough on their own to promote sustainable wetland management. A vast body of experience world-wide has shown that integrated environmental management and development initiatives often lack the capacity to impact effectively on key development and investment decisions or on complex cumulative processes of resource allocation and consumption. Many a thoughtful master plan is left to gather dust on shelves, having failed to create vital political will and to raise the support of local stakeholders. The loss and degradation of natural resources are generally rooted in a complex web of institutional, political, social and economic factors which constitute the real fabric of social and economic change. Ignoring these factors and their site-specific threads by relying on technically biased approaches makes sustainable resource management largely ineffective. The size of this challenge to sustainable development cannot be overestimated. While field-level sustainable development initiatives can hardly rely on blueprints, a pragmatic approach can often identify a number of management options: resource management initiatives need to root themselves in local complexities if they are to impact meaningfully on processes of change. Hence the most up-to-date and experience-based recommendations urging the establishment of *participatory wetland management* processes or *co-management systems*. These approaches advocate the active participation of local stakeholders in assessment, planning and management processes with the ultimate goal of developing a sense of ownership of the resources and creating a locally driven sustainable management system. These ideas are justified by the fact that local people have traditionally enjoyed access to the wetland resources on which their livelihood, security and cultural identity are directly dependent; they have often developed customary management systems; their participation is essential in order to ensure equitable allocation of access rights and to address conflicts among contrasting economic and social interest groups. This approach does, however, have certain shortcomings and weaknesses, which must also be taken into account. While a thorough review of the circumstances and lessons learnt from these experiences is beyond our scope here, Table 17 summarises a list of issues, which generally characterise such participatory management initiatives.

Table 17. Feature analysis of participatory wetland management initiatives.

Strengths	***Weaknesses***	***Opportunities***	***Threats***
• Promoting an explicit link between development and conservation goals and chiefly on sustainable and equitable allocation of wetland benefits • Adoption of multi-disciplinary approach • Involvement of broad range of actors (government, NGOs, public, private sector) with defined responsibilities through a consultative and decision-making process • Addressing key access rights over natural resources: who, how much, how, what benefit. • Improving and diversifying income generation (e.g., through irrigation, new crop varieties and methods, improved soil management, improved fisheries post-harvest sector, improved access to credit and markets, etc.) • Improving local living standards (e.g., through improved health and education services) • Improved local awareness of wetland values (through direct exposure, education and campaigns) • Improved sense of ownership of and custodianship role in wetland resources	• The link between conservation and development goals is often fuzzy • Development initiatives proposed merely as incentives to conservation • Inadequacy of local conservation efforts versus basin-wide or up-stream threats to wetland functions • Inadequate understanding of wetland ecosystem and of causal links leading to resource degradation • There is often lack of substitutes for wetland resources under pressure • Difficult to achieve adequate representation of local stakeholders in management processes • Revision of traditional tenure systems may introduce equity problems • Lack of scientific data to support management systems based on traditional practices and vernacular knowledge	• Government commitment, • Conducive policy context and availability of a national wetland policy framework • Establishment of inter-agency coordination mechanisms • Understanding of local social conditions • Focus on sustainable livelihood and on locally perceived priorities and resource problems • Facilitation of resolution of conflicts over resource access and establishment of local-level management agreements • Adequate project design without excessive expectations • Project management from within the local administration • Promote human resource develop. and networking among locally organised social actors • Use of local skills and organ.s • Involvement of beneficiaries in all project stages • Technical innovations and use of locally adapted alternatives to resource harvesting • Effective monitoring of progress towards agreed-upon wetland management goals • Restoration of degraded wetland functions	• Top-down approach • Reliance on blueprints • Too large scale • Prevalent sectoral management approach • Conflicting basin-wide/national/regional/local development plans • Unsupportive economic and investment environment (e.g., structure and incentives within agricultural and fisheries markets) • Short-term interventions • Inflexible management and lack of adaptive processes • Lack of technical / production alternatives for wetland resource harvesting • Lack of clear definition of enforceable legal rights for traditional or alternative resource tenure systems • Lack of trust and cooperation among local stakeholders • Weak technical and absorption capacities of concerned institutions • Loss of experienced personnel at local institutions

LESSONS LEARNT FROM THE SIPHANDONE WETLANDS PROJECT

The SWP was based on two main considerations: the project was borne out of a previous experience with fisheries- co-management, which it helped to expand on and strengthen. At the same time, considering the complexity and importance of Siphandone as a major floodplain wetland site, the project attempted to gain more information on other resources and values of the wetland area. Despite its relatively short-term duration in relation to the size of the challenges posed by the large wetland complex, a number of valuable insights were gained from our experience.

Development of a co-management system for wetland aquatic resources

The main focus of the project was the management of aquatic resources in the large complex of riverine wetland habitats found within the boundaries of Khong District. The project's specific objectives (see Introduction) focus on the establishment of an effective and participatory aquatic resource management system, with particular emphasis on fisheries, and also recognise the importance of establishing research support for the management system.

The fisheries resource management system was established in the area in 1993, through the earlier LCFDP project. The main rationale for its establishment was the general perception, widespread among the local people in the project area, of excessive harvesting due to overfishing and the occurrence of certain unsustainable fisheries practices (such as those targeting juvenile stages of fish, breeding phases, etc.). The system, reviewed in detail in Chapter 8, has been characterised since that early phase as a joint effort involving both rural communities and the District and Provincial administrations. The system can be defined as a resource co-management system: it addresses the crucial issue of decentralisation of resource management responsibility, acknowledged and directly promoted by the Lao Government, through the sharing of responsibility between community organisations and local Government; the management system is also guided by local social and cultural features and locally-perceived priorities. The co-management system is built on social features particular to the area, chiefly the relative social homogeneity and strong community links which have been maintained thanks to the relative isolation of these communities. It also found that a foundation of regulatory systems had already been established by the District administration for special fisheries of the area (*tone* and *lee* trap fisheries). The co-management system developed extensively, reaching fifty-nine communities throughout the wetland by 1997 (which represent 44% of the rural communities of Khong District), embracing a wide range of regulatory measures, and building a link between the actions of the local administration and the community-based regulatory processes. During the inception phase, a detailed evaluation of the LCFDPP and consultations with local stakeholders were carried out (AIT Aqua Outreach Lao PDR, 1997; CESVI, 1997). The evaluation revealed a number of achievements of the LCFDPP, which were used as a baseline for this project, namely: (a) issues of aquatic resource management had been brought to the forefront of discussions and debates at the local level; (b) the project had helped to strengthen village structures in terms of their interest and say in the management of common resources; (c) the local government had established and was supporting a formal administrative process which allowed villages to lay down co-management rules; and (d) according to anecdotal reports from local fishermen, there was a broad perception in the area that the co-management measures had had a positive impact on the stocks of certain species of fish and frog. The following main constraints were also revealed: (a) few follow-ups had been undertaken in the villages and structured and formal monitoring of the co-management system was not in place; (b) the district administration still needed to develop the capacity to effectively monitor and implement the process in the future, without external support; and (c) limited qualitative and no quantitative evidence was available on the ecological and economic impact of the co-management system.

This assessment during the inception phase led to a more defined scoping of project activities, in the spirit of adaptive management and participatory / consultation-based planning. In particular, it was deemed appropriate to focus most of the effort for this critical co-management process on the institutional consolidation of the existing co-management system, rather than on its geographical expansion. At that stage the project revised the scope of the first two specific objectives and set a number of specific and closely-interrelated goals (CESVI, 1997), which can be summarised as follows:

- The establishment of an adequate and effective participatory assessment and monitoring process for the aquatic resources co-management system. This process should consider two fundamental sets of issues: biological / ecological issues and socio-economic issues.

- The building of institutional capacity through (a) ensuring involvement of the local authorities and improving assessment, monitoring and evaluation skills; (b) producing suitable training material, including a training manual; c) sharing of information and knowledge at several levels, from the community level to scientific level; and (d) the establishment of a participatory assessment and monitoring programme.

The project established a structured process of monitoring the implementation of the co-management system through the execution of a repeated village monitoring survey. This monitoring exercise was the core action undertaken by the project, so that less effort was eventually spent on the promotion of new village co-management sites. These monitoring surveys were carried out by the project team, which was composed of five government staff members. These staff were seconded to the project by the District Forestry Section, the Provincial Forestry Office and the District Livestock and Fisheries Section. The staff developed significant skills in data collection concerning fisheries as well as in organising and carrying out the community-level evaluation processes based on village workshops, questionnaires and interviews. They collected information on the range and type of village rules and the evaluation based on impact as reported by local villagers; they gained significant skills in recognising fish species and moreover became acquainted with the extensive traditional knowledge available locally regarding fisheries and aquatic resources, which was the foundation for the establishment of this co-management system and still remains its driving force. By the end of the project, it was felt that the staff's experience had given them a basic ability to establish and monitor the co-management system, or community-based process within the limited scale of the project. Moreover, the public administration bodies had acknowledged the capacity of each community in self-regulation, resource allocation and conflict resolution, and had institutionalised their role in the process.

The development of the system gained its momentum from the perception that riverine habitat protection measures and the restriction of harvesting in certain fishing grounds had had a positive short-term impact on fish stocks. The system, however, needed a mechanism to convey the assessment of the results to the stakeholders in order to ensure fully adaptive regulatory processes and to complement the fisher folk’s perception of fish resources. It should be noted that the range and type of measures adopted by the villagers vary greatly throughout the area, depending on local perceptions, habitats, fisheries practices, seasons, etc. A number of typical aquatic resource management rules adopted by the villages of Khong rely on fairly open ecological considerations: notably, those rules devised to reduce the fishing efforts targeting critical life-cycle phases (e.g., spawning) of fish species or those banning very effective and/or destructive harvesting practices (e.g., stream blocking, night fishing with lights). A further widespread rule is the banning of fishing in deep pools of the river, where villages establish fish conservation zones (FCZ). Despite the width of the scope of these regulations, deep pool FCZs have somehow become the flagship of the co-management system in Siphandone, because of their high visibility, their symbolic value and their perceived effect on some of the major local fisheries.

The project gradually introduced technical measures to assess the impact of the resource management measures on fish catches. The monitoring team initially collected extensive anecdotal information on fish species perceived by villagers as having benefited from the conservation measures. In a second phase, the project focused most of its efforts on developing capacities for monitoring basic ecological aspects of FCZs and then began to establish a monitoring system in selected pilot villages based on the collection of catch-per-unit-effort (CPUE) data. This monitoring programme is reviewed in detail by Baird (chapter 8); it built-up basic data collection capacities in groups of fisherfolk during the first year of implementation, which was the last year of the SWP. The process was designed both to strengthen the fisherfolk's ability to assess their resource base through a structured approach, and also to provide a quantitative assessment of the resource base and the fishing effort for external stakeholders (higher levels of GOL administration, as well as researchers on riverine ecology). The link between local traditional ecological knowledge (TEK) and scientific knowledge is always essential for feedback to the policy-making level. It is also vital if we are to gain a meaningful understanding of the long-term and cumulative effects of local resource management efforts.

Nevertheless, the quantitative justification of the rationale of the FCZs in the Mekong main course provides formidable scientific challenges. Fish catches may well be affected by a broad range of variables (biological, hydrological, climatic, etc.) which vary from year to year and relate to the riverine ecosystem as a whole, rather than to merely local factors. In addition, the opportunistic nature of the capture fisheries tend to undermine attempts to scientifically estimate and monitor fishing effort, which is required for rigorous quantitative studies. These intrinsic factors and the limited knowledge presently available today on the ecology of the very diverse Mekong fish fauna should realistically temper expectations for rocket-science assessments of similar fisheries management initiatives. These constraints do not deny the need for a quest for a more rigorous quantitative approach to aquatic resource management, which must be pursued through research efforts sustained over a long period of time and supported by resources adequate to the scale of the system. On the other hand, the constraints do emphasise the importance of looking at such initiatives in aquatic resources management within their broader social, institutional and resource management context.

This project advocated TEK as a suitable foundation for local-level resource management in the context of a genuine concern expressed among the local people about declining fish stocks. Indeed, one of the main factors which enabled the relative success of the management system in terms of social acceptance, was the impressive depth and breadth of knowledge owned by the local people about the local aquatic resources. The acceptance of the co-management system by the fishing community, and their pro-active participation in it, were due to the crucial fact that they were given the role of common resource custodians of the system. Indeed, the project's most evident impact has been on the sense of stewardship over local resources among the communities of Siphandone who were involved in the co-management process. This project helped to strengthen awareness about the impacts they could have on finite resources. This happened not only through the direct support given to the co-management process, but also of their active targeting of other social groups through awareness raising activities carried out through local mass organisations and educational institutions. Through these activities, the project extended the environmental awareness agenda in the area, broadening its perspective, the actions it undertook and the actors who were involved. The importance of this factor should not be underestimated when we consider that closer market integration, improved access to the area and infrastructural development will soon bring rapid change to the local lifestyle and economy. While going through such a transition, the people of Khong will have to face increasingly complex questions and decisions. While the quest for economic development rightly tops the local agenda, a strengthened sense of stewardship over local resources and broader local awareness of resource management problems may help to extend the complexity of the social discourse and local common perceptions, which hopefully will be important factors in promoting sustainable development patterns.

The development by SWP of a monitoring system for the social and economic factors and effects of the co-management system produced less clear results, mainly because of the monitoring programme's predominant focus on ecological issues. It is definitely felt that a number of issues would benefit from further in-depth assessment of the participating communities. These issues include: the economic impact and distributional effects of aquatic resource management measures; the effects of economic stratification within the villages on the community's allocation of open access resources, such as fish stocks, and also on the resilience of village institutions and mechanisms which were established as part of the co-management system; and the relevance and scope of mechanisms which were set up to solve resource allocation conflicts within and between communities. As economic changes are likely to increase in the near future under the influence of broader economic factors, further studies on these topics are vital.

A fundamental concern of the project was to address the institutional side of the co-management system in cooperation with the local authorities. This should be seen in the broader context of local-level resource management in Lao P.D.R.. This is a relatively new approach in the country, embraced by the Government in 1993 with an Act aimed at decentralising the management of natural resources to local level authorities, with the intention of better addressing local needs, overcoming the fundamental capacity constraints of the central administration and avoiding the establishment of unsustainable and donor-dependent structures. Practical experience of decentralisation is still very limited in the country and the pilot co-management system established in Siphandone probably is one of the few examples which have reached a phase of implementation and have included participation of local stakeholders. Despite the emphasis placed on decentralisation at policy level, local-level administrative structures are generally very weak: technical, financial and management capacities are in short supply and Khong is no exception to this rule. The SWP aimed at developing human resources in the area, especially the skills and experience of its field staff through on-the-job training and some formal events, such as workshops, etc., as well as through the preparation of training aids. The project field team was composed of staff belonging to the relevant local GOL authorities. They were also from the project area, a fact that proved a tremendous advantage in ensuring that local institutions and people spoke the same language and shared the same background and perceptions.

The ease of communication between project staff and the local community, along with the fact that a large rural population participated in the project with no major conflicts, does suggest that this community-based system may well have a built-in resilience. This is, of course, with the proviso that it addresses local needs and perceptions, is based on local knowledge and implements activities through local means. The continued work of these staff members in the local administration, as well as the continuation of the consultative processes established, will hopefully be instrumental in consolidating, expanding and further adapting the overall process. In a wider perspective, it is hoped that the management process in general, and the experience of local staff in particular, will lay a foundation which will contribute to the equipping of local authorities with more sophisticated capacities, something which will definitely be necessary for the future development of the area.

Improvement of the understanding of wetland values

Aquatic resource management was the core resource management issue addressed by the project. At the same time, we attempted to introduce a broader perspective to wetland resource management. Siphandone is in fact one of the major wetland sites of the country; it is endowed with diverse and remarkable natural resources; it provides a variety of natural and economic functions and services. It also contains both natural and man-made tourism attractions and is inhabited by a large population, which has a traditional lifestyle closely dependent on the local resource base. The area is facing growing development challenges and opportunities. Sustained population growth, infrastructural development, the intensification of agricultural production, an increase in tourist arrivals and attempts to conserve its biodiversity are already placing an ever-growing range of often conflicting demands on the area. Natural resources will have to be allocated for multiple and potentially conflicting uses. The Government of Lao P.D.R. and the local administration are facing decisions which will have long term implications.

Wetlands are recognised by GOL as important natural resources: the SWP was part of the wetland programme of the Department of Forestry, which was coordinated by the then Centre for Protected Areas and Watershed Management (CPAWM)[18]. At the time of its inception, this project was one of the first field-level wetland projects undertaken in the country.

The project, implemented over a period of 28 months, was intended to be a pilot attempt to introduce a multi-disciplinary ecosystem perspective to wetland management as a pilot case. Given the relatively short life-span and the limited resources of the project, the scope of activities was focused on the collection of baseline data on the wetland as an essential first step towards laying the foundation for integrated wetland management. The project did succeed in acquiring fairly extensive baseline knowledge of the area, through surveys, remote sensing and inputs from specialists. The preceding chapters have presented an overview of the information collected (with the exception of a substantial amount of data on fisheries which the project compiled, reviewed and analysed in more detail in technical reports). The baseline information collected shed light on the critical values, ecological functions and the resources management problems of the wetland complex. Table 18 summarises the values and resource management problems identified through SWP's site assessment activities, while Table 19 presents a synopsis of the same information in graphic form with an attempt to rank values and threats. These assessment activities were not expected to result in a full resource management phase within the life of the project, but aquatic resource management remained the entry point for resource management tasks. However, the project did succeed in identifying specific entry points for the development of further resource management capacities; these included water resource management and flood vulnerability assessment and mitigation; riverbank erosion mitigation; forest rehabilitation; agroforestry; and the development of ecotourism. Project’s results were presented to a final provincial workshop along with a conceptual outline for follow-up actions (Daconto, 1999) centred on eco-tourism development and based on the rationale explained in the following sections.

The assessment study activities also provided a range of opportunities for on-the-job training of counterpart staff, involving staff from both local and central agency. Close co-operation was established with the Department of Biology of the Lao National University for the investigations on plant biodiversity and the traditional use of local plants. At local level, the project acknowledged that the involvement and mobilisation of local institutional resources in project activities must be a fundamental point in the process. A large number of Provincial and Khong District offices, including mass organisations such as the Lao Women Union and the Youth Union, were closely involved in activities ranging from extension work on various resource management issues, to awareness raising activities, educational activities, small-scale rural development initiatives, etc., all broadly connected to the core theme of the project, i.e., sustainable natural resource management. All these activities were implemented through and often by district administrative structures, who were involved at all stages: from identification, to planning, approval and often implementation and reporting. The project also spent considerable effort to involve primary and secondary educational institutions through environmental awareness activities which covered a range of topics. There was also a critical need for teaching aids: the project therefore produced a number of publications and provided materials tailored to local experiences and perceptions. In all these ways, the project attempted to engage a wide cross-section of rural society and to mobilise local networks and organisations in a manner that would suit the Lao context.

[18] Soon after the termination of the project, administrative responsibility within the Ministry of Agriculture and Forestry was restructured and the Department of Fisheries and the Living Aquatic Resources Research Institute were given a leading role in the wetland sector. Because these major changes are occurring as the present work is being prepared for publication, it is impossible to address these crucial institutional issues and their implications in any depth.

FUTURE CHALLENGES

Sustainable development - still a challenge

The country has limited experience in area-wide resource planning and the management of critical ecosystems. The lack of experience particularly affects areas such as this wetland, endowed as it is with many natural and cultural assets, while also being inhabited by a large population and facing growing pressures from development and the harvesting of resources. Promoting the much needed economic development of the local people while at the same time preserving the exceptional resources and ecological functions of this wetland are formidable challenges.

The growth of the local population calls for a diversification of income-generating opportunities. The closer integration with outside markets facilitated by the recent development of transport infrastructure may lead in future to the development of a small-scale industry base for the transformation of agricultural produce, a base which at the moment is almost non existent. At the same time the government is pursuing the intensification of agricultural practices in particular through large-scale development of irrigation, which has the potential in the eyes of local planners to turn the alluvial areas into a rice basket. While it is undeniable that this development may well bring much-needed improvement in the food security of the large number of people residing in the area, the long-term impact of these intensive agricultural practices on soil conditions and water quality will have to be monitored closely. The useful diversification of agricultural production has also been hampered by the lack of effective extension services. Their improvement and an increased availability of capital and access to credit, would enable the local farmers to experiment with a range of commercial agro-forestry products, such as fruit production, which may provide more feasible and sustainable alternatives to current activities which rely mainly on small-scale forest plantations.

Increased market penetration is likely to exert growing pressure on the riverine fish stocks. The further commercialisation of the artisanal fisheries sector, which plays a crucial role in local food security, will increase harvesting pressures, both in general quantitative terms and with regard to sensitive fish migration phenomena, fish habitats and selected target species. The local experience in fisheries co-management will, if sustained in the future, lay a foundation for the management of these site-specific concerns. In addition, it may well have to deal with the effect of basin-wide development processes and with the resulting environmental changes on riverine ecology, over neither of which it has any control.

While most of these are common dilemmas for lowland areas in Laos, the exceptional features of the Siphandone wetlands call for the establishment of an area-wide management process which will be able to weight its special requirements and the long-term implications of economic development, and which moreover could facilitate the sustainable long-term harnessing of the income-generation opportunities offered by local resources. Any such a process will have to rely on a gradual improvement of the management framework, backed-up by the development of human and technical resources in the local administration, which are at present fairly basic. The positive side of this situation is that at local level the promotion of an integrated approach to area management would be made somewhat easier by the limited size of the district administration. Similarly, the lack of a definite national policy and legislative framework for wetland management may not necessarily undermine the development of a district-level area management process, provided that a consensus on development goals could be promoted at this level and that the need to plan the rational allocation of local resources to multiple uses was recognised. This would entail the development of a district-wide management plan, whereas at present the Land Allocation Programme has only established land use management at village level. The management processes will also need to strengthen the cooperation and mutual understanding between the administrations of Khong and Mounlapamok Districts, which share the Mekong floodplain. It should also closely involve the Xe Pian NBCA and the management of the nearby lowland areas of Dong Khanthung, which will be increasingly affected by the growing population and development pressure in the river corridor. An even greater challenge may well be the necessary coordination of sectoral development plans among higher-level government authorities and parastatals. This would become of immediate concern if and when plans for major capital investments in the area (from hydropower to tourism) are resumed and implemented, as far as there is no compulsory management framework which could avoid the jeopardising of local resources and the ecology. The aim of any investment would naturally be to produce flows of revenue; this may not necessarily benefit the local population directly, and may even be to its detriment.

The safeguard of the most delicate and as yet little understood ecological functions of these reaches of the Mekong River definitely requires that site conservation measures be put into place. The southernmost sector of the wetlands (Map 7 in Annex-1) deserves protection because of its exceptional natural features: these include the extensive complex of waterfalls, rapids, the *hou* (channels) which are crucial for fish migrations, the Tholati wetland, the remnants of lowland humid vegetation spared until now because of the unsuitability of the islands for paddy cultivation, the special floral associations which dominate the seasonally-flooded riparian habitats, the wide range of riverine in-stream habitats created by the dynamic conditions of the river over its seasonal cycle, the presence of the Irrawaddy dolphins, and the spawning grounds for the freshwater croaker *B. microlepis*. These features make this site truly exceptional; its conservation would benefit the local people as well as ensure the preservation of a unique site along the Mekong course. Among other advantages, the fish migrations along the *hou* on which the fisheries of the Mekong River rely, would be conserved. A special management system for this area should probably be extended to the associated lowland habitats in the floodplain west of the river in Mounlapamok District, which has been spared to some extent from land conversion due to lower population pressure; its lowland wetland features have thus been preserved in less disturbed conditions.

To summarise, the southern sector needs to be managed in such a way that its ecological values are taken into account and accepted as fundamental factors determining development decisions. Historically, however, nature conservation policy in Lao P.D.R. has always concentrated on forest rather than riverine areas, and has paid relatively little attention to the benefits of the riverine ecosystem, facts which will make the establishing of a conservation system over this area more difficult to achieve.

Tourism: a win-win opportunity?

After almost two decades of isolation, over the last few years the Lao government has been promoting tourism as an important source of income and as a major opportunity for economic development and the creation of jobs. The flow of foreign tourists to the country has steadily increased over the years, particularly following the relaxation of formal entry requirements in 1993. The National Tourism Authority (NTA) reported that over 500,000 tourists visited Laos in 1998, representing a good 500% growth since 1993. The majority of foreign tourists are Thai, but the number of tourists from outside the region is becoming to overshadow them. Most remarkably, the industry became Lao P.D.R. top revenue earner in 1998: tourism receipts amounted to US$ 79,9 million, followed by those from textiles and electricity exports. Data from the NTA shows a tremendous growth in the industry, with earnings tripling between 1995 and 1998, injecting much-needed foreign exchange into the Lao economy. The further development of the tourism industry and the tapping of its large potential in the country depends on the upgrading of transport, communication and hospitality infrastructure, the development of human resources in the service sector, and the creation of a conducive environment for foreign business enterprises.

The province of Champassak, easily accessible from Thailand and close to the main urban centres of its north-eastern region, is one of the major tourist destinations in the country, ranking as the fourth most visited province after Vientiane, Savannaketh and Luang Prabang (NTA data, 1999) thanks to almost 30,000 visitors in 1998, a number which has been growing rapidly from an initially very low base. In 1994 the Tourism Authority of Thailand (TAT), following an agreement with the NTA, commissioned a tourism sector review and feasibility study in Champassak Province, in order to provide a basis for tourism sector planning in the province (Thailand Institute for Scientific and Technological Research, 1995). This study identified the Siphandone area as one of the major attractions in the province, along with others such as the town of Champassak and the archaeological site of the ruins of the Khmer temple Wat Phou; the Phou-Asa area, including Khmer relics of Wat Oumong in the Phathumphone district, Wat Phu Asa, and the neighbouring villages and countryside; and Pakxong and its agricultural and natural sites (Tadfan waterfalls) on the Boulevan Plateau. This study was the first attempt towards developing a regional tourism master plan which relied on the complex of attractions available in the province. The main opportunities for development of the sector, and for linking it to a regional tourism network, were identified as follows: the mix of man-made and natural attractions, which would appeal to middle-class foreign tourists; the internationally known attractions which would be easy to promote; government's support for development and foreign direct investment in the area; the early stage of tourist development; and donor support for infrastructural development in the province. The study also identified several constraints, namely: insufficient services and infrastructure and the inadequacy of their centralised management; difficult access to scattered tourism sites which requires considerable infrastructural improvement; the need for preservation of cultural and natural attractions; the lack of institutions responsible for full-fledged tourist development; the lack of a legal and administrative framework supportive of foreign investment.

Siphandone has been attracting a steadily growing flow of international tourists. At the time of compiling the present publication, a simple search on the Internet generates a large number of sites mentioning Khong and Siphandone, from travel agencies and tour operators' sites to the personal reports of travellers. The complex of waterfalls also places Siphandone high on the wish list of the limited number of Lao who can afford to travel. The recent upgrading of Route 13 and the construction of a bridge across the Mekong at Pakse have dramatically improved the access to this extreme southern corner of the country, which is now a mere few hours' drive away from Ubon Ratchathani, in north-eastern Thailand, via the ChongMek border post. This development together with the improvement of the road connections between Savannaketh and Pakse, have enormously improved the access to Siphandone via the road network from central Laos and Thailand, while until only a few years ago it still appeared a remote destination to the few independent tourists and organised groups which ventured so far. The tourist industry in Khong is also a relatively recent development. The first hotel catering to foreign tourists was established in Khong town only in 1992, but since then the accommodation capacity has steadily expanded, reaching 70 rooms in 1999. Facilities ranged from a couple of comfortable resorts to simple guesthouses. A few entrepreneurial locals have been responsible for the recent mushrooming of basic guesthouses in the southern island of Done Det. Most of the establishments offer services such as restaurants, boat hire and bicycle hire. Organised tourist information services are not available and foreign tourists travelling outside package tours rely on information published in travel guides and the advice of local people and the few local tourist operators. There are a significant number of constraints, which must be overcome if the tourist industry is to develop further. These include the general lack of infrastructure and communications, the lack of medical facilities, tourist organisations, the lack of natural resources management, few financial resources, the occurrence of health hazards, the lack of a legal and policy framework for the sector, and local concerns about the possible social impacts of increased numbers of tourists.

Tourists are not only attracted by the natural beauty of the area (chiefly Phapheng and Lipee falls and the dolphins), but also by its cultural and architectural attractions (temples and historical remains on Khong Island and the old French railway). Furthermore Khong itself and indeed most of the villages and communities of Siphandone embody cultural values which have a considerable attraction for foreign tourists. The traditional lifestyle of the rural communities is closely linked to the special features of the unique natural landscape. In Siphandone water merges with land, through the seemingly endless spreading of islands and river, in their variable aspects of large channels, rapids, pools, falls, large islands, islets, sand bars, creating a landscape which changes dramatically with the seasons and the changing level of the river. Siphandone's communities have adapted with great skills to this exceptional riverine landscape as witnessed by their varied agricultural practices and ingenious fishing methods which visitors enjoy observing. Local people have also developed skills in basket weaving for domestic products and fish traps: these skills could well be used for the development of a village-based handicraft industry, possibly supplemented by weaving and textile production. These handicraft products, if sold to tourists, would help boost and diversify local income in the villages. The potential for tourist development also includes other natural attractions of the area, currently out of reach for all but the most adventurous tourists, such as the turbulent channels of the attractively-forested southern islands, where spectacular fisheries take place during the fish migrations. Appropriate conservation measures could also help to re-establish populations of waterbirds, which visitors would be able to observe in their attractive habitats. The eco-tourism potential of these sites is at present almost entirely untapped, due to lack of promotion and difficult access. Nevertheless, if properly developed and promoted, they could greatly increase the appeal of nature-oriented tourism. Proper tourist site planning would require the design and marking of trails across the islands leading to selected viewpoints on rocky banks; the creation of nature trails through the forest and the agricultural land of the islands; the organisation of boat tours; the training of local guides; the organisation of visits and recreational activities tailored to and respectful of the local lifestyle and traditional practices.

The creation of basic tourist facilities and services in the area could be a stepping stone for a wider range of activities and developments. For example, the complex of natural and man-made attractions thus provides an exceptional opportunity for developing an eco-tourism attraction which would be ideally linked to educational activities and services; these would be dedicated to raising awareness of the wetland site and the needs and practices for the conservation and management of its resources. The area is uniquely suited to host a wetland interpretation centre focused on the Mekong river ecology and lifestyle. In addition, if developed within a perspective of regional development, the area could also act as a base for tourism in more remote areas of extraordinary natural interest, such as the Xe Pian NBCA. It could also be actively linked and promoted together with the famous archaeological complex of What Phu, as a natural and historical destination representative of the lower Mekong River. Furthermore, the wetland lies at the border with Cambodia and local people on both sides of the border already share traditions, social links and resources (migrating fish, dolphins, habitats). A long-term vision for the broader area could also consider the establishment of some form of solid transfrontier cooperation on shared resource management issues and even the creation of a transfrontier area with recognised special status. As well as improving political and management conditions between the two border areas, this could also stand as tangible evidence of broader collaboration at the level of policy and development planning within the basin. An excellent opportunity to initiate that kind of cooperation could also be offered by the expected accession of Cambodia to the Ramsar Convention with the designation of an approximately 40 km long stretch of the Mekong River corridor in Stung Treng, just south of the border, as a wetland site preserved under the aegis of the Convention.

The development of tourism can have a positive economic impact through direct payments, taxes on purchases and services, job creation, corporate taxes and the multiplier effect within the local and regional economy. At this early stage of tourist development in Siphandone, it is still possible to guide the sector in beneficial rather than harmful directions. An earlier plan to develop a large-scale luxury tourism complex near Khone Phapheng (including an international airport, 3-5 star hotels, a casino, a golf course, restaurants, an open zoo, a resort, night clubs, a duty free shop and a power station), with financing from Thai investors, has probably been shelved for the near future at least. While such an investment would prove attractive to the Lao development planners as a catalyst for regional development, its environmental and social costs might well outweigh its economic benefits. Now is time to ask the basic question: what kind of tourism and for whose benefits. An option which certainly deserves a thorough appraisal is the development of a low-scale tourism sector based on the natural and cultural heritage of the area, backed-up by the development of local human resources, low impact infrastructure and adequate services.

This type of tourism could provide a win-win development option for this rural area and its pressing development needs. It would need to be built within the framework of an integrated approach to the management of the wetland resources in order to ensure the sustainable development of productive and recreational activities and at the same time to safeguard the inherent social and environmental values of the site. Although Lao P.D.R. does not have much institutional experience in establishing rural and nature based tourism, Siphandone could be a pilot case, especially if support were to be given to the establishment of local enterprises and the direct involvement of local people in the sector through suitably designed institutional arrangements. These in turn would encourage the wise long-term use of natural resources in the area, on which the eco-tourism industry relies. Threats of uncontrolled tourist development and the associated degradation of landscape and social fabric are unfortunately evident throughout the world and examples abound in south-east Asian countries. The fact that the tourist industry in Lao P.D.R. is still in the early stages should be used to encourage everyone involved to urgently develop a sustainable framework which will safeguard the exceptional natural and social qualities of sites like Siphandone, while at the same time promoting economic growth and ensuring that any economic benefits are equitably shared out.

Table 18. Summary of Siphandone wetlands values and management problems.

VALUES	INDICATORS	DESCRIPTION	PROBLEMS
RESOURCES (use values)			
Plant production	**Forestry production**	Few wooded areas remain on the islands. The southernmost islands (D. Saddam, D. Saniat, D. Phapheng, D. Khone and other minor islands) retain a mixed-deciduous-evergreen forest habitat somehow still attractive, which supports residual avian fauna and, if conserved, could add to the attractiveness of the area for tourism. Small patches of forest on the islands have traditional spiritual value for local people and are used as village shrines. Riparian vegetation mitigates erosion phenomena.	Forest cover has been degraded by centuries of agricultural practices, seasonal fires and wood harvesting. This pressure is bound to grow due to population growth and land hunger to meet the basic subsistence requirements of local people (including firewood collection, grazing, etc.). Encroachment in Xe Pian NBCA conflicts with conservation goals. Effectiveness of existing forest conservation measures (Xe Pian NBCA, Khong Island provincial conservation area, Done Khone District conservation area and village level conservation areas established as a result of the Land Allocation programme) need to be improved. Implementation goals and means should be reassessed and tailored to local needs and capacities. Fuel-wood collection is bound to grow. It could be alleviated through dissemination of efficient stoves and planting of suitable species for harvesting. Plantation programmes may introduce exotic species. Reforestation plans need to be reviewed for consistency with agricultural, tourism and conservation requirements. Bank clearing undermines riverine vegetation's capacity to mitigate erosion phenomena.
	Agricultural production	Alluvial deposits offer vast areas for rice agriculture. Most of the alluvial land has been converted to agricultural production for a long time. Proximity to water facilitates the introduction and development of irrigation. The extensive network of canals provides hundreds of kilometres of riverbanks which are cultivated for vegetables and minor cash crops.	Land scarcity due to high population density. Encroachment on forest land. Potential soil degradation problems due to further development of paddy fields and intensification of agriculture in poor /unsuitable soils. Intensification of agriculture based on chemical inputs will also impact on water quality with potentially adverse effects on aquatic ecosystem's structure, diversity, food chains and reproduction of aquatic fauna. Lack of adequate agriculture extension services has prevented, inter alia, the development of fruit production, which might suit the area. Riverbank clearing reduces riparian natural habitat (important for fish and birds) and accelerates colonisation by invasive plant species and erosion phenomena. Floods periodically hit many low-lying areas with severe impact on the food security of the affected villages. The area requires a detailed flood vulnerability assessment and planning of mitigation measures, such as crop diversification. On the other hand, land conversion for

VALUES	INDICATORS	DESCRIPTION	PROBLEMS
			agriculture and alteration of natural drainage patterns have profound effects on seasonal wetland habitats, which are generally lost, with negative impacts on the aquatic fauna which relies on them for reproduction and nutrient inputs.
	Forage production	Riverine areas support large number of livestock (buffaloes). Extensive shallow areas such as the Tholati wetland are particularly important as foraging ground for nearby villages.	
	Harvest of other plant products	Local people have a rich tradition of collection and utilisation of non-timber forestry products (for medicinal use, food, housing, construction of fishing gear, etc.)	Habitat degradation due to land encroachment severely limits the availability of forest products.
Animal production	**Livestock**	Riverine habitats support large herds of buffaloes.	Veterinary extension services are very weak and need strengthening.
	Fisheries production	The exceptional capture fisheries sector targets a wide range of species with extraordinarily rich and varied techniques. Some of the fisheries are very characteristic, probably unique in southern Laos, in terms of kind and overall variety of gear, the overall number of species targeted, the relative high abundance of migratory species and the fundamental importance of fisheries, in social and economic terms, for the local population. The wide range of species caught throughout the year (over 100 fish species can be indicatively considered economically "important", see Chapter 8) and the significant quantities caught underline the economic value of these capture fisheries for the livelihood of the local population, all of which is involved with fisheries, although to a variable extent depending on locations.	The fisheries could be threatened by a range of local factors such as over-fishing due to a larger and more effective effort; harmful and unsustainable fishing practices; and riverine habitat degradation. The impact on fish stocks due to these local factors vis-à-vis the influence of natural and basin-wide ecological factors is difficult to assess. Basin-wide ecological and management issues need a suitably scaled assessment. Local fisheries co-management initiatives have been established. Their further evolution needs monitoring with particular regard to their resilience in face of external social and economic changes; the effectiveness with particular regard to biodiversity conservation issues of local concern; the effectiveness in relation to their management goals; the building of a quantitative monitoring baseline through a suitably scoped scientific study. Destructive fishing practices downstream along the Cambodian reaches may affect fisheries in Siphandone and need cross-border cooperation. Post-harvest techniques are basic and should be appraised with a view to increasing the value of marketed products. However, increasing market penetration due to improved transport will increase the overall fishing effort, which is already high.
	Wildlife production	The game populations (mainly birds) are hunted for local consumption. The government banned firearms for hunting in 1999.	Wildlife has been by-and-large extirpated from the area due to the loss of habitats and intense population pressure. Bird snaring is common. In certain areas (e.g., southern islands) improved conservation of residual habitats could lead to the re-establishment of bird populations and thus to increase the attractiveness for tourists.
	Aquaculture	In certain areas of the corridor river-based fish farming (e.g., cage farming) could have a still unexplored potential as an income diversification option.	Suitability of local species to be assessed along with site selection and management requirements. Few on-going fish-farming activities and pilot studies have mainly dealt with pond culture and exotic species. Introduction of exotic species both locally and in the basin could impact on indigenous fish stocks.

VALUES	INDICATORS	DESCRIPTION	PROBLEMS
Mineral production	**Sand deposits**	Sand extraction could be occasionally observed and needs better appraisal.	
Water supply	**Irrigation**	Natural web of canals provides easy access to water for irrigation, which has been recently introduced extensively throughout the area and will improve local food security.	Impact of irrigation practices on soil conditions and of water abstraction from shallow areas during the dry season should be assessed.
	Domestic consumption	Easy access to river water for villages settled on riverbanks.	Lack of sanitation facilities and dense human population cause recurrent public health hazards. A number of villages farther form the riverbanks experience water shortage problems during dry season.
Energy	**Hydropower**	The steep elevation gradient of the fault area makes this reach of the Mekong interesting for hydropower development. A few options have been appraised in the past, including a dam across Hou Sahong and a run-of-the-river system based on a by-pass channel around Phapheng waterfalls.	Any dam would probably have a major impact on fisheries on a wide scale, as it would hamper longitudinal fish migrations. Traditional mitigation measures such as fish ladders have not proved effective in dams of the region. Water diversion through a by-pass channel may have adverse effect on water re-oxygenation and hence on the fish fauna associated with the microhabitats and downstream reaches of the falls.
Waste disposal	**Domestic waste disposal**	The river provides a ready means of disposal for domestic waste.	Water contamination due to human and agricultural waste is an ever-present health hazard. Epidemics occur from time to time, due to the high population density. Basic rural sanitation facilities and safer habits should be introduced on a large scale. The indiscriminate dumping of solid waste is common and highly visible at the main settlements and markets. Basic but adequate solid waste collection and disposal facilities should be introduced.
Transport	**Land transport**	The floodplain is easily accessible and has been a main traditional communication route between northern-central Laos and the lower Mekong basin.	Recent improvements to Route 13 have dramatically facilitated land communications. This, jointly with the construction of a Mekong mainstream bridge in Pakse put the border with Thailand at about a two hour journey from Khong. The economic, social and environmental impact of this will be vast.
	Water transport	The falls hamper river transport to and from Cambodia. However river transport between Khong and Pakse and upstream reaches is a common means for trading and travelling. The extensive local web of channels provides a unique system of waterways for local transport, which has been a factor in supporting the establishment of dense human settlements. It also adds to the attractiveness of the area for tourism.	
Land development	**Potential projects**	Improved access to the river plain, the strategic location, the presence of exceptional natural resources with vast potential for the development of tourism, intensive agriculture and agriculture-based industries, the large populace, improved infrastructures (electrification, land communications, services) are all factors contributing to the future potential of the area for land development. Two major infrastructure developments are known to have been proposed for the area: a hydropower plant and a large-scale tourism development, which have gone through some preliminary appraisals.	There is an expectation in Laos that Siphandone will play a role in regional and national development. In addition, the development of economic initiatives is warranted to support income generation and diversification for the benefit of the local population and to decrease their reliance on the natural resource base. At present there is virtually no industry, save for a sawmill and small-scale family-based basic processing of agricultural and fisheries produce.

VALUES	INDICATORS	DESCRIPTION	PROBLEMS
			The development of the alluvial land for agriculture, processing industry and tourism initiatives will require careful planning, through which the resources of Siphandone can be allocated to different uses. A master plan of the area capable of accommodating future needs and opportunities ought to be developed along with strengthening of the local administration. Projects need to be carefully screened for their potential impact (local, upstream/downstream due to cumulative factors).
Tourism	**Tourism sector and its potential development**	Siphandone is one of the major tourist attractions in Laos. International tourist arrivals are growing, providing a much-needed source of income to local people. The strategic location of the area makes it possible to predict that the local centres could develop in the future as bases for nearby biodiversity rich areas.	There is a lack of facilities, infrastructure, services and institutional backing for the sustainable development of the sector. Uncontrolled tourism-related developments or large-scale tourism infrastructural investments might degrade the area's attractiveness and undermine the long-term sustainability for the growing industry. There is no institutional experience of rural and nature-based tourist development and there is a need to experiment with the development of local-level management agreements to ensure both the participation of local people in the industry and their active role in resource management and conservation.
Research	**Ongoing and potential research programmes**	The area is endowed with exceptional natural resources and is a striking example of the Mekong riverine landscape.	The site provides an ideal location for long-term scientific study of Mekong aquatic ecology. The SWP and research programmes promoted by the Department of Fisheries and other organisations have carried out investigations in the area. The expected development of a follow-up programme should address both near-term management objectives as well as long-term research into fundamental scientific issues.
Education	**Potential educational services**	The educational potential of the area's unique natural features, rich traditional culture and historic remains could well be harnessed for the benefit of both local people and foreign visitors. This would be helped by the fact that access to the area is now easy.	The likely development of tourist-related services should ideally be accompanied by initiatives, such as an education centre, which will strengthen the capacity of Siphandone to provide educational services to the local public.
ATTRIBUTES (non use values)			
Biological diversity	**Flora**	Over 700 species of plants have been identified in terrestrial and aquatic habitats.	Centuries of agricultural practices have heavily impacted the vegetation cover. The alien invasive *Mimosa pigra* is widespread along the banks and sandbars, as a result of degradation of the autochthonous vegetation.
	Fauna	Over 200 fish species have been identified in the area. A number of species are listed for their conservation value (see Chapter 8). While it appears that the area may not have endemic species, however a large number of habitats (particularly the rapids) await investigations. Terrestrial fauna has been impoverished by human consumption and habitat loss. However less disturbed areas still show interesting avian fauna. The site is the northern boundary of the range of the Irrawaddy dolphin (*Orcaella brevirostris*) along the Mekong's main course. The species is classified by IUCN	The knowledge about the aquatic biodiversity of the Mekong basin is generally fairly patchy at present and this hinders a proper assessment of the biodiversity value of sites such as Siphandone. This means that a precautionary approach to wetland management and conservation should be taken. A bird survey should be carried out in the Tholati wetland. Effective conservation of selected riverine and forest habitats would help the re-establishment of avian populations associated with the river.

VALUES	INDICATORS	DESCRIPTION	PROBLEMS
		as insufficiently known.	Little is known about the presence of reptiles, amphibians and aquatic invertebrates; this needs investigations so that an inventory is produced. The Irrawaddy dolphin population needs close monitoring and protection measures to counter the risk posed by gill-nets.
	Natural processes	A large number of Mekong fish species undertake long migrations between the upper and lower reaches and between the mainstream and floodplain habitats, but the origin and destination of migratory species and the ecological factors determining these behaviours are still by and large unknown. Wet-season migrations mainly involve Pangasidae, Siluridae, Bagridae, Sisoridae and Cyprinidae, while dry season migrations mainly involve Cyprinidae (Singhanouvong et. al., 1996). The complex of the Khone Falls limits their migratory movements to a few channels. These processes need to be preserved and should not be disturbed in any way, in order to ensure the integrity of the riverine ecology.	Excessive fishing effort, the construction of dams across the mainstream for hydropower generation, water abstraction for hydropower generation and irrigation, and the impacts of land development on local hydrological processes and water quality are all potential threats to the integrity of fish migration patterns.
	Humid habitats	Despite intense human pressure, these reaches of the Mekong maintain a very high diversity of riverine habitats (see Chapter 1) over a vast area. Their diversity is due to hydrological and geomorphological characteristics and vegetation structure. These habitats provide a wide range of niche conditions for aquatic species and are still relatively undisturbed. This makes the site unique and at the same time a clear example of the complexity of the lower Mekong River ecosystem.	Critical and unique wetland habitats (i.e., those surrounding the shores of the southern islands and their rocky channels, the Tholati wetland and the residual floodplain habitats still preserved in Mounlapamok) should be placed under an appropriate conservation system. The importance of Siphandone riverine habitats to fish species has been highlighted, e.g.: known breeding sites in deep pools for dry-season bottom spawners such as *Boesemania microlepis* and the red listed *Probarbus jullieni* (Roberts and Warren, 1994; Baird, herewith), whose populations have both experienced dramatic declines in the basin. However, the limited knowledge of the ecology of Mekong fish species prevents a satisfactory assessment and the subject needs further investigation. Lao P.D.R. lacks a policy framework for the management of wetlands. Existing conservation policies and legislation are not adequate to ensure protection and wise use of riverine habitats. An area-wide local management system should be gradually developed in a pilot form.
	Terrestrial habitats	Natural habitats on land have generally been severely impacted upon by man. Less degraded MXF forest areas in the southern islands remain.	The preservation of the residual mixed evergreen deciduous forest areas in the southern islands should be included in future conservation plans.
Scenic beauty	**Natural landscape**	The area is endowed with exceptional scenic beauty, due to a complex of landscape elements, which are both natural and man made. Natural features include the large complex of waterfalls across the river course, the myriad islands, the endless web of channels, the striking Tholati wetland with its labyrinthine expanse of vegetated alluvial deposits and the lunar landscape N of Somphamit waterfalls, the variety of riverine habitats; the rocky channels bordered by semi-evergreen forests in the southern islands.	Increased human population pressure will impact on local natural resources on which people rely for their livelihood. There is a strong need to diversity income sources and introduce small-scale artisanal and processing activities to make local livelihoods less dependent on the natural resource base.

VALUES	INDICATORS	DESCRIPTION	PROBLEMS
	Man-made landscape	Man-made landscape elements include the peaceful agricultural land and the busy river banks dotted with villages, the easily observable exceptional fisheries, both the striking seasonal fisheries of the falls area, targeting the fish migrations with large traps, and the more common and intense fisheries activities which take regularly along the channels.	
	Visible and attractive species	Visitors to Siphandone can easily observe the Irrawaddy dolphins near the border with Cambodia; spectacular fish behaviour (such as the seasonal migrations along the southern channels when they are targeted by local fisherfolk; the noisy spawning of croakers in the deep pools); a large variety of fish species in the catches, including large species; riverine birds.	
Historical and cultural values	**Historical role and remains**	Siphandone has always been the southern gateway of Laos and this role is visibly represented by the ruins of the railway with its piers and bridge built by the French colonisers around 1900. More ancient remains scattered among the many temples and villages which dot the archipelago are still awaiting an inventory and would probably show the legacy of ancient settlements and a trading route along the Mekong River. Khong town and villages located in Done Khong island offer a number of architectural attractions. These include the old temples in Khong (Wat Puan Arunotai, Wat Jomthong), Ban Senhat-Gnai (Wat Phukhao Kaew), Ban Na (Wat Nuenbanna) and Ban Houay (Wat Hang Khong).	Historical remains are in a state of neglect and need attention for restoration and to improve their recreational and tourism value.
	Lifestyle	The peaceful and natural life of the thousands of people settled along the shore and in dozens of islands, busily involved with their intense agricultural and fisheries activities in the middle of the striking riverine landscape is very attractive. The local people have a deep and vast knowledge of riverine ecology and have adopted a wide range of fishing techniques, finely adapted to the diversity of riverine habitats and fish species. The capture fisheries of the southern islands are probably unique in the basin.	Increased market penetration and closer economic integration will bring about fundamental changes in the local lifestyle and socio-economic fabric. Fear of loosing control on social change may prevent Government authorities to support participatory development processes. Social and economic change may also bring about the breaking down of traditional resource management systems.
	Educational and social values	The close social fabric of the local people is still relatively preserved and is testimony of Lao traditions and culture.	
Scientific value	**Reference site for the Mekong River**	The area with its striking natural features, observable rare fish species, overall fish biodiversity, diversity of habitats and migration patterns, provides an excellent site for scientific investigations on the aquatic biodiversity and the ecological processes of the Mekong river.	Long term scientific research programmes should be established in the area.
FUNCTIONS (indirect use values)			
Maintenance of the integrity and stability of the Mekong River ecosystem	**Hydrological processes**	Siphandone's morphological features such as the network of winding channels, extensive shallow vegetated areas with low flow during the dry season and larger seasonally flooded areas are all likely to have a significant impact on the maintenance of the integrity of hydrological processes for downstream reaches, such as the regulation of flow velocity, flooding, the transport of sediment, water quality. The complex of waterfalls could play an important role in maintaining oxygen concentration in downstream reaches	Detailed knowledge of local hydrological processes is limited. The system is unstable and still subject to geomorphological changes, mainly due to continuing erosion which affects the alluvial system of the islands. The lack of information, coupled with weak impact assessment procedures, complicate the planning of large-scale infrastructure investments, which need to be appraised with a precautionary approach.

VALUES	INDICATORS	DESCRIPTION	PROBLEMS
	Nutrient cycling processes	The vast range of hydrological conditions within the wetland complex suggests it could play potentially significant roles in nutrient transport and cycling: the extensive network of winding channels, extensive shallow vegetated areas with low flow during the dry season, the larger seasonally-flooded areas and the extensive presence of riparian vegetation may all affect local nutrient trapping capacity, primary productivity and allochthonous inputs into the river system.	Knowledge about the aquatic ecology of the Mekong, its hydrological conditions and the transport of sediment is inadequate. This lack of detailed information has so far prevented a meaningful assessment of the functions of complex reaches of the river such as in the Siphandone area and elsewhere, functions which are critical for the maintenance of the integrity of the river's ecosystem, such as the role in the nutrient cycling process. Proper assessment is also hindered by the lack of detailed information on hydrological conditions, including the transport of sediments. Any alteration to the morphology and hydrology of the area due to infrastructural development may generate cumulative impacts on the river's ecology which would be felt further downstream. Natural and man-made changes to key ecological factors within the catchment area, such as changes in precipitation, sediment load, etc., could have a profound impact on the riverine ecology and hence on the special ecological features and habitats found within Siphandone: e.g., impact on fish migrations due to reduced / seasonally-changed river flow caused by upstream dams, climatic changes and land use changes; impact on local water quality due to increased sediment load caused by catchment area deforestation and land degradation, etc.. Cumulative changes due to external factors might induce significant changes in key features of the aquatic ecosystem, such as overall productivity, the overall size of the wetland area, inter-species competition, etc..
	Role in the life cycle of species	The diversity of hydrological conditions and the range of riverine vegetation structures and hence the diversity of riverine habitats suggest that the complex of wetlands within the Siphandone area could provide a wide range of niche habitats for aquatic organisms and particularly fish species at various stages of their life cycle. Given the very limited knowledge about the aquatic ecology of the Mekong River, it is premature to draw conclusions and the scope for further research is very large. Nevertheless the traditional knowledge documented and the initial evidences collected through fisheries studies identify various preferences shown by fish species for riverine habitats. The Mekong ichthyofauna is highly migratory. Hou Sahong is an extraordinary feature of the Mekong course, as it is the main route used by migrating fish species to by-pass the waterfalls towards or from the upper reaches and it is of critical importance to migrations occurring at low water. Therefore its importance to the conservation of their life cycle and hence the Mekong aquatic ecosystem and the fisheries economy of the entire basin cannot be overestimated. The falls complex may act as a biogeographic barrier for certain species of aquatic fauna. This is certainly the case for the *O. brevirostris*; a number of fish species found in the lower Mekong basin are also reported as absent from above the waterfalls (Roberts, 1993).	The available knowledge on the identification and presence of fish species is based on studies conducted almost exclusively in the falls area. Niche habitats within this sector as well as the range of other riverine habitats outside this sector still await proper investigation. The further loss of seasonal wetland habitats due to land development for agriculture, settlements and infrastructure will further reduce important habitats for fish species which migrate laterally during the flood season. They may also affect the nutrient load of the river due to reduced inputs.
	Habitat for fish	The wide range of riverine in-stream habitats suggests that the area provides a	The fisheries co-management system established in the area protects

VALUES	INDICATORS	DESCRIPTION	PROBLEMS
		wide range of niche habitats for different life-stages and seasons for fish species: these habitats include deep pools which could provide refuge habitats during the dry season or could act as spawning and nursery sites. Known cases of fish spawning in deep pools during the dry season are *Boesemania microlepis* and *Probarbus jullieni*. The local people report a larger number of species as benefiting from the protection of deep pools.	a large number of riverine habitats (and particularly deep pools) considered critical by the local people for different species of fish. Its further evolution and implementation should be monitored. Traditional knowledge on which this system is based should be confirmed by scientific studies, along with a quantitative assessment of the effectiveness of the system on fish catches and recruitment: however, this requires a major long-term research programme.
	Habitat for wildlife	The deep pool south of the falls line is the upstream limit of the range of the *Orcaella brevirostris* in the Mekong main course. The area has the potential to support a large number of bird species associated with riverine or lowland habitats. However numbers are much reduced to population pressure. Our study in Done Khone revealed the presence of over 150 species of birds. Of special interest were observations of various regionally threatened water birds (Adjutants, Woolly-necked Stork, River Tern, Oriental Darter, Greater Thick-knee), Grey-headed Fish-Eagle and three species of vulture (Red-headed Vulture, White-rumped Vulture and Long-billed Vulture).	The survival of the population of *O. brevirostris* requires continued monitoring and probably in the near future a reassessment of the impact of gill-net fisheries. Levels of disturbance, habitat encroachment and hunting affect local bird populations. Their preservation may benefit both biodiversity and local people through ecotourism. Terrestrial and avian fauna might increase in number thanks to improved wildlife protection and habitat conservation measures as well as by making available additional sources of income and food for the local people.

Table 19. Synopsis of Siphandone wetlands values and problems.

	VALUES	Initial assessment	Value Rank: Potential future value	Value Rank: Moderate present value	Value Rank: High present value	Human Pressure Rank: Potential future pressure	Human Pressure Rank: Low present pressure	Human Pressure Rank: High present pressure
Resource use values	Forestry production	✓	■			■	■	■
	Agriculture production	✓	■	■	■	■	■	
	Forage production		■	■				
	Non timber forestry products	✓	■	■		■	■	■
	Livestock production		■	■	■	■		
	Fisheries production	✓	■	■	■	■	■	■
	Wildlife production		■	■		■	■	
	Aquaculture production		■					
	Water supply		■	■	■	■		
	Hydropower production	✓	■			■		
	Fuel wood production	✓	■	■		■	■	■
	Local transport		■	■	■			
	Regional transport		■					
	On-site tourism	✓	■	■	■	■		
	Base for near-by tourism	✓	■					
	Environmental education	✓	■					
	Domestic waste disposal		■	■		■	■	
	Land development areas		■			■		
Non use values	Richness of flora diversity	✓	■	■		■	■	■
	Richness of aquatic fauna diversity	✓	■	■	■	■	■	
	Richness of terrestrial fauna diversity	✓	■			■	■	■
	Richness of natural processes		■	■		■	■	
	Diversity of humid habitats		■	■	■	■		
	Diversity of terrestrial habitats	✓	■			■	■	
	Not facing uncontrollable external threats		■	■		■		
	Significant topographic / hydrological variations	✓	■	■	■			
	Only one of this type in the Mekong basin	✓	■	■	■			
	Attractive scenic qualities	✓	■	■	■			
	Range of landscape types	✓	■	■				
	Range of riverine habitats	✓	■	■	■	■	■	
	Large number of visible or attractive species	✓	■	■		■	■	
	Unique riverine landscape features in the basin	✓	■	■	■			
	Accessible wilderness area		■			■	■	
	Site of historical significance	✓	■	■	■			
	Archaeological sites		■					
	Significant cultural features and lifestyle	✓	■	■		■		
	Presence of distinctive fisheries techniques	✓	■	■	■	■		
	Place for public educational		■					
	Reference site for research on riverine ecology		■					
	Presence of rare / endangered species	✓	■	■	■	■	■	
Functions	Hydrological processes		■	■		■		
	Nutrient cycling processes		■	■		■		
	Role in the life cycle of species	✓	■	■	■	■	■	
	Habitat for fish	✓	■	■	■	■	■	

Renato Novelli and Silanh Senethavy	James F. Maxwell	Bounpheng Philavanh, Bounthong Senesouk, Khamsouk Xayyamanyvong, Somphong Bounphasy, Ian Baird, Visay Inthaphaisy, Pongsavath Kisouvannalath
Savay Phimmasone *(left)*	Antonio Brambati and Giovanni Battista Carulli	Peter Cunningham
Pheng Phaengsintham and hosts	Max with his specimens and local experts	Stephen Elliott

The GIS team in Vientiane: Keovisan Kongsayasak Sisai Chounnacanh Aloyadeth Banauvong Cristina Milesi Amala Sounlivong	Suvat of Khong Forestry Office	Listening to the croakers in the pool	The Deputy Governor of Khong at our final fishermen meeting
Giuseppe Daconto and Pongsavath Kisouvannalath	Class at km 20 Fruit Station	Our hosts never let us go hungry	Petsamone Sourivong, Sisay Chounnavanh and Max posing in Tholati wetland

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Appendix 1

Maps of Siphandone wetlands

- ❶ **Geology**
- ❷ **Morphological units and habitats**
- ❸ **River bank stability**
- ❹ **Land cover**
- ❺ **Main islands**
- ❻ **Key villages**
- ❼ **Southern sector**

Appendix 2

Flora of Siphandone wetlands

Compiled by James F. Maxwell

Key to abbreviations

Habit	t	tree	**Habitat**	cult	cultivated area
	l	treelet		da	disturbed area, overgrown places
	s	shrub		dof	Deciduous dipterocarp-oak forest
	h	herb		mxf	mixed everg.+decid., seasonal, hardwood forest
	v	vine		pon	ponds
	wc	woody climber		rvf	riverine flood zone
	sc	scandent		rvs	riverine backshore
	cr	creeping		sg	secondary growth
				str	streams
Phenology	a	annual		wa	wet areas
	pe	perennial evergreen			
	pd	perennial deciduous	**Substrate**	Gv	gravel
	ped	perennial evergreen-deciduous		Rk	bedrock
				Sa	sand
Life Mode	aqu	aquatic		St	silt/mud
	cul	cultivated			
	epi	epiphytic	**Bedrock**	ry	rhyolite
	epl	epilithic		sh	shale
	gro	ground		ss	sandstone
	hemi par	hemiparasite			
	int	introduced, not native	**Month**	ja	january
	nat	naturalised, not native		fe	february
	par	parasite		mr	march
	rhe	rheophyte		ap	april
	str	strangler		my	may
	wee	weed		jn	june
				jl	july
Abundance	0	probably extirpated		ag	august
	1	down to a few individuals		sp	september
	2	rare		oc	october
	3	medium abundance		nv	november
	4	common but not dominant		dc	december
	5	abundant			

FAMILY	SPECIES	HABIT	PHEN.	ABUN	LIFE MODE	HABITAT	SUBST-RATE	BEDROCK	FLOWER MTH	FRUIT MTH	LEAF MTH
Dilleniaceae	*Dillenia hookeri Pierre*	s	pd	3	gro	dof		ry ss	fb-sp	my-oc	jl-mr
	Dillenia ovata Wall. ex Hk. f. & Th.	t	pd	3	gro	mxf		ry	ja-fb	mr-ap	ja-dc
	Dillenia pentagyna Roxb.	t	pd	3	gro	dof		ss	ap-my	jn-jl	jn-dc
	Tetracera lourieri (Fin. & Gagnep.) Pierre ex Craib	sc	pe	3	gro	da sg		ry ss	ap-my (sp)	jn-jl	ja-dc
Annonaceae	*Annona squamosa L.*	l	pd	3	gro cul int	cult		ry	ap-my	sp-oc	my-mr
	Anomianthus dulcis (Dun.) Sincl.	wc	pd	3	gro	da sg mxf		ss ry	ap-my	ag-oc	ap-ja
	Artabotrys intermedius Hassk.	wc	pe	3	gro	mxf		sh ss	fb-mr	mr-ap	ja-dc
	Cananga latifolia (Hk. f. & Th.) Fin. & Gagnep.	t	pd	3	gro nat	sa be		ss	my-jn	sp-oc	ap-dc
	Cyathostemma micrantha (Hk. f. & Th.) Sincl.	s sc	pd	3	gro	da sg mxf	sa	sh ss ry	ap-my	sp-oc	ap-ja
	Desmos velutinus (Hance) Ast	l	pd	3	gro	mxf		ry	ap-my	sp-oc	ap-ja
	Ellipelopsis cherrevensis (Pierre ex Fin. & Gagnep.) R.E. Fr.	s	pd	2	gro	dof		ry	my-jn	sp-oc	my-fb
	Miliusa cuneata Craib	t (l, s)	pd	3	gro	da sg		ss	ap-my	ap-my	ap-dc
	Polyalthia evecta (Pierre) Fin. & Gagnep. var. evecta	s	pd	3	gro	da sg		sh ss	ag-oc	oc-dc	my-fb
	Polyalthia modesta (Pierre) Fin. & Gagnep.	s	pd	3	gro rhe	streams in rvf	sa rk	ss	dc	mr-ap	nv-jn
	Polyalthia sp.	l	pe	3	gro	mxf		sh ss	?	sp-oc	ja-dc
	Polyalthia sp.	s	pe	3	gro	mxf		sh ss	?	sp-oc	ja-dc
	Uvaria cordata (Dun.) Alst.	wc	pe	3	gro	mxf		sh ss ry	jl-sp	sp-nv	ja-dc
	Uvaria dac Pierre ex Fin. & Gagnep.	wc	pe	3	gro	mxf		sh ss ry	my-jn	sp-oc	ja-dc
	Uvaria fauveliana Pierre ex Fin. & Gagnep.	wc	pe	2	gro	mxf		sh ss	mr-ap	sp-oc	ja-dc
	Uvaria pierrei Fin. & Gagnep.	s	pe	2	gro	mxf da sg		ry	ap-my	sp-oc	ja-dc
	Uvaria rufa Bl.	wc	pd	3	gro	mxf		sh ss ry	my-jn	sp-oc	my-fb
Menispermaceae	*Cyclea barbata Miers*	v	pd	3	gro	da sg mxf		sh ss ry	sp-oc	nv-dc	ja-dc
	Limacia scandens Lour.	v	pe	3	gro	da sg		ss	my-jn	sp-oc	ja-dc
	Stephania venosa (Bl.) Spreng.	v	pd	3	gro	mxf da sg		sh ss ry	jn-jl	ag-sp	my-ja
	Tiliacora triandra (Colebr.) Diels	wc (v)	pd	3	gro	da sg mxf		ry ss	dc-fb	sp-oc	jn-ap
	Tinospora ? siamensis For.	v	pe	3	gro	da sg		ss	?	?	jn-ja
	Tinospora crispa (L.) Hk. f. & Thoms.	v	pd	3	gro	mxf da sg		ss	fb-mr	my-jn	jn-ja
Ceratophyllaceae	*Ceratophyllum demersum L.*	h	pe	4	aqu	streams in rvf	sa rk	sh ss	?	?	ja-dc
Nymphaeaceae	*Nelumbo nucifera Gaertn.*	h	pd	3	aqu cul int	ponds in		sh ss ry	jl-oc	sp-nv	jn-ja
	Nymphaea nouchali Burm. f.	h	pd	3	aqu	ponds in		sh ss ry	jl-oc	sp-nv	jn-ja
Capparaceae	*Capparis micracantha DC.*	sc	pd	3	gro	da sg rvs mxf	sa	sh ss	sp-fb	ap-jn	my-fb
	Cleome gynandra L.	h	a	3	gro wee	da sg	sa	ss	ja-dc	ja-dc	ja-dc
	Cleome viscosa L.	h	a	3	gro wee	da sg	sa	ss	ja-dc	ja-dc	ja-dc
	Crateva magna (Lour.) DC.	t	pd	4	gro	streams in rvf	rk st sa	sh ss	sp-ap	sp-jn	my-dc
Moringaceae	*Moringa oleifera Lmk.*	t	pd	3	gro cul int	da sg		sh ss	sp- nv	ag-sp	my-dc
Polygalaceae	*Polygala brachystachya DC.*	h	a	3	gro	wet areas in dof		sh ss ry	ag-oc	sp-nv	jn-dc
	Polygala persicariaefolia DC.	h	a	3	gro wee	rvf	sa	sh ss	nv-fb	dc-mr	nv-jl
	Salomonia cantoniensis Lour. var. cantoniensis	h	a	3	gro	wet areas in da cult dof	sa ry	sh ss	sp- nv	oc-dc	my-dc
	Xanthophyllum lanceatum (Miq.) J.J. Sm.	t	pe	3	gro	mxf rvs		ss	mr-ap	jl-ag	ja-dc
Caryophyllaceae	*Polycarpaea corymbosa (L.) Lmk.*	h	a	3	gro	rocks in dof	rk	ry	ag-oc	sp-nv	jn-dc
	Polycarpon prostratum (Forsk.) Arch & Sch	h	a	3	gro wee	3	sa	sh ss	nv-dc	dc-mr	nv-jl
Portulacaceae	*Portulaca oleracea L.*	h	a	3	gro wee	rvf	sa	sh ss	ap-my	ja-fb	nv-jl
	Trianthema portulacastrum L.	h	a	3	gro cul int	da sg		sh ss ry	ag-nv	sp-dc	my-dc
Guttiferae (Hypericaceae)	*Calophyllum retusum Wall. ex Pl. & Tr.*	s	pe	3	gro	mxf da		ry	jl-ag	ap-my	ja-dc
	Cratoxylum formosum (Jack) Dyer ssp. pruniflorum (Kurz) Gog.	t (l)	pd	3	gro	da sg		ry ss	mr-my	jl-sp	mr-dc
	Cratoxylum maingayi Dyer	t	pd	3	gro	dof da sg		ss ry	ap-my	sp-nv	my-dc
	Garcinia cowa Roxb.	t	pd	3	gro	rvs	sa	ss	ap-my	mr-ap	ap-fb

FAMILY	SPECIES	HABIT	PHEN.	ABUN	LIFE MODE	HABITAT	SUBST-RATE	BEDROCK	FLOWER MTH	FRUIT MTH	LEAF MTH
	Mammea siamensis (Miq.) T. And.	t	pe	3	gro	mxf da sg rvs		ry ss sh	ja-fb	ap-my	ja-dc
Flacourtiaceae	*Casearia grewiifolia Vent. var. grewiifolia*	t	pd	3	gro	da sg rvs		ry sh ss	ap	ap-my	ap-fb
	Flacourtia indica (Burm. f.) Merr.	t (l,s)	pd	3	gro	da sg		ss ry	mr-my	sp-oc	ap-dc
	Homalium tomentosum (Vent.) Bth.	t	pe	2	gro	mxf da sg		sh ss	ag-oc	jl-sp	ja-dc
	Hydnocarpus anthelminthica Pierre ex Lanes.	t	pe	3	gro	mxf rvs	sa gv	ss	mr-ap	ap-my	ja-dc
Dipterocarpaceae	*Dipterocarpus alatus Roxb. ex G Don*	t	pe	3	gro	mxf rvs		ss ry	ja-fb	ap-my	ja-dc
	Dipterocarpus intricatus Dyer	t	pd	4	gro	dof		ry sh ss	nv-dc	fb-mr	jn-mr
	Dipterocarpus obtusifolius Teijsm. ex Miq. var. obtusifolius	t	pd	4	gro	dof		ry sh ss	oc-dc	dc-fb	my-fb
	Dipterocarpus tuberculatus Roxb. var. tuberculatus	t	pd	4	gro	dof		ry sh ss	mr-ap	ap-my	ap-fb
	Hopea ferrea Pierre ex Lanes.	t	pe	2	gro	mxf		ry	jl-sp	fb-mr	ja-dc
	Shorea obtusa Wall. ex Bl.	t	pd	4	gro	dof		ry sh ss	mr-my	ap-jn	ap-fb
	Shorea siamensis Miq. var. siamensis	t	pd	4	gro	dof		ry sh ss	ja-fb	mr-ap	fb-nv
Ancistrocladaceae	*Ancistrocladus tectorius (Lour.) Merr.*	sc s	pe	3	gro	mxf		sh ss	ap-my	jn-jl	ja-dc
	Ancistrocladus wallichii Pl.	l (s)	pe	2	gro	wet areas in mxf		ss	ap-my	jn-jl	ja-dc
Cochlospermaceae	*Cochlospermum religiosum (L.) Alst.*	l	ped	3	gro cul int	da cult		ry	ja-fb	mr-ap	my-dc
Malvaceae	*Abelmoschus moschatus Medic. ssp. moschatus var. moschatus*	h	a	3	gro	da sg		sh ss ry	ag-oc	oc-nv	my-dc
	Abelmoschus moschatus Medic. ssp. tuberosus (Span.) Borss.	h	pd	3	gro	dof		sh ss ry	ag-oc	oc-nv	my-dc
	Decaschistia harmandii Pierre	h	pd	2	gro	dof		ry ss	ap-sp	jn-oc	ap-dc
	Hibiscus glanduliferus Craib	l	pd	3	gro	da sg		sh ss ry	ag-oc	nv-dc	my-ja
	Sida rhombifolia L. ssp. rhombifolia	h	ped	4	gro wee	da sg		sh ss ry	ag-oc	nv-dc	ja-dc
	Urena lobata L. ssp. lobata var. lobata	h	pe	3	gro wee	da sg cult		ss	sp-ja	oc-fb	ja-dc
Bombacaceae	*Bombax anceps Pierre var. anceps*	t	pd	3	gro	da sg dof		ry sh ss	dc-fb	mr-ap	my-nv
	Bombax ceiba L.	t	pd	3	gro	da sg		ry sh ss	ja-fb	mr-ap	my-nv
	Ceiba pentandra (L.) Gaertn.	t	pd	3	gro cul int	cult		ry sh ss	fb-ap	fb-ap	my-nv
Sterculiaceae	*Byttneria aspera Colebr.*	wc	pe	2	gro	mxf		sh ss	jn-jl	dc-ja	ja-dc
	Byttneria echinata Wall. ex Kurz	wc	pe	3	gro	mxf da sg		ry	jn-jl	sp-oc	ja-dc
	Helicteres hirsuta Lour.	s	pd	3	gro	da sg mxf		ry sh ss	sp-oc	ja-fb	my-dc
	Helicteres lanceolata A. DC. var. lanceolata	l (h)	pd	4	gro	dof sg da		ry sh	sp- nv	ja-fb	my-dc
	Melochia corchorifolia L.	h	a	3	gro wee	da sg cult		sh ss ry	sp- nv	nv-dc	my-dc
	Pterospermum diversifolum Bl.	t	pe	3	gro	mxf rvs		ss	ap-sp	sp-oc	ja-dc
	Pterospermum grande Craib	t	pd	3	gro	mxf da sg		ry sh ss	ja-mr	dc-fb	my-fb
	Pterospermum semisagittatum Ham. ex Roxb.	l	pd	3	gro	mxf		sh ss ry	mr-ap	ag-oc	my-mr
	Sterculia urena Roxb. var. thorelii (Pierre) Pheng.	t	pd	3	gro	mxf rvs		ry sh ss	oc-nv	ja-fb	ap-oc
	Waltheria americana L.	h	a	3	gro wee	da sg cult		sh ss ry	ag-oc	oc-dc	my-dc
Tiliaceae	*Berrya mollis Wall. ex Kurz*	t	pd	3	gro	da sg		sh ss	ap-my	sp-nv	my-dc
	Brownlowia emarginata Pierre	t	pe	3	gro	mxf rvs		ss	ap-my	sp-oc	ja-dc
	Colona auriculata (Desf.) Craib	s	pd	4	gro	da sg dof		ry sh ss	ag-oc	oc-ja	my-ja
	Colona floribunda (Kurz) Craib	t	pd	3	gro	da sg		sh ss ry	sp- nv	dc-ja	jn-fb
	Corchorus aestuans L.	h	a	3	gro wee	da sg cult		sh ss ry	ag-nv	oc-dc	my-dc
	Grewia eriocarpa Juss.	t (l)	pd	3	gro	da sg		ss ry	ap-jn	ag-oc	my-fb
	Grewia hirsuta Vahl	l (wc,s)	pd	3	gro	dof		sh ss ry	jl-sp	oc-dc	my-dc
	Microcos paniculata L.	t (l)	pd	3	gro	da sg		sh ss	ap-my	sp-nv	my-dc
	Muntingia calabura L.	l	Pe	3	int gro nat cul	da sg cult		ry sh ss	ja-dc	ja-dc	ja-dc
Erythroxylaceae	*Erythroxylum cambodianum Pierre*	l	Pe	2	gro	mxf		ry	jl-sp	sp-nv	ja-dc
Oxalidaceae	*Averrhoa carambola L.*	t	pe	3	gro cul int	cult		ss	ap-my	nv-dc	ja-dc
	Biophytum sensitivum (L.) DC.	h	a	3	gro wee	da sg cult		sh ss ry	jl-nv	ag-dc	my-dc
Balsaminaceae	*Hydrocera triflora (L.) Wight & Arn.*	h	a	2	aqu gro	wet areas in dof	st	sh ss ry	ag-oc	oc-nv	my-dc
Rutaceae	*Acronychia pedunculata (L.) Miq.*	t	pe	3	gro	mxf		sh ss ry	jl-sp	nv-dc	ja-dc
	Aegle marmelos (L.) Corr.	t	pd	3	gro	da sg rvs		ry ss	ap-my	sp-oc	ap-dc

FAMILY	SPECIES	HABIT	PHEN.	ABUN	LIFE MODE	HABITAT	SUBST-RATE	BEDROCK	FLOWER MTH	FRUIT MTH	LEAF MTH
	Atalantia monophylla (L.) DC.	t (l)	pe	2	gro	mxf da sg		ry	oc-dc	my-jl	ja-dc
	Clausena excavata Burm. f. var. excavata	l (t)	pd	3	gro	da sg		ry sh ss	ap-nv	sp-dc	ap-dc
	Euodia simplicifolia Ridl.	h	pd	2	gro	dof		ss	ap-my	jl-ag	ap-nv
	Feronia limonia (L.) Swing.	t	pd	3	gro	sg da		ry sh ss	ja-fb	sp-nv	my-ja
	Glycosmis parva Craib	s	pe	3	gro	mxf		ss ry	mr-my	ap-jn	ja-dc
	Glycosmis pentaphylla (Retz.) DC. var. pentaphylla	l (s)	pe	3	gro	sg		ry sh ss	sp-ap	ja-my	ja-dc
	Micromelum sp.	h	pd	3	gro	dof		ss	ap-my	?	ap-dc
	Murraya paniculata (L.) Jack	t (l)	pe	3	gro	mxf		sh ss	ap-my	sp-oc	ja-dc
	Zanthoxylum rhetsa (Roxb.) DC.	t	pe	2	gro	mxf		sh ss	my-jn	sp-oc	ja-dc
Simaroubaceae	*Brucea javanica (L.) Merr.*	l	pd	3	gro	dof da sg		ry ss	ag-sp	sp-nv	my-dc
	Eurycoma longifolia Jack	l	pd	3	gro	mxf		ry ss	mr-ap	my-jn	my-fb
	Harrisonia perforata (Blanco) Merr.	wc sc	pd	3	gro	da sg		ry sh ss	ap-my	sp-oc	ap-fb
	Quassia larmandiana (Pierre) Noot.	t	pe	3	gro	mxf rvf rvs	sa gv	sh ss	ap-my	jn-jl	ja-dc
Irvingiaceae	*Irvingia malayana Oliv. ex Benn.*	t	pe	3	gro	dof mxf		ry ss	ap-jn	sp-oc	ja-dc
Ochnaceae	*Gomphia serrata (Gaertn.) Kanis*	l	pd	3	gro	da sg mxf		ry	nv-ja	fb-mr	my-mr
	Ochna integerrima (Lour.) Merr.	t (l)	pd	2	gro	dof		ry ss	ja-my	mr-ap	fb-nv
Burseraceae	*Canarium subulatum Guill.*	t	pd	3	gro	dof da sg		ss ry	ap-my	my-jl	ap-dc
Meliaceae	*Aglaia malaccensis (Ridl.) Pann.*	t	pe	3	gro cul int	cult		ry	sp-oc	mr-ap	ja-dc
	Aglaia odorata Lour.	l	pe	3	gro	rocks in mxf rvs	sa gv	sh ss	oc nv	ap-my	ja-dc
	Aphanamixis polystachya (Wall.) R. Parker	t	pe	3	gro	mxf		ry	ag-sp	mr-ap	ja-dc
	Azadirachta indica A. Juss.	t	pd	3	gro cul int	cult		ss	fb-jn	my-jl	fb-dc
	Chukrasia tabularis A. Juss.	t	pd	2	gro	mxf		ry	ap-my	ag-oc	ap-ja
	Sandoricum koetjape (Burm. f.) Merr.	t	pe	3	gro	mxf		ss	mr	ap-my	ja-dc
	Turraea pubescens Hell.	l (s)	pd	3	gro	mxf da		ss	ap-my	?	my-dc
	Walsura pinnata Hassk.	t	pe	3	gro	mxf rvs	sa gv	ry ss	ap-my	ag-sp	ja-dc
	Walsura robusta Roxb.	t	pe	3	gro	mxf rvs	gv	ss	ap-my	ag-sp	ja-dc
Olacaceae	*Olax scandens Roxb.*	wc	pe	3	gro	da sg		ry ss	ja-jn	mr-sp	ja-dc
	Olax sp.	wc	pd	3	gro	mxf da		ry	?	ja-fb	my-mr
Celastraceae	*Euonymus similis Craib*	t (l)	pe	3	gro	streams in mxf		sh ss	my-jl	ag-sp	ja-dc
	Maytenus (Gymnosporia mekongensis Pierre)	l (s)	pd	3	gro rhe	rvf	sa gv rk	sh ss	ja-fb	fb-mr	nv-jl
	Maytenus sp.	l	pd	3	gro	mxf		sh ss	?	sp-nv	my-dc
	Salacia chinensis L.	l (s, sc)	Pe	3	gro	mxf da		ry	ja-mr	ap-jn	ja-dc
Rhamnaceae	*Colubrina pubescens Kurz*	l (s scand ent)	Pd	3		mxf da sg		sh ss	sp- nv	dc-fb	my-dc
	Ventilago denticulata Willd.	wc	Pd	2	gro	mxf rvs		ss	oc nv	fb-mr	my-mr
	Ziziphus cambodiana Pierre var. cambodiana	sc	Pd	3	gro	da sg		sh ss	ap-my	sp-nv	ap-dc
	Ziziphus nummularia (Burm. f.) Wight & Arn.	l	Pe	3	gro	da sg		ry ss	ap-oc	nv-ja	ja-dc
	Ziziphus oenoplia (L.) Mill. var. oenoplia	Wc sc	Pd	4	gro	da sg		sh ss	sp- nv	dc-ja	my-fb
Vitaceae	*Ampelocissus martinii Planch.*	v	Pd	3	gro	mxf da sg		ss	mr-my	sp-oc	ap-dc
	Cayratia roxburghii (Wight & Arn.) Gagnep.	wc	Pd	2	gro	da sg		ss	ap-my	jl-sp	my-dc
	Cayratia trifolia (L.) Dom. var. trifolia	v	pd	3	gro	da sg in rvs mxf		sh ss	ap-my	jl-sp	ja-dc
	Cissus adnata Roxb.	wc	pd	3	gro	mxf da sg		ss ry	jl-sp	sp-nv	my-dc
	Cissus discolor Bl. var. discolor	v	pe	3	gro	da sg dof mxf		ry sh ss	sp- nv	oc-dc	ja-dc
	Cissus hastata Miq.	v	a pe	3	gro	dof		sh ss ry	ag-nv	oc-dc	my-dc
	Cissus modeccoides Pl. var. modeccoides	v	pe	3	gro	da sg		sh ss	sp- nv	nv-dc	ja-dc
	Cissus quadrangularis L.	v	pe	3	gro	da sg		sh ss	sp- nv	nv-dc	ja-dc
Leeaceae	*Leea indica (Burm. f.) Merr.*	h (s)	pe	3	gro	da sg		sh ss ry	jl-oc	sp-nv	ja-dc
Sapindaceae	*Cardiospermum halicacabum L. var. halicacabum*	v	pd	3	gro wee	da sg		ss	sp-oc	ja-fb	jn-fb
	Dimocarpus longan Lour. ssp. longan var. longan	t	pe	2	gro cul int	cult		sh ss ry	mr-ap	ag-sp	ja-dc
	Lepisanthes fruticosa (Roxb.) Leenh.	l	pe	3		mxf		sh ss	ja-fb	fb-mr	ja-dc

FAMILY	SPECIES	HABIT	PHEN.	ABUN	LIFE MODE	HABITAT	SUBST-RATE	BEDROCK	FLOWER MTH	FRUIT MTH	LEAF MTH
	Lepisanthes senegalensis (Poir.) Leenh.	l	pe	3	gro	rocks in mxf rvs	gv rk	sh ss	ja-fb	fb-mr	ja-dc
	Lepisanthes tetraphylla (Vahl) Radlk.	t	pe	3	gro	mxf		sh ss	ja-fb	fb-mr	ja-dc
	Schleichera oleosa (Lour.) Oken	t	pd	3	gro	dof		ry ss	ja-mr	my-jn	mr-dc
Anacardiaceae	*Buchanania glabra Wall. ex Hk. f.*	t (l)	pd	3	gro	dof		ry ss	nv-dc	ja-fb	my-mr
	Buchanania lanzan Spreng.	t	pd	3	gro	dof		ss ry	ja-mr	mr-my	my-mr
	Lannea coromandelica (Houtt.) Merr.	t	pd	3	gro	dof da sg		ss ry	ja-mr	ap-my	my-dc
	Mangifera camptosperma Pierre	t	pe	3	gro	mxf da	sa	ss	ap-my	mr-ap	ja-dc
	Mangifera indica L.	t	pe	3	gro cul	cult		ry sh ss	fb-mr	jl-ag	ja-dc
	Semecarpus cochinchinensis Engl.	t	pe	2	gro	mxf		sh ss ry	dc-mr	mr-my	ja-dc
	Spondias pinnata (L. f.) Kurz	t	pd	3	gro	dof		ry ss	ja-mr	dc-mr	my-dc
Connaraceae	*Connarus cochinchinensis (Baill.) Pierre*	s wc sc	pe	3	gro	rvs mxf	sa	ry sh ss	ap-my	sp-my	ja-dc
	Rourea minor (Gaertn.) Leenh. ssp. minor	wc	pe	3	gro	mxf		ry	sp- nv	ja-mr	ja-dc
Leguminosae, Mimosoideae	*Acacia harmandiana (Pierre) Gagnep.*	t	pd	4	gro rhe	rvf	sa gv rk	ss	fb-ap	dc-ja	nv-jl
	Acacia leucophloea (Roxb.) Willd.	l	pd	3	gro	da sg		ry	ag-sp	ap-my	my-ja
	Acacia megaladena Desv. var. indo-chinensis I. Neils.	wc	pd	3	gro	da sg		ss ry	ap-my	oc-nv	mr-dc
	Acacia megaladena Desv. var. megaladena	wc	pd	3	gro	da sg		sh ss	sp- nv	fb-mr	my-fb
	Albizia lebbeck (L.) Bth.	t	pd	3	gro	da sg rvs	sa	sh ss	sp- nv	ap-my	ja-dc
	Albizia procera (Roxb.) Bth.	t	pe	2	gro	da sg rvs		ry	ag-sp	mr-ap	ja-dc
	Entada glandulosa Pierre ex Gagnep.	v	a	2	gro	da sg		sh ss	jn-ag	sp-oc	my-dc
	Mimosa diplotricha C. Wright ex Sauv. var. diplotricha	h	a	3	nat wee gro int	da sg cult		sh ss ry	sp- nv	nv-ja	my-ja
	Mimosa pigra L.	l	pe	5	gro wee int nat rhe	da sg rvf	sa	ry sh ss	ja-dc	ja-dc	ja-dc
	Mimosa pudica L. var. unijuga (Duch. & Walp.) Griseb.	h	a, pe	3	gro int nat wee	da sg cult		sh ss ry	ag-oc	nv-dc	ja-dc
	Samanea saman (Jacq.) Merr.	t	pd	3	int cul gro	cult		ry sh ss	ap-my	fb-mr	my-mr
	Xylia xylocarpa (Roxb.) Taub. var. kerrii (Craib & Hutch.) Niels.	t	pd	3	gro	dof		ry sh ss	ja-fb	oc-nv	mr-dc
Leguminosae, Caesalpinioideae	*Bauhinia glauca (Wall. ex Bth.) Bth. ssp. tenuiflora (Watt ex Cl.) K.& S. S. Lar.*	wc	pd	3	gro	da sg		sh ss	sp- nv	ja-fb	jn-fb
	Bauhinia malabarica Roxb.	t	pd	3	gro	da sg dof		sh ss	oc nv	ja-fb	my-ja
	Bauhinia penicilliloba Pierre ex Gagnep.	v	pd	3	gro	da sg		ry	sp- nv	ag-oc	my-dc
	Caesalpinia hymenocarpa (Prain) Hatt.	wc sc	pd	3	gro	da sg		ry sh ss	sp- nv		my-fb
	Caesalpinia mimosoides Lmk.	wc v sc	pd	3	gro	da sg		sh ss	dc-mr	fb-ap	my-mr
	Cassia fistula L.	t	pd	3	gro	dof da sg		ss ry	fb-mr	nv-ja	my-fb
	Cassia grandis L. f.	t	pd	3	gro cul int	da cult		ss ry	ap-my	fb-mr	mr-dc
	Chamaecrista mimosoides (L.) Greene	h	a	4	gro wee	da sg cult		sh ss ry	oc-dc	ja-fb	jn-fb
	Leucaena leucoocephala (Lmk.) De Wit	t (l)	pe	3	cul gro int nat	da sg cult		sh ss ry	ag-sp	nv-dc	ja-dc
	Peltophorum dasyrhachis (Miq.) Kurz var. dasyrhachis	t	pd	3	gro cul	da sg		ss ry	mr-ap	ja-ap	mr-dc
	Senna tora (L.) Roxb.	h	a	4	gro wee	da sg cult		sh ss ry	sp-oc	nv-dc	my-dc
	Sindora siamensis Teysm. ex Miq. var. siamensis	t	pd	3	gro	dof mxf		ry ss	ap-jn	nv-dc	ap-fb
	Tamarindus indica L.	t	pe	3	gro cul nat int	cult		ry sh ss	my-jn	sp-oc	ja-dc
Leguminosae, Papilionoideae	*Abrus precatorius L. ssp. precatorius*	v	a	3	gro	da sg		sh ss	sp- nv	ja-fb	ap-ja
	Aganope thyrsiflora (Bth.) Polh.	wc	pe	3	gro	mxf rvs	sa	sh ss	jl-ag	oc-dc	ja-dc
	Alysicarpus vaginalis (L.) A. DC.	h cr	a	3	gro wee	da sg cult		sh ss ry	ag-oc	oc-dc	my-dc
	Butea monosperma (Lmk.) Taub.	t	pd	3	gro	da sg cult		ry sh ss	ja-fb	jn-jl	my-fb
	Cajanus scarabaeoides (L.) du P.-T. var. scarabaeoides	v	pe	2	gro nat	da sg		sh ss	sp-oc	nv-dc	ja-dc
	Calopogonium mucunoides Desv.	v	a	3	gro wee	da sg		sh ss	sp- nv	ja-fb	my-fb
	Clitoria mariana L.	v	pd	3	gro	dof		sh ss ry	ag-oc	nv-dc	my-dc

FAMILY	SPECIES	HABIT	PHEN.	ABUN	LIFE MODE	HABITAT	SUBST-RATE	BEDROCK	FLOWER MTH	FRUIT MTH	LEAF MTH
	Crotalaria pallida Ait.	l (h)	ape	3	gro wee	da sg		ry sh ss	ja-dc	ja-dc	ja-dc
	Crotalaria verrucosa L.	h	a	3	gro	da sg		sh ss	sp- nv	ja-fb	my-dc
	Dalbergia nigrescens Kurz var. nigrescens	t	pd	3	gro	da sg		sh ss	mr-ap	sp-nv	my-dc
	Derris scandens (Roxb.) Bth.	wc (s)	pe	3	gro	mxf da sg rvs	ry sa gv	sh ss	ag-sp	oc-dc	ja-dc
	Desmodium biarticulatum (L.) Muell.	h	a	3	gro	da in dof		ss	ag-sp	sp-oc	my-dc
	Desmodium pulchellum (L.) Bth.	l (s)	pd	3	gro	dof		ry	sp-oc	dc-ja	my-fb
	Desmodium triangulare (Retz.) Merr.	l (s)	pd	3	gro	da sg		ss	oc nv	ja-fb	my-fb
	Desmodium triflorum (L.) DC.	h cr	pe	3	gro wee	da sg		ss ry	oc-dc	dc-fb	ja-dc
	Desmodium vestitum (Bth.) ex Bak.	l (s)	pd	3	gro	dof		ss	oc nv	ja-fb	my-fb
	Dolichos sp.	v	a	3	gro	da sg rvs	sa	ss	dc-fb	fb-mr	jn-mr
	Eriosema chinense Vog.	h	pd	3	gro	dof		sh ss ry	my-jn	ag-sp	ap-dc
	Flemingia strobilifera (L.) R. Br. ex Ait. f. var. strobilifera	l	pd	3	gro	da sg		ss	oc nv	ja-fb	jn-fb
	Indigofera galegoides DC.	s	pd	3	gro	da sg		sh ss	sp- nv	dc-ja	my-dc
	Indigofera wightii Grah. ex Wight & Arn.	l (s)	pd	3	gro	dof		ry	jl-ag	oc-nv	my-ja
	Lespedaza henryi Schindl.	l	pd	4	gro	dof da sg rvs	gv rk	ry sh ss	oc nv	ja-fb	my-ja
	Millettia pubinervis Kurz	t	pd	3	gro	dof da sg		ss	mr-ap	dc-fb	my-fb
	Mucuna pruriens (L.) DC. var. utilis (Wall. ex Wight) Bak. ex Burck	h	a	2	gro	rvf rvs	sa	ss	ja-fb	nv-dc	nv-jl
	Pterocarpus macrocarpus Kurz	t	pd	2	gro	mxf		ry sh ss	mr-ap	sp-ja	my-fb
	Pueraria phaseoloides (Roxb.) Bth. var. phaseoloides	v	a	3	gro	da sg		sh	sp- nv	dc-ja	my-dc
	Sesbania grandiflora (L.) Poir.	l	pd	3	gro cul int nat	cult		ry sh ss	ja-dc	ja-dc	my-fb
	Sesbania javanica Miq.	h	a	3	aqu gro	pound in	st	ss	ag-oc	nv-dc	my-dc
	Spatholobus parviflorus (Roxb.) O.K.	wc	pd	3	gro	dof		sh ss ry	jl-ag	sp-nv	my-fb
	Stylosanthes sundaica Taub.	h	a	3	gro	da in dof		ry	sp-fb	mv-mr	jn-mr
	Tephrosia kerrii Drum. & Craib	l (h)	pd	2	gro	dof		ss ry	sp-oc	dc-ja	jn-ja
	Tephrosia purpurea (L.) Pers. ssp. purpurea	h	pe	3	gro	da sg cult		sh ss ry	ag-sp	dc-ja	ja-dc
	Uraria crinita (L.) Desv. ex DC.	l (h)	pd	3	gro	da sg		sh ss	ag-oc	oc-dc	my-dc
	Uraria lagopodioides (L.) Desv. ex DC.	l (h)	pd	3	gro wee	da sg		sh ss ry	ag-oc	oc-dc	my-dc
	Vigna unguiculata (L.) Walp. ssp. sesquipedalis (L.) Verd.	v	a	3	gro cul int	cult rvs	sa	ss	ja-dc	ja-dc	ja-dc
	Vigna vexillata (L.) A. Rich. var. angustifolia (Schum. & Thonn.) Baker	v	a	3	gro	da sg		sh	sp- nv	nv-ja	my-fb
	Zornia gibbosa Span.	h	a	3	gro wee	dof	rk	ss ry	ag-oc	sp-nv	my-dc
Rosaceae	*Eriobotrya bengalensis (Roxb.) Hk. f. forma bengalensis*	t	pe	2	gro	mxf		ss	fb-mr	ap-my	ja-dc
	Parinari anamensis Hance	t	pe	3	gro	dof mxf		ry sh ss	ja-ap	nv-my	ja-dc
Droseraceae	*Drosera burmannii Vahl*	h	a	2	car gro	wet areas in da cult		ss	jl-ag	ag-sp	jn-dc
	Drosera indica L.	h	a	2	car gro	wet areas in dof da cult		ss	ag-sp	sp-oc	jn-dc
Rhizophoraceae	*Carallia brachiata (Lour.) Merr.*	t	pe	3	gro	mxf rvs		ry sh ss	dc-ja	my-jn	ja-dc
Combretaceae	*Anogeissus acuminata (Roxb. ex DC.) Guill. & Perr.*	t	pd	3	gro	da sg		ry sh ss	ja-mr	ap-my	ap-fb
	Anogeissus rivularis (Gagnep.) Lec.	t	pd	4	gro rhe	streams in rvf	sa gv rk	sh ss	nv-dc	ja-fb	nv-jl
	Calycopteris floribunda (Roxb.) Lmk.	wc sc	pd	3	gro	da sg		ry sh ss	ja-fb	my-jn	my-fb
	Combretum latifolium Bl.	wc	pd	3	gro	mxf		sh ss	dc-fb	my-jn	ap-fb
	Combretum quadangulare Kurz	t	ped	3	gro	da sg rvf	sa gv	ry sh ss	ap-my	oc-fb	my-fb
	Combretum trifoliatum Vent.	s wc sc	pd	3	gro rhe	streams in rvf	sa st	ry sh ss	ja-ap	jn-jl	nv-jl
	Terminalia alata Hey. ex Roth	t	pd	3	gro	dof		ry sh ss	my-jn	oc-nv	my-fb
	Terminalia chebula Retz. var. chebula	t	pd	3	gro	dof		ry sh ss	mr-ap	oc-dc	ap-ja
	Terminalia corticosa Pierre ex Gagnep.	t	pd	3	gro	dof		ss ry	my-jn	ag-oc	my-dc
	Terminalia harmandii Gagnep.	t	pd	3	gro	dof		ss ry	my-jn	ag-sp	my-dc
	Terminalia mucronata Craib & Hutch.	t	pd	3	gro	dof		ry sh ss	ja-fb	oc-dc	mr-dc

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Myrtaceae	*Eucalyptus rudis Endl.*	t	pe	2	gro cul int	da cult		ry	ag-oc	nv-dc	ja-dc
	Eugenia cumini (L.) Druce	t (l)	pd	3	gro	dof da		ss ry	ja-fb	ap-my	ap-fb
	Eugenia grandis Wight var. grandis	t	pe	3	gro	mxf da		ry	ja-fb	jl-ag	ja-dc
	Eugenia grata Wight var. grata	t	pe	3	gro	mxf da		ry sh ss	ja-fb	jn-jl	ja-dc
	Eugenia mekongensis Gagnep.	s	pd	3	gro rhe	streams in rvf	sa gv rk	sh ss	ja-fb	mr-my	nv-jl
	Eugenia thorelii Gagnep.	t	pe	3	gro	mxf da		ry	ap-sp	?	ja-dc
	Psidium guajava L.	l	pe	3	gro cul int	da cult		ss ry	mr-ap	ag-oc	ja-dc
	Rhodamnia cinerea Jack	l (s)	pe	3	gro	mxf		ry	my-jn	sp-oc	ja-dc
	Tristaniopsis burmanica (Griff.) Wils. & Wat. var. rufescens (Hance) Parn. & Lug.	t (l)	pd	3	gro	dof		ry sh ss	ja-mr	mr-ap	ap-fb
Lecythidaceae	*Barringtonia acutangula (L.) Gaertn.*	t (l)	pd	3	gro rhe	streams in rvf	sa gv rk	sh ss	ja-fb	ag-sp	nv-jl
	Careya arborea Roxb.	t	pd	3	gro	dof		ry sh ss	mr-ap	my-jn	my-fb
Melastomataceae	*Melastoma sanguineum Sims*	s	pe	3	gro	da sg		ss ry	sp-oc	nv-dc	ja-dc
	Memecylon amplexicaule Roxb.	l	pe	3	gro	mxf		ry sh ss	fb-mr	sp-nv	ja-dc
	Memecylon edule Roxb. var. edule	l	pe	3	gro	mxf	gv rk	ry sh ss	ja-fb	sp-ja	ja-dc
	Memecylon scutellatum (Lour.) Naud.	l (s)	pe	3	gro	dof da sg		ry sh ss	ap-my	sp-fb	ja-dc
	Osbeckia chinensis L. var. chinensis	h	a	3	gro	da sg		ry	oc-ja	dc-fb	jn-fb
	Sonerila erecta Jack	h	a	3	gro	dof		ry	sp- nv	oc-dc	my-dc
Lythraceae	*Ammannia baccifera L.*	h	a	3	gro wee	rvf	st sa	ry sh ss	jl-fb	sp-mr	ag-mr
	Lagerstroemia calyculata Kurz	t	pd	3	gro	mxf		ss ry	jl-ag	sp-oc	my-dc
	Lagerstroemia cochinchinensis Pierre var. ovalifolia Furt. & Mont.	t	pd	3	gro	mxf da	gv rk	ss	jl-sp	fb-ap	ap-ja
	Lagerstroemia floribunda Jack var. floribunda	t	pd	3	gro	da sg		ry sh ss	sp- nv	dc-mr	ap-dc
	Lagerstroemia loudonii Teysm. & Binn.	t	pd	3	gro	da		sh ss	ja-fb	ag-oc	my-fb
	Lagerstroemia tomentosa Presl	t	pd	3	gro	da sg		ry sh ss	ap-my	ag-oc	ap-fb
Crypteroniaceae	*Crypteronia paniculata Bl.*	t	pe	3	gro	mxf		ss	dc-ja	mr-ap	ja-dc
Onagraceae	*Ludwigia adscendens (L.) Hara*	h	a	3	aqu wee	ponds wet areas in da sg cult	st sa	ss ry	ja-dc	ja-dc	ja-dc
	Ludwigia hyssopifolia (G. Don) Exell	h	a	3	often aqu gro wee	da rvf	st sa	ss ry	ja-dc	ja-dc	ja-dc
Passifloraceae	*Adenia heterophylla (Bl.) Kds. ssp. heterophylla var. heterophylla*	v	pe	3	gro	da sg		ss	ja-mr	ap-my	ja-dc
	Passiflora foetida L.	v	pe	3	nat gro wee int	da cult		ss	mr-oc	ap-nv	ja-dc
Cucurbitaceae	*Coccinia grandis (L.) Voigt*	v	a	3	gro	da		ss	jl-oc	nv-fb	ja-dc
	Gymnopetalum cochinchinense (Lour.) Kurz	v	a	3	gro	da sg		ss ry	ag-oc	oc-nv	my-dc
	Luffa cylindrica (L.) M.J. Roem.	v	a	3	gro wee	da sg rvf		sh ss	dc-fb	mr-ap	nv-jl
	Trichosanthes tricuspidata Lour.	v	a	3	gro	da sg		ss	jn-ag	sp-oc	my-dc
Begoniaceae	*Begonia yunnanensis Lev.*	h	pd	3	gro epi epl	mxf		ry sh ss	ag-nv	oc-dc	my-dc
Datiscaceae	*Tetrameles nudiflora R. Br. ex Benn.*	t	pd	3	gro	mxf		ss	mr-ap	ap-my	my-ja
Aizoaceae	*Glinus lotoides L.*	h	a	3	gro wee	da sg rvf	sa	ry sh ss	nv-my	dc-mr	nv-jl
	Glinus oppositifolius (L.) A. DC.	h	a	3	gro wee	da sg rvf	sa	ry sh ss	nv-my	dc-jn	ap-jl
Umbelliferae	*Anethum graveolens L.*	h	a	3	cul int	cult rvf	sa	ss	dc-mr	ap-my	nv-my
	Hydrocotyle sibthorpioides Lmk.	h cr	a	2	gro wee	da rvf	sa	ss	fb-mr	ap-my	nv-jn
Alangiaceae	*Alangium salvifolium (L.f.) Wang. ssp. hexapetalum (Lmk.) Wang.*	t	pd	3	gro	da sg		ry ss	ja-mr	ap-jn	my-fb
Rubiaceae	*Aphaenandra uniflora (Wall. ex G. Don) Brem.*	h cr	pd	3	gro	dof		ss ry	jn-ag	sp-oc	my-dc
	Borreria brachystema (R. Br. ex Bth.) Valet.	h	a	3	gro	dof		ry	ag-sp	sp-oc	jn-dc
	Borreria repens DC.	h	a	3	gro wee	da sg cult		ss ry	ag-oc	sp-nv	my-dc
	Canthium umbellatum Wight	l	pe	3	gro	streams in dof mxf		ss ry	mr-my	jl-ag	ja-dc
	Catunaregam spathulifolia Tirv.	l	pd	3	gro	dof		ss ry	ap-jn	sp-nv	my-dc
	Catunaregam tometosa (Bl. ex DC.) Tirv.	t l, s	pd	3	gro	dof da sg		ry	ap-my	sp-nv	ap-dc
	Coptosapelta flavescens Korth. (var.	wc	pe	2	gro	mxf		ss	ag-sp	?	ja-dc

FAMILY	SPECIES	HABIT	PHEN.	ABUN	LIFE MODE	HABITAT	SUBST-RATE	BEDROCK	FLOWER MTH	FRUIT MTH	LEAF MTH
	flavescens)										
	Dentella repens (L.) J.R. & G. Forst.	h	a	3	gro wee	da sg rvf	sa	ry sh ss	nv-jn	dc-jl	nv-jn
	Dioecrescis (Gardenia) erythroclada (Kurz) Tirv.	l	pd	2	gro	dof		ss ry	ap-my	fb-ap	my-ja
	Diplospora viridiflora DC.	s	pe	3	gro	streams in mxf rvs	sa rk	sh ss	ja-ap	ap-my	ja-dc
	Gardenia cambodiana Pierre ex Pit.	s	pd	3	gro	dof da sg		ry ss	mr	sp-nv	ap-dc
	Gardenia obtusifolia Roxb. ex Kurz	l	pd	3	gro	dof		ry sh ss	ja-fb	oc-nv	my-dc
	Gardenia sootepensis Hutch.	t	pd	3	gro	dof mxf		ry sh ss	ap-my	dc-fb	my-mr
	Haldina cordifolia (Roxb.) Rids.	t	pd	3	gro	dof mxf		ry sh ss	ap-my	dc-fb	ap-fb
	Hedyotis coronaria (Kurz) Craib	h	pd	3	gro	da sg		sh ss	sp- nv	nv-ja	jn-dc
	Hedyotis corymbosa (L.) Lmk.	h	a	3	wee gro	da cult		sh ss ry	jl-oc	ag-nv	my-dc
	Hedyotis gracilipes (Craib) Fuku. var. gracilipes	h	a	3	gro	dof	rk	ry	ag-sp	sp-oc	jn-dc
	Hedyotis nodiflora Wall. ex G. Don	h	a	3	gro	mxf		ry	sp- nv	nv-ja	my-dc
	Hedyotis ovatifolia Cav.	h	a	3	gro	dof		ss ry	ag-oc	sp-nv	jn-dc
	Hedyotis pruinosa Wight & Arn.	s	pe	2	gro	mxf rvs	gv	sh	sp- nv	nv-dc	ja-dc
	Hedyotis tetrangularis (Korth.) Walp.	h	a	3	gro	dof		ry	sp- nv	oc-dc	my-dc
	Ixora cibdela Craib var. cibdela	l (s)	pe	3	gro	dof mxf		ry sh ss	ja-mr	sp-nv	ja-dc
	Ixora finlaysoniana Wall. ex G. Don	l (s)	pe	3	gro	mxf		sh ss	mr-my	sp-nv	ja-dc
	Ixora javanica (Bl.) DC. var. javanica	s	pe	3	gro	mxf		ry sh ss	dc-fb	fb-ap	ja-dc
	Ixora nigricans Wight & Arn. var. nigricans	l (s)	pe	3	gro	mxf		sh ss	mr-my	sp-nv	ja-dc
	Ixora sp.	l	pe	2	gro	mxf		sh ss	?	sp-nv	ja-dc
	Kailarsenia godefroyana (O.K.) Tirv.	l	pd	3	gro	dof da sg		ss	ja-fb	?	my-dc
	Knoxia brachycarpa R. Br. ex HK. f.	h	pd	2	gro	dof		ss ry	ag-oc	oc-nv	my-dc
	Mitragyna rotundifolia (Roxb.) O.K.	t	pd	3	gro	dof da sg		ss ry	ap-my	jl-ag	mr-dc
	Morinda pandurifolia O.K. var. oblonga (Pit.) Craib	s	pd	3	gro rhe	streams in rvf mxf	sa gv rk	ss	ja-fb	my-jn	nv-jl
	Morinda tomentosa Hey. ex Roth	t	pd	3	gro	dof		ry sh ss	ap-my	jl-sp	my-fb
	Nauclea orientalis (L.) L.	t	pe	3	gro	mxf rvs		ss	mr-ap	ag-oc	ja-dc
	Ophiorrhiza hispidula Wall. ex G. Don var. hispidula	h	a	3	gro	da sg mxf		sh ss	sp- nv	nv-dc	my-dc
	Oxyceros longiflora (Lmk.) Yama.	sc	pe	3	gro	da sg		sh ss	ap-my	sp-nv	ja-dc
	Paederia linearis Hk. f	v	a	3	gro	da sg		ry sh ss	ja-fb	mr-ap	my-dc
	Paederia pallida Craib	v	a	3	gro	da sg		sh ss	sp- nv	my-jn	my-dc
	Pavetta fruticosa Craib	s	pd	3	gro	dof		ry ss	ap-my	sp-nv	my-fb
	Pavetta indica L.	t (l)	pe	3	gro	mxf da sg		sh ss	mr-my	sp-nv	ja-dc
	Prismatomeris tetrandra (Roxb.) K. Sch. ssp. tetrandra	l (s)	pe	2	gro	streams in dof mxf		ss ry	my-ag	sp-nv	ja-dc
	Rothmannia wittii (Craib) Brem.	t (l)	pd	3	gro	dof da sg		ry	ap-my	sp-nv	my-dc
	Vangueria (Meyna) spinosa Roxb.	l sc	pd	3		da sg		ss	my-jn	ag-sp	my-dc
	Wendlandia tinctoria (Roxb.) DC. ssp. orientalis Cowan	t (l)	pe	3	gro	dof		ry sh ss	nv-dc	ja-fb	ja-dc
	Xantonnea parvifolia (O.K.) Craib var. salicifolia (Pierre ex Pit.) Craib	s	pd	3	gro rhe	streams in rvf	gv rk	ss	ja-my	ap-jn	nv-jl
Compositae	*Ageratum conyzoides L.*	h	a	3	gro wee	cult rvf	st sa	ry sh ss	oc-mr	mv-mr	my-fb
	Blumea napifolia DC.	h	a	3	gro wee	da sg cult	st	ss	ja-mr	fb-ap	sp-ap
	Eupatorium odoratum L.	h	pd	3	gro nat int wee	da sg cult		ry sh ss	nv-ja	dc-fb	jn-fb
	Grangea maderaspatana (L.) Poir.	h	a	3	gro wee	da sg cult	st	ry sh ss	nv-fb	dc-mr	jl-mr
	Sphaeranthus indicus L.	h	a	3	gro nat wee	cult	st	ry sh ss	dc-fb	ja-mr	jl-mr
	Spilanthes paniculata Wall. ex DC.	h	a	3	gro wee	cult rvf	sa	ry sh ss	nv-fb	dc-mr	nv-jn
	Synedrella nodiflora (L.) Gaertn.	h	a	3	gro wee	da cult		ss ry	jn-dc	jl-ja	my-ja
	Thorelia montana Gagnep.	h	a	2	gro	dof		ry	sp-oc	oc-nv	my-dc
	Vernonia cinerea (L.) Less. var. cinerea	h	a	3	wee gro	da cult rvf	sa	sh ss ry	ja-dc	ja-dc	ja-dc
Campanulaceae	*Lobelia alsinoides Lmk.*	h	a	3	gro	wet areas in da sg cult		sh ss	sp- nv	oc-dc	my-dc
Myrsinaceae	*Ardisia amherstiana A. DC. var. amherstiana*	l	pe	3	gro	mxf rvs	sa	ry sh ss	ja-fb	my-jn	ja-dc
	Ardisia helferiana Kurz	l	pe	3	gro	mxf		ry	sp-oc	ja-fb	ja-dc

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Sapotaceae	*Chrysophyllum cainito L.*	t	pe	3	gro cul int	cult		ry sh ss	sp-oc	mr-ap	ja-dc
	Palaquium aff. poilanei Lec.	t (l)	pe	2	gro	mxf		ry	?	ja-fb	ja-dc
Ebenaceae	*Diospyros bejaudii Lec.*	t (l)	pe	3	gro	mxf		ss ry	jl-ag	ag-oc	ja-dc
	Diospyros ehretioides Wall. ex G. Don	t	pd	3	gro	dof		ss ry	mr-ap	sp-oc	my-fb
	Diospyros filipendula Pierre ex Pit.	s	pe	2	gro	mxf		ry sh ss	?	fb-mr	ja-dc
	Diospyros malabarica (Desr.) Kostel. var. siamensis (Hochr.) Pheng.	t	pe	3	gro	mxf rvs		sh ss	mr-my	ja-fb	ja-dc
	Diospyros montana Roxb.	t	pd	3	gro	mxf da sg		ss ry	mr-ap	ag-oc	mr-dc
	Diospyros sp.	t	pe	2	gro	mxf rvs	sa gv	sh ss	?	sp-nv	ja-dc
Symplocaceae	*Symplocos racemosa Roxb.*	t (l)	pd	3	gro	dof		ry sh ss	nv-ja	mr-ap	jn-ap
Oleaceae	*Chionanthus ramiflorus Roxb.*	t	pe	3	gro	mxf		ss ry	ja-fb	nv-dc	ja-dc
	Jasminum multiflorum (Burm. f.) Andr.	wc v	pe	3	gro	da sg		sh ss	ja-mr	jn-jl	ja-dc
	Jasminum nervosum Lour.	v	pe	3	gro	mxf		ry ss	ap-my	jl-ag	ja-dc
	Jasminum scandens (Retz.) Vahl	wc v	pe	3	gro	da sg in mxf		ry	ja-fb	jn-jl	ja-dc
	Myxopyrum smilacifolium (Wall.) Bl. var. smilacifolium	wc	pe	2	gro	mxf		sh ss	mr-ap	oc-nv	ja-dc
Apocynaceae	*Aganonerion polymorphum Pierre ex Spire*	v	pe	3	gro	da sg		sh ss	sp- nv	?	ja-dc
	Aganosma marginata (Roxb.) G. Don	wc	pd	3	gro	dof		ry sh ss	ja-my	dc-fb	my-fb
	Alstonia scholaris (L.) R. Br. var. scholaris	t	pd	2	gro	mxf		ss	oc-dc	fb-ap	ap-fb
	Holarrhena curtissii King & Gamb.	s	pd	3	gro	da sg dof		ry sh ss	fb-jn	sp-fb	my-dc
	Hunteria zeylanica (Retz.) Gard. ex Thw.	l (s)	pe	2	gro	da		sh	sp-oc	ag-sp	ja-dc
	Ichnocarpus frutescens (L.) W. T. Ait.	wc (v)	pe	3	gro	da sg		ry	sp- nv	jn-ag	ja-dc
	Strophanthus scandens (Lour.) Roem. & Schult.	wc	pd	2	gro	da sg in mxf		ry	ja-fb	dc-fb	my-fb
	Thevetia peruviana (Pers.) K.Sch.	l	pe	3	gro cul int	cult		ss ry	ja-dc	ja-dc	ja-dc
	Wrightia arborea (Dennst.) Mabb.	t	pd	3	gro	da sg		ss	my-jn	ag-sp	my-ja
	Urceola Minutiflora (Pierre) D.J. Midd.	wc	pd	3	gro	da sg in mxf		ss	?	ja-fb	my-fb
Asclepiadaceae	*Calotropis gigantea (Willd.) Dry. ex W. T. Ait.*	s	pe	3	gro cul	cult		ss ry	ja-dc	ja-dc	ja-dc
	Dischidia sp.	h	pe	2	epi	da sg		ss	?	?	ja-dc
	Drega volubitis (L.f.) Bth. ex Hk. f.	v	pd	3	gro	da sg		ss	my-jn	sp-oc	ap-dc
	Heterostemma aff. grandiflorum Cost.	v	a	2	gro	da sg in mxf		sh ss	my-jn	sp-oc	my-dc
	Hoya kerrii Craib	v (cr)	pe	3	epi	dof		ss ry	my-jl	ag-sp	ja-dc
	Hoya nummularioides Cost.	v cr	pe	2	epi	dof		ry	ag-sp	?	ja-dc
	Myriopteron extensum (Wight) K. Sch.	v	a	3	gro	da sg		sh ss	sp- nv	ja-fb	my-dc
	Oxystelma esculentum (L. f.) R. Br.	v	pe	3	gro	wet areas in da sg rvf		sh ss	sp-ja	fb-mr	ja-dc
	Raphistemma pulchellum (Roxb.) Wall.	v (h)	pd	2	gro	da sg		sh ss	sp- nv	mr-ap	my-dc
	Rhapistemma hooperanum (Bl.) Dcne.	v	a	2	gro	da sg		sh ss	sp- nv	mr-ap	my-dc
	Streptocaulon juventas (Lour.) Merr.	v	pe	3	gro	da sg		ry sh ss	ag -fb	nv-ap	ja-dc
	Telectadium edule H. Baill.	s	pd	5	gro rhe	rvf	gv rk	ss	ja-fb	dc-fb	nv-jl
	Toxocarpus villosus (Bl.) Dcne.	v	pe	3	gro	da sg in mxf		sh ss	sp- nv	mr-ap	ja-dc
	Tylophora indica (Burm. f.) Merr.	v	a	2	gro	da sg		sh ss	sp- nv	mr-ap	my-dc
	Vincetoxicopsis harmandii Cost.	h	pe	3	gro	rocks in rvs rvf	rk sa	sh ss	oc-ja	ja-mr	ja-dc
	Zygostelma benthamii Baill.	v	pe	3	gro	da sg		ss ry	sp- nv	?	ja-dc
Loganiaceae	*Buddleja asiatica Lour.*	l	ped	3	gro	da sg rvf	sa	ss	oc-dc	dc-fb	my-mr
	Fagraea fragrans Roxb.	t	pe	3	gro	mxf		ss ry	ap-my	oc-nv	ja-dc
	Mitrasacme erophila Leenh. ssp. erophila	h	a	3	gro	wet areas in dof		ss ry	ag-sp	sp-oc	jn-dc
	Strychnos nux-vomica L.	t (l)	pd	3	gro	da sg		ry sh ss	mr-ap	sp-nv	my-dc
	Strychnos rupicola Pierre ex Dop	sc	pd	3	gro	dof da sg		ry	ap-my	sp-nv	my-dc
Gentianaceae	*Nymphoides indica (L.) O.K.*	h	ped	3	aqu gro	ponds streams in rvf	sa st	ss ry	ag-oc	sp-nv	ja-dc
Hydrophyllaceae	*Hydrolea zeylanica (L.) Vahl*	h	a	3	gro	wet areas in dof	st	ss ry	ag-oc	oc-nv	my-dc
Boraginaceae	*Coldenia procumbens L.*	h	a	3	gro wee	da cult	sa st	ry sh ss	sp-dc	dc-fb	jl-fb
	Cordia dichotoma Forst. f.	t	pd	2	gro	rvs	sa	sh ss	sp- nv	oc-nv	my-fb
	Heliotropium indicum L.	h	a	3	gro wee	da cult	st	ry sh ss	ja-dc	ja-dc	ja-dc
	Heliotropium strigosum Willd.	h	a	3	gro	dof	rk	ry	ag-sp	sp-oc	jn-dc
	Rotula aquatica Lour.	s	pd	4	gro rhe	streams in rvf	gv rk	ss	dc-fb	fb-ap	nv-jl
Convolvulaceae	*Aniseia martinicensis (Jacq.) Choisy*	v	a	3	gro	da sg in dof		ss ry	ag-oc	nv-dc	my-dc
	Argyreia obtecta (Choisy) Cl.	v (wc)	pd	3	gro	da sg rvf	sa gv	sh ss	jn-jl	sp-nv	my-fb
	Erycibe subspicata Wall. ex G. Don	wc	pe	3	gro	mxf		ss ry	sp- nv	fb-mr	ja-dc

FAMILY	SPECIES	HABIT	PHEN.	ABUN	LIFE MODE	HABITAT	SUBST-RATE	BEDROCK	FLOWER MTH	FRUIT MTH	LEAF MTH
	Evolvulus alsinoides (L.) L. var. hirsutus (Lmk.) Oost.	h cr	pe	2	wee gro	da sg in dof		ss	jl-oc	oc-dc	ja-dc
	Ipomoea aquatica Forsk.	v (cr)	pe	3	gro cul aqu	wet areas in cult rvf	sa	ss ry	mr-my (sp)	ap-jn	ja-dc
	Ipomoea mauritiana Jacq.	v	a	3	gro	da sg		ss sh ry	ag-oc	nv-dc	my-dc
	Ipomoea nil (L.) Roth var. nil	v	a	3	gro	da sg		ss ry	nv-ja	dc-fb	jn-fb
	Ipomoea quamoclit L. var. quamoclit	v	a	3	gro cul int	da sg cult		ss ry	ag-oc	nv-dc	my-dc
	Jacquemontia paniculata (Burm. f.) Hall. f. var. paniculata	v	a	3	gro	da sg		ry sh ss	sp-dc	ja-fb	jn-fb
	Merremia hederacea (Burm. f.) Hall. f.	v	a	3	gro	streams wet areas in da sg rvf rvs	sa gv	sh ss	sp- nv	dc-ja	my-dc
	Merremia vitifolia (Burm. f.) Hall. f.	v	pe	3	gro wee	da sg	st sa	ss ry	ja-fb	mr-my	ja-dc
	Operculina turpethum (L.) Manso	v	a	3	gro	da sg		ry	nv-fb	ja-fb	my-fb
Solanaceae	*Datura stramonium L.*	s	pd	3	gro cul int rhe	rvf	sa	ss	dc-fb	ja-mr	nv-jl
	Nicotiana tabacum L.	h	a	3	gro cul int	cult	sa	ss	ja-dc	ja-dc	ja-dc
	Physalis angulata L.	h	a	3	gro wee	cult rvf	sa	ss	nv-fb	ja-mr	nv-jl
Scrophulariaceae	*Adenosma sp.*	h	a	3	gro	wet areas in dof	rk	ss ry	ag-oc	oc-nv	jn-dc
	Bacopa floribunda (R. Br.) Wett.	h	a	3	gro wee	wet areas in cult	st	ss ry	ag-oc	sp-nv	jn-dc
	Centranthera cochinchinensis (Lour.) Merr. ssp. cochinchinensis	h	a	3	gro	wet areas in dof	st	ss ry	ag-oc	sp-nv	my-dc
	Centranthera cochinchinensis (Lour.) Merr. ssp. lutea (Hara) Yama.	h	a	3	gro	wet areas in dof	st	ss ry	ag-oc	sp-nv	my-dc
	Centranthera tranquebarica (Spreng.) Merr.	h	a	3	gro	wet areas in dof	st	ss ry	ag-oc	sp-nv	my-dc
	Dopatrium acutifolium Bon.	h	a	4	aqu gro	wet areas in dof cult	st	ss ry	ag-oc	sp-nv	my-dc
	Limnophila erecta Bth.	h	a	3	gro	wet areas in dof cult	st	ss ry	ag-oc	sp-nv	my-dc
	Limnophila geoffrayi Bon.	h	a	3	gro cul	cult	sa	ss	dc-fb	ja-mr	nv-my
	Lindenbergia philippensis (Cham.) Bth.	h	apd	3	gro wee	cult rvf	sa	sh ss	dc-fb	ja-mr	nv-jl
	Lindernia antipoda (L.) Alst.	h	a	3	gro wee	cult rvf	sa	ry sh ss	nv-mr	dc-ap	nv-jn
	Lindernia crustacea (L.) F. Muell. var. crustacea	h	a	3	gro wee	cult rvf	sa	sh ss	nv-fb	dc-mr	nv-jn
	Lindernia viscosa (Horn.) Bold.	h	a	3	gro	wet areas in dof	st	ss ry	ag-oc	sp-nv	my-dc
	Mazus pumilus (Burm. f.) Steen.	h	a	2	gro wee	cult rvf	sa	sh ss	dc-fb	ja-mr	nv-my
	Scoparia dulcis L.	h	a	3	gro nat wee	cult rvf	sa st	ry sh ss	ja-dc	ja-dc	ja-dc
	Stemodia verticillata (Mill.) Bold.	h	a	2	gro	cult rvf	sa	sh ss	nv-fb	dc-mr	nv-my
	Torenia benthamiana Hance	h	a	3	gro	wet areas in dof	st	ss ry	ag-oc	sp-nv	my-dc
	Torenia flava B.-H. ex Bth.	h	a	3	gro	dof		ss ry	ag-oc	sp-nv	jn-dc
	Torenia violacea (Aza. ex Blanco) Penn.	h	a	3	gro	dof sg		ry sh ss	sp- nv	nv-dc	my-dc
	Verbascum chinensis (L.) Sant.	h	a	3	gro wee	cult rvf	sa	sh ss	dc-fb	ja-mr	nv-my
Orobanchaceae	*Aeginetia indica Roxb.*	h	pd	3	par gro	dof mxf		ry sh ss	sp-oc	oc-nv	none
Lentibulariaceae	*Utricalaria aurea Lour.*	h	a	2	aqu	ponds in dof	st	sh ss	jl-ag	sp-oc	jn-dc
	Utricularia bifida L. var. bifida	h	a	4	gro	wet areas in da sg cult		ry sh ss	sp- nv	oc-dc	jl-dc
	Utricularia minutissima Vahl	h	a	4	gro	wet areas in da sg cult		ry sh ss	sp- nv	oc-dc	jl-dc
Gesneriaceae	*Boea bonii Pell.*	h	pd	2	gro	mxf		ss ry	my-jn	sp-nv	my-ja
Bignoniaceae	*Markhamia stipulata (Wall.) Seem. ex K. Sch. var. stipulata*	t	pd	3	gro	mxf da sg		ss ry	sp-fb	sp-mr	ap-fb
	Millingtonia hortensis L. f.	t	pd	3	gro cul int	cult		ry ss	ap-sp	oc-nv	ap-dc
	Oroxylum indicum (L.) Kurz	t (l)	pd	3	gro	da sg cult		ry sh ss	sp-oc	ja-mr	ap-dc
	Sesamum orientale L.	h	a	3	gro cul int	da cult		ss ry	ag-oc	nv-dc	my-dc
	Stereospermum neuranthum Kurz	t	pd	3	gro	da sg dof		ss ry	my-jn	sp-nv	my-fb
Acanthaceae	*Barleria strigosa Willd.*	h	pd	3	gro	dof		ss ry	sp- nv	nv-dc	jn-dc
	Clinacanthus nutans (Burm. f.) Lindau	h v	pe	3	gro	da sg	sa	sh ss	ja-fb	mr-ap	ja-dc
	Hygrophila incana Nees	h	pd	3	gro rhe	streams in rvf	sa rk	ss	ja-fb	mr-ap	nv-jl
	Lepidagathis incurva Ham. ex D. Don	h	pe	2	gro	dof		ry	sp- nv	nv-dc	my-dc
	Nelsonia canescens (Lmk.) Spr.	h	pd	3	gro wee	da cult		ry sh ss	ja-fb	fb-ap	my-fb
	Perilepta siamensis (Cl.) Brem.	h	pd	2	gro	dof mxf		ss	nv-ja	fb-mr	jl-mr
	Pseuderanthemum couderci R. Ben.	h	pd	3	gro	da sg		sh ss	dc-fb	fb-mr	jl-fb
	Pseuderanthemum latifolium (Vahl) B. Han.	l (s, h)	pe	3	gro	mxf da sg		sh ss	sp-oc	dc-ja	my-dc

FAMILY	SPECIES	HABIT	PHEN.	ABUN	LIFE MODE	HABITAT	SUBST-RATE	BEDROCK	FLOWER MTH	FRUIT MTH	LEAF MTH
	Ruellia tuberosa L.	h	pd	3	gro wee	da cult	ry	ss	sp-oc	oc-nv	my-dc
	Rungia parviflora Nees var. parviflora	h	a	3	gro	da sg cult		ry sh ss	oc-fb	mv-mr	jn-mr
	Thunbergia similis Craib	v	ped	3	gro	dof da sg		ry sh ss	sp- nv	nv-dc	my-dc
Verbenaceae	*Callicarna cana L. var. cana*	s	pd	3	gro	da sg		sh ss	my-jn	sp-nv	my-dc
	Clerodedrum godefroyi O.K.	s	pd	4	gro	da sg mxf		ry sh ss	sp- nv	dc-ja	my-dc
	Clerodendrum paniculatum L.	l (h)	pd	2	gro	da sg		ss ry	ag-oc	nv-dc	my-dc
	Clerodendrum serratum (L.) Moon var. wallichii Cl.	l (s)	pd	3	gro	wet areas in dof		ss ry	jl-sp	sp-nv	my-dc
	Congea tomentosa Roxb. var. tomentosa	wc sc	pd	3	gro	da sg		ry sh ss	ja-mr	mr-ap	ap-fb
	Gmelina philippensis Cham.	sc	pe	3	gro	wet areas in da sg		ry	mr-ap	mr-my	ja-dc
	Phyla nodiflora (L.) Greene	h	a	3	gro wee	cult rvf	sa	ry sh ss	dc-my	ja-jn	nv-jl
	Premna flavescens Ham. ex Cl. var. flavescens	wc sc	pd	3	gro	rvs	sa gv	ry sh	sp-ap	sp-oc	my-dc
	Premna herbacea Roxb.	s (h)	pd	3	gro	dof		ss ry	ap-jn	jn-ag	ap-dc
	Premna nana Coll. & Hemsl.	s (h)	pd	3	gro	dof		ss ry	ap-my	jn-jl	ap-dc
	Tectona grandis L. f.	t	pd	3	gro cul int	da sg cult		ry sh ss	jl-oc	nv-ja	my-fb
	Vitex canescens Kurz	t	pd	3	gro	da sg		ss	mr-my	my-jn	ap-dc
	Vitex limoniifolia Wall. ex Kurz	t	pd	3	gro	dof da sg		ry sh ss	jl-sp	oc-dc	ap-fb
	Vitex peduncularis Wall. ex Schauer	t	pd	3	gro	dof		ry sh ss	ap-my	my-jl	ap-dc
	Vitex trifolia L. var. trifolia	s	pe	3	gro cul int	cult		ss	ap-my	jl-ag	ja-dc
Labiatae	*Acrocephalus indicus (Burm. f.) O.K.*	h	a	2	gro	dof		ry	sp- nv	oc-dc	my-dc
	Basilicum polystachyon (L.) Moen.	h	a	2	gro wee	cult rvf	sa	sh ss	dc-fb	fb-mr	nv-my
	Geniosporum coloratum (D. Don) O.K.	h	pd	3	gro	dof		ss ry	ap-jn	jn-jl	ap-dc
	Gomphostemma lucidum Wall. ex Bth.	h	pe	3	gro	mxf		sh ss	sp- nv	dc-ja	ja-dc
	Hyptis suaveolens (L.) Poit.	h	a	3	gro wee	da sg		sh ss	sp- nv	oc-dc	my-dc
	Leucas zeylanica (L.) R. Br.	h	a	3	gro wee	da cult		ss ry	ag-oc	sp-nv	jn-dc
	Salvia plebeia R. Br.	h	a	3	gro	da sg rvf	sa	ss	ap-my	my-jn	nv-jn
Nyctaginaceae	*Boerhavia diffusa L.*	h	a	3	gro nat wee	da		ss ry	jl-nv	sp-dc	my-dc
Basellaceae	*Basella alba L.*	v	a	3	cul	cult		ss ry	ja-dc	ja-dc	ja-dc
Chenopodiaceae	*Chenopodium ambrosioides L.*	h	a	3	gro wee	cult rvf	sa	sh ss	dc-my	fb-jn	nv-jl
	Chenopodium ficifolium Sm.	h	a	3	gro wee	cult rvf	sa	sh ss	dc-my	fb-jn	nv-jl
Amaranthaceae	*Aerva sanguinolenta (L.) Bl.*	h	pe	3	gro	da sg		ry sh ss	ja-mr	fb-ap	jn-ap
	Alternanthera sessilis (L.) DC. var. sessilis	h	a	3	gro wee	cult rvf	sa	sh ss	nv-ap	dc-my	nv-jl
	Amaranthus spinosus L.	h	a	3	gro nat wee	da sg rvf	st sa	ss ry	ja-dc	ja-dc	ja-dc
	Amaranthus viridis L.	h	a	3	gro wee	da sg rvf	st sa	ss ry	ja-dc	ja-dc	ja-dc
	Psilotrichum ferrugineum (Roxb.) Moq.-Tand	h	a	3	gro	dof	rk	ss ry	ag-oc	sp-nv	my-dc
Polygonaceae	*Polygonum flaccidum Meissn.*	h	a	3	gro rhe	streams in rvf	sa	ss	dc-mr	ja-ap	nv-jl
	Polygonum persicaria L.	h	a ped	3	aqu	ponds wet areas in dof mxf rvf	st sa	ss ry	ag -fb	sp-mr	ja-dc
	Polygonum plebeium R. Br.	h	a	3	gro wee	cult rvf	sa	sh ss	nv-mr	dc-ap	nv-jl
	Rumex dentatus L.	h	a	3	gro wee	da sg rvf	sa	ss	ja-fb	mr-my	nv-my
Aristolochiaceae	*Aristolochia pothieri Pierre ex Lec.*	v	a	3	gro	da sg mxf		sh ss	sp- nv	ja-fb	my-dc
Piperaceae	*Peperomia pellucida (L.) H.B.K.*	h	a	3	nat gro epl epi int	da in mxf		ss ry	jl-nv	ag-dc	my-dc
	Piper retrofractum Vahl	v (h, cr)	pe	3	gro	mxf		ss ry	ag-oc	oc-dc	ja-dc
	Piper aff. retrofractum Vahl	v cr	pe	2	gro	mxf		sh ss	?	sp-nv	ja-dc
	Piper aff. sarmentosum Roxb. ex Hunt.	v (cr)	pe	3	gro	mxf		ry	ag-oc	?	ja-dc
	Piper sylvaticum Roxb.	h cr	pe	3	gro	da sg in mxf		ss	ag-oc	?	ja-dc
Myristicaceae	*Horsfieldia thorelii Lec.*	t	pe	2	gro	mxf		sh ss ry	sp- nv	ap-jn	ja-dc
	Knema conferta (King) Warb.	t	pe	3	gro	mxf		sh ss	sp- nv	ap-my	ja-dc
Lauraceae	*Cassytha filiformis L.*	v	pe	3	epi hemipar	dof da sg		ry ss	sp- nv	oc-ja	none
	Litsea glutinosa (Lour.) C.B. Rob.	t	pd	3	gro	da sg		ry	ag-sp	nv-dc	my-ja
	Litsea monopetala (Roxb.) Pers.	t	pd	3	gro	mxf da sg		ss	ap-my	ag-sp	jn-ap
Hernandiaceae	*Illigera thorelii Gagnep.*	wc (v)	pd	3	gro	da sg		ry sh ss	sp- nv	oc-fb	my-dc
Thymelaeaceae	*Enkleia siamensis (Kurz) Nev.*	sc	pd	3	gro	dof		ry ss	oc-dc	ja-fb	jn-mr
Loranthaceae	*Helixanthera pulchra (DC.) Dans.*	s	pe	3	epi par	mxf		ss ry	mr-my	my-jn	ja-dc

FAMILY	SPECIES	HABIT	PHEN.	ABUN	LIFE MODE	HABITAT	SUBST-RATE	BEDROCK	FLOWER MTH	FRUIT MTH	LEAF MTH
	Macrosolen lowii (King) Tiegh.	s	pe	3	hemipar epi	da sg		ry	sp- nv	ja-mr	ja-dc
	Scurrula parasitica L.	s	pe	3	epi hemipar	da sg		sh ss	sp- nv	ja-mr	ja-dc
Santalaceae	*Henslowia frutescens Bth.*	v	pe	2	gro	mxf		ry	ja-fb	?	ja-dc
	Scleropyrum wallichianum (A. DC.) Arn. var. mekongensis (Gagnep.) H. Lec.	wc	pe	3	gro	mxt da sg		sh ss	ja-fb	jn-ag	ja-dc
Opiliaceae	*Cansjera rheedii J.F. Gmel.*	wc	pe	3	gro	mxf		ry	oc-dc	mr-ap	my-mr
Euphorbiaceae	*Acalypha australis L.*	h	a	3	gro wee	cult rvf	sa	sh ss	dc ja fb	ja-mr	nv-jn
	Acalypha siamensis Oliv. ex Gage	s	pe	2	gro	mxf		ss	ap-my	?	ja-dc
	Alchornea trewioides (Bth.) M.-A.	s	pd	3	gro	da sg	st	ry	ap-my	sp-oc	my-dc
	Antidesma acidum Retz.	l	pd	3	gro	dof da sg		ry sh ss	ap-my	sp-nv	my-dc
	Aporusa ficifolia Baill.	l	pe	3	gro	mxf da		ry	sp-oc	ap-my	ja-dc
	Aporusa villosa (Lindl.) Baill.	t (l)	pd	3	gro	dof		ry sh ss	ja-mr	ap-my	ap-fb
	Baliospermum montanum (Willd.) M.-A.	s (h)	pd	3	gro	da		ss ry	nv-fb	ja-ap	jn-mr
	Blachia cotoneaster Gagnep.	l (s)	pd	4	gro rhe	rvf	sa gv rk	ss	ja-fb	fb-mr	nv-jl
	Breynia fruticosa (L.) Hk. F.	l	pd	3	gro	da in mxf		ry	ja-fb	ag-oc	ap-fb
	Breynia vitis-ideae (Burm. f.) C.E.C. Fisc.	l	pd	3	gro	da sg		ry sh ss	jl-sp	sp-nv	my-dc
	Bridelia harmandii Gagnep.	s	pd	2	gro	dof		ss	ag-oc	nv-ja	my-dc
	Bridelia Retusa (L.) A. Juss.	t	pd	3	gro	dof		ss ry	jl-ag	sp-oc	my-dc
	Bridelia tomentosa Bl.	t (l) wc	pd	3	gro	sg be		sh ss	ag -fb	ja-mr	my-fb
	Cleidion spiciflorum (Burm. f.) Merr.	t	pe	2	gro	mxf		ss	ja-fb	jn-jl	ja-dc
	Croton crassifolius Geisel.	h	pd	3	gro	dof		ry	dc ja fb	fb-mr	jn-mr
	Croton bonplandrianus Baill. .	h	a	3	gro wee	cult rvf	sa	sh ss	dc-mr	ja-mr (sp)	nv-jl
	Euphorbia hirta L.	h	a	3	gro wee nat int	da cult		ss sh ry	ja-dc	ja-dc	ja-dc
	Euphorbia bifida H.K. Arn	h	a	3	gro wee	wet areas in dof da cult		ss ry	ag-oc	sp-nv	my-dc
	Euphorbia serpens Kunth	h	a	3	gro wee	cult rvf	sa	ss	dc-mr	ja-ap	nv-jl
	Euphorbia thymifolia L.	h	a	3	gro wee	da cult	sa	ry	oc-mr	nv-ap	jl-ap
	Homonoia riparia Lour.	s	pd	4	rhe gro, often amphibious	rvf	sa gv	sh ss	ja-fb	jn-ag	oc-jl
	Hura crepitans L.	t	pe	3	gro cul int	cult		ss	ap-jn	ag-sp	ja-dc
	Hymenocardia punctata Wall. ex Lindl.	l (s)	pd	3	gro	da sg		ry	ap-my	ag-sp	my-dc
	Jatropha curcas L.	l (s)	pe	3	gro cul int	da cult		ss ry	ja-dc	ja-dc	ja-dc
	Jatropha gossypiifolia L.	s (h)	pe	2	gro int nat	da		ss	ja-dc	ja-dc	ja-dc
	Leptopus australis (Zoll. & Mor.) Poj.	s	pd	3	gro	dof		ss	ag-oc	nv-ja	my-dc
	Mallotus cochinchinensis Lour.	l (s)	pe	3	gro	mxf rvs		sh ss	sp- nv	ap-nv	ja-dc
	Mallotus cuneatus Ridl.	l (s)	pd	3	gro	da sg		sh	sp- nv	oc-dc	my-dc
	Mallotus glabriusculus (Kurz) Pax & Hoffm.	s	pe	3	gro	mxf		sh ss	sp- nv	oc-dc	my-dc
	Mallotus philippensis (Lmk.) M.	t	pe	3	gro	mxf da		sh ss	jl-sp	sp-oc	ja-dc
	Mallotus thorelii Gagnep.	s	pd	3	gro	mxf rvs	gv rk	ss	ap-my	jl-ag	my-dc
	Pantadenia adenanthera Gagnep.	s	pd	3	gro	mxf		ry sh ss	ap-nv	?	ap-dc
	Phyllanthus acidus (L.) Skeels	l	pd	3	cul gro int nat	cult		ss ry	dc-ja	sp-oc	my-ja
	Phyllanthus amarus Schum. & Thonn.	h	a	3	gro nat wee	da cult rvf	st sa	ry sh ss	nv-mr	dc-ap	nv-jl
	Phyllanthus emblica L.	t (l)	pd	3	gro	dof		ss ry	fb-mr	sp-dc	mr-ja
	Phyllanthus jullienii Beille	s (h)	ped	5	gro	rocks in rvf rvs	gv sa	sh ss	sp-my	ja-jn	ag-mr
	Phyllanthus pulcher Wall. ex M.-A.	h	pd	3	gro	da sg rvs	gv rk	sh ss	sp- nv	nv-dc	my-dc
	Phyllanthus reticulatus Poir.	l (s,wc, sc)	pd	4	gro	da sg rvs	sa	sh ss	jl-ag	sp-nv	my-dc
	Phyllanthus taxodiifolius Beille	h	pd	2	gro	dof da sg		ry	jl-ag	sp-nv	my-dc
	Phyllanthus urinaria L.	h	a	3	gro nat wee	da cult		sh ss ry	ja-dc	ja-dc	ja-dc

FAMILY	SPECIES	HABIT	PHEN.	ABUN	LIFE MODE	HABITAT	SUBST-RATE	BEDROCK	FLOWER MTH	FRUIT MTH	LEAF MTH
	Phyllanthus virgatus Forst. f.	h	a	3	gro	dof		ss ry	jl-nv	ag-dc	my-dc
	Riccinus commumis L.	h	pe	3	gro cul int	da cult		ss	ja-dc	ja-dc	ja-dc
	Sampantaea amentiflora (A.S.) A.S.	l (s)	pe	3	gro	rocks in mxf rvs	gv rk	sh	oc-my	mr-jn	ja-dc
	Sauropus androgynus (L.) Merr.	l	pd	3	gro	da sg		sh ss	sp- nv	oc-dc	my-dc
	Sauropus heteroblastus A.S.	s	ped	2	gro rhe	mxf rvf rvs		sh ss	?	sp-nv	ja-dc
	Thyrsanthera suborbicularis Pierre ex Gagnep.	h	pd	3	gro	dof		ss ry	ap-my	?	my-dc
	Trewia nudiflora L.	t	pd	3	gro	da sg		ry ss	ap-my	oc-fb	jn-fb
	Trigonostemon quocensis Gagnep.	s	pe	3	gro	mxf		sh ss	sp- nv	oc-dc	ja-dc
	Trigonostemon reidioides (Kurz) Craib	h	pd	4	gro	dof		ss	dc ja fb	ja-mr	jn-mr
Moraceae	*Artocarpus sp.*	t	pd	3	gro	mxf		sh ss	?	?	my-dc
	Broussonetia papyrifera (L.) Vent.	t (l)	pd	3	often cul gro	da sg		sh ss ry	sp- nv	jn-jl	my-fb
	Ficus altissima Bl.	t	pe	3	gro str epi	mxf da		ss	ap-sp	ap-sp	ja-dc
	Ficus benjamina L. var. benjamina	t (l)	pe	3	epi, epl str	mxf		ss ry	ja-mr	ja-mr	ja-dc
	Ficus curtipes Corn.	t	pe	2	epi gro str	da sg		sh ss	sp- nv	oc-dc	ja-dc
	Ficus heterophylla L. f. var. heterophylla	wc sc (h)	pe	3	epi gro	da sg rvf		sh ss	nv-mr	dc-ap	nv-jl
	Ficus hirta Vahl var. hirta	l	pe	3	gro	da sg		sh ss ry	ja-dc	ja-dc	ja-dc
	Ficus hispida L. f. var. hispida	t (l)	pe	3	gro	da sg		sh ss ry	ja-dc	ja-dc	ja-dc
	Ficus pisocarpa Bl.	t	pe	3	gro epl str	mxf da		ss	ap-jn	ap-jn	ja-dc
	Ficus racemosa L. var. racemosa	t	pd	3	gro	rvs	sa gv	ry sh ss	ja-dc	ja-dc	oc-ag
	Ficus religiosa L.	t	pd	3	gro cul epi int str	cult		ss	jn-ag	jn-ag	ja-dc
	Ficus rumphii Bl.	t	pd	3	gro epi epl str	da rvf rvs	rk	ss	ap-my	ap-my	ap-dc
	Ficus superba (Miq.) Miq. var. japonica Miq.	t	pd	3	gro epi str	mxf		ry	nv-dc	nv-dc	ap-dc
	Morus australis L.	t (l)	pd	3	gro cul int	cult		ss	mr-ap	my-jn	ap-dc
	Streblus asper Lour. var. asper	t (l)	pe	4	gro	da sg		ry sh ss	ja-mr	dc-fb	ja-dc
Urticaceae	*Laportea interrupta (L.) Chew*	h	a	3	gro, less often epl	da sg	st	sh ss ry	jn-nv	ag-dc	my-dc
	Pouzolzia zeylanica (L.) Benn.	h	a	3	gro	da sg	st	sh ss ry	jl-oc	sp-nv	my-dc
Cannabidaceae	*Cannabis sativa L.*	h	a	3	gro cul int	cult	sa	ss	fb-jn	mr-jn	fb-jn
Fagaceae	*Quercus kerrii Craib var. kerrii*	t	pd	2	gro	dof		ry sh ss	ap-jn	ag-sp	my-fb
Salicaceae	*Salix tetrasperma Roxb.*	t	pd	3	gro rhe	rvf		sh ss	nv-dc	dc-ja	nv-jl
Hydrocharitaceae	*Hydrilla verticillata (L. f.) Roy.*	h	pe	3	aqu gro	ponds in rvf dof	sa gv	sh ss	sp-oc, dc-fb	?	ja-dc
	Ottelia alismoides (L.) Pers.	h	pd	3	aqu gro	ponds in dof	st	ss ry	ag-oc	sp-nv	my-dc
Potamogetonaceae	*Potamogeton crispus L. var. crispus*	h	pe	4	aqu	streams in rvf	sa rk	sh ss	?	?	ja-dc
Commelinaceae	*Belosynapsis ciliata (Bl.) R. Rao*	h	a	2	gro	da sg in mxf		ss	ag-oc	sp-nv	my-dc
	Commelina benghalensis L.	h	pe	3	gro wee	da cult	ry	sh ss	jn-nv	jl-dc	ja-dc
	Commelina diffusa Burm. f.	h	pe	3	gro wee	da cult		sh ss ry	jn-nv	jl-dc	ja-dc
	Cyanotis axillaris (L.) D. Don	h	a	3	aqu gro	ponds in dof	st	sh ss ry	jl-oc	ag-nv	my-dc
	Cyanotis cristata (L.) D. Don	h	a pd	3	gro epl epi	rocks in dof	rk	ry	jn-nv	jl-dc	my-dc
	Murdania gigantea (Vahl) Bruck.	h	pd	2	gro	wet areas in dof	st	ss	ag-oc	sp-nv	jn-dc
	Murdannia loureirii (Hance) Rao & Kam.	h	pd	4	gro	dof		ss ry	ap-sp	jn-oc	my-dc
	Murdannia nudiflora (L.) Bren.	h	ped	3	aqu gro	da cult		sh ss ry	jn-nv	jl-dc	my-dc
	Murdannia scapiflora (Roxb.) Roy.	h	pd	3	gro	wet areas in dof		ss ry	jl-oc	ag-nv	my-dc
Eriocaulaceae	*Eriocaulon quinquagulare L.*	h	a	4	gro	wet areas in da sg cult		ry sh ss	sp- nv	sp-nv	jn-dc
Zingiberaceae	*Alpinia malaccensis (Burm. f.) Rosc.*	h	pe	2	gro	da in mxf		sh ss	ap-my	sp-nv	ja-dc
	Boesenbergia rotunda (L.) Mansf.	h	pd	3	gro	mxf		ry sh ss	sp- nv	oc-dc	my-dc
	Costus speciosus (Koeh.) J.E. Sm.	h	pd	3	gro epl	dof da		sh ss ry	ag-sp	nv-dc	my-dc
	Curcuma gracillima Gagnep.	h	pd	3	gro	dof		ss ry	ag-oc	oc-nv	my-dc
	Curcuma longa L.	h	pd	3	gro	mxf		ss ry	jn-jl	sp-oc	my-dc
	Curcuma zedoaria (Berg.) Rosc.	h	pd	4	gro	dof		ss ry	ap-my	jn-jl	jn-dc
	Curcuma sp.	h	pd	4	gro	dof		ss ry	ap-my	jn-jl	jn-dc
	Globba schomburgkii Hk. f. var. schomburgkii	h	pd	4	gro epl	dof mxf		sh ss ry	ag-oc	oc-nv	my-dc
	Globba thorelii Gagnep.	h	pd	4	gro	mxf		sh ss ry	ag-oc	oc-nv	my-dc

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	Kaempferia harmandii Gagnep.	h	pd	3	gro	mxf		sh ss ry	ag-oc	oc-nv	my-dc
	Kaempferia roscoeana Wall.	h	pd	2	gro	mxf		ss	jl-ag	ag-sp	my-dc
	Stahlianthus thorelii Gagnep.	h	pd	4	gro	dof		ss ry	ap-my	jn-jl	jn-dc
	Zingiber pellitum Gagnep.	h	pd	3	gro	dof		sh ss	ag-sp	sp-nv	my-dc
	Zingiber zerumbet (L.) J.E. Sm.	h	pd	3	gro	mxf		sh ss ry	jl-ag	sp-oc	my-dc
Marantaceae	*Halopegia blumei (Koern.) K. Sch.*	h	pd	3	gro cul	cult		ss	jl-ag	ag-sp	my-dc
	Schumannianthus dichotomus (Roxb.) Gagnep.	h	pe	3	gro	cult		ss	jl-ag	sp-oc	ja-dc
Liliaceae	*Gloriosa superba L.*	v	pd	2	gro	da		ss ry	ag-sp	oc-nv	my-dc
	Peliosanthes teta Andr. ssp. humilis (Andr.) Jess.	h	pe	3	gro	mxf		ss	ap-my	sp-oc	ja-dc
Amaryllidaceae	*Crinum wattii Baker*	h	pd	3	gro	dof		ss ry	ap-my	jl-ag	my-dc
	Hypoxis aurea Lour.	h	pd	3	gro	dof		ss ry	ap-sp	jn-oc	my-dc
Pontederiaceae	*Eichhornia crassipes (Mart.) Solms*	h	pe	2	aqu int wee	streams		ss ry	jl-dc	?	ja-dc
	Monochoria vaginalis (Burm. f.) Presl	h	a	3	aqu gro	ponds in dof	st	sh ss ry	jl-oc	sp-nv	my-dc
Smilacaceae	*Smilax extensa Wall. ex A. DC.*	v	pe	3	gro	da sg		ry sh ss	jn-jl	sp-nv	ja-dc
	Smilax verticalis Gagnep.	v	pd	3	gro	dof		ss ry	ap-my	jl-sp	my-dc
Araceae	*Aglaonema simplex (Bl.) Bl.*	h	pe	3	gro	mxf		ss ry	ap-my	sp-oc	ja-dc
	Alocasia macrorhizos (L.) G. Don	h	pe	3	gro cul	cult		sh ss ry	ja-dc	ja-dc	ja-dc
	Alocasia odora C. Koch	h	pd	3	gro	mxf		sh ss ry	ag-sp	?	my-dc
	Amorphophallus koratensis Gagnep.	h	pd	3	gro	dof		ss ry	ap-my	jl-ag	jn-dc
	Amorphophallus laoticus Hett.	h	pd	2	gro	mxf da		ss	ap-my	jl-ag	jn-dc
	Amorphophallus paeoniifolius (Denn.) Nichol.	h	pd	3	gro	da		sh ss ry	my-jn	nv-ja	my-dc
	Amorphophallus parvulus Gagnep.	h	pd	3	gro	dof		ry	jl-ag	oc-nv	jl-nv
	Arisaema sp.	h	pd	3	gro	dof		ry	?	sp-nv	jl-nv
	Colocasia esculenta (L.) Schott	h	pe	3	aqu gro	ponds wet areas in dof	st	ss ry	my-oc	sp-dc	ja-dc
	Colocasia fallax Schott	h	pd	2	epi	mxf		ss	ag-sp	oc-nv	jn-dc
	Cryptocoryne tonkinensis Gagnep.	h	pd	4	gro rhe	rvf	sa gv rk	sh ss	fb-mr	?	nv-jl
	Pseudodracontium lacourii (Linden ex Andre) N.E. Br.	h	pd	3	gro	dof		ss	ap-my	ag-sp	jn-dc
	Rhaphidophora peepla (Roxb.) Schott	v cr	pe	3	gro	mxf		ss ry	jl-sp	sp-nv	ja-dc
	Typhonium flagelliforme (Lodd.) Bl.	h	pd	3	aqu gro	ponds in dof mxf	st	ss ry	ag-oc	oc-nv	my-dc
	Typhonium roxburghii Schott	h	pd	2	gro	da in mxf		ss	ag-sp	nv-dc	my-dc
Lemnaceae	*Lemna perpusilla Torr.*	h	pe	5	aqu	ponds in dof mxf		ss ry	?	?	ja-dc
Stemonaceae	*Stemona burkillii Prain*	v	pd	3	gro	dof		ss ry	ap-my	jn-jl	my-dc
Dioscoreaceae	*Dioscorea alata L.*	v	pd	3	gro	da		sh ss ry	nv-ja	fb-ap	my-ja
	Dioscorea arachidna Prain & Burk. var. arachidna	v	pd	3	gro	dof da sg		ry sh ss	sp- nv	dc-fb	jn-fb
	Dioscorea bulbifera L.	v	pd	3	gro	da sg		ry sh ss	sp- nv	dc-fb	jn-dc
	Dioscorea glabra Roxb. var. glabra	v	pd	3	gro	da sg		ry sh ss	sp- nv	dc-fb	jn-dc
	Dioscorea hispida Denn.	v	pd	3	gro	dof da sg		ss ry	my-jn	sp-oc	jn-dc
	Dioscorea oryzetorum Pr. & Burk. var. oryzetorum	v	pd	3	gro	da sg		ry sh ss	sp- nv	nv-dc	my-dc
Palmae	*Borassus flabellifer L.*	t	pe	3	gro	cult		ry sh ss	jn-jl	ap-my	ja-dc
	Calamus palustris Griff. var. cochinchinensis Becc.	wc v	pe	2	gro	mxf		sh ss	sp- nv	ap-my	ja-dc
	Caryota mitis Lour.	t (l)	pe	2	gro	mxf		ry ss	jn-jl	nv-ja	ja-dc
	Cocos nucifera L.	t	pe	3	gro cul	cult		ry sh ss	ja-dc	ja-dc	ja-dc
	Phoenix loureiri Kunth var. loureiri	l (h)	pe	3	gro	dof		ry ss	ja-mr	my-jn	ja-dc
Apostasiaceae	*Apostasia wallichii R. Br.*	h	pe	2	gro	mxf		ss ry	jl-ag	sp-oc	ja-dc
Burmanniaceae	*Burmannia coelestis D. Don*	h	a	3	gro	wet areas in da sg cult		ry sh ss	sp- nv	oc-dc	jn-dc
Orchidaceae	*Aerides falcata Lindl.*	h	pe	2	epi	mxf		ss ry	my-jn	ag-oc	ja-dc
	Cymbidium bicolor Lindl.	h	pe	2	epi	da sg mxf		ry ss	mr-ap	fb-ap	ja-dc
	Dendrobium delacourii Guill.	h	pd	2	epi	dof		ry	sp-oc	?	my-dc
	Dendrobium venustum Teijsm. & Binn.	h	pd	2	epi	da sg rvs		ss	ap-my	jl-ag	ap-dc
	Eulophia graminea Lindl.	h	pd	2	gro	da sg 2		sh ss	ja-fb	?	jl-dc
	Geodorum attenuatum Griff.	h	pd	3	gro	dof da in mxf		ss ry	ap-my	?	my-dc

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	Geodorum recurvum (Roxb.) Alst.	h	pd	3	gro	dof		ss ry	ap-my	?	my-dc
	Habenaria apetala Gagnep.	h	pd	3	gro	wet areas in dof		ss ry	ag-oc	nv-dc	my-dc
	Habenaria dentata (Sw.) Schltr.	h	pd	2	gro	dof		ry	sp-oc	?	jn-dc
	Habenaria rumphii (Brong.) Lindl.	h	pd	3	gro	wet areas in dof		ss ry	ag-oc	nv-dc	my-dc
	Habenaria trichosantha Lindl.	h	pd	2	gro	mxf		sh ss	sp-oc	?	jn-dc
	Liparis acutissima Rchb. f.	h	pd	3	gro	wet areas in dof		ss ry	ag-oc	nv-dc	my-dc
	Nervilia aragoana Gaud.	h	pd	2	gro	mxf		sh ss	ap-my	?	my-dc
	Nervilia plicata (Andr.) Schltr.	h	pd	2	gro	mxf		sh ss	ap-my	?	jl-dc
	Pecteilis susannae (L.) Raf.	h	pd	2	gro	wet areas in dof		ss ry	ag-oc	?	my-dc
	Peristylus densus (Lindl.) Sant. & Kapad.	h	pd	3	gro	wet areas in dof		ss ry	ag-oc	nv-dc	my-dc
	Pomatocalpa spicata Breda	h	pe	2	epi	streams in dof mxf		ss ry	mr-my	ag-oc	ja-dc
	Smitinandia micrantha (Lindl.) Holtt.	h	pe	2	epi	mxf rvs		ss	mr-my	my-jl	ja-dc
	Vanda denisoniana Bens. & Rchb. f.	h	pe	2	epi	mxf		ss ry	mr-ap	ag-oc	ja-dc
Cyperaceae	*Cyperus babakan Steud.*	h	a	3	gro wee	wet areas in da cult		ss ry	ag-oc	sp-nv	my-dc
	Cyperus compactus Retz.	h	a	3	gro	wet areas in dof da cult		sh ss ry	jl-nv	ag-dc	my-dc
	Cyperus iria L.	h	a, pe	3	gro wee	wet areas in dof da cult		sh ss ry	jl-nv	ag-dc	my-dc
	Cyperus laxus Lmk. var. laxus	h	pe	3	gro	da sg		ss ry	ja-dc	ja-dc	ja-dc
	Cyperus leucocephalus Retz.	h	pd	3	gro	rvs	gv rk	sh ss	my-nv	jn-nv	my-fb
	Cyperus michelianus (L.) Link ssp. pygmaeus (Rottb.) Asch. & Graebn.	h	a	3	gro wee	cult rvf	sa	sh ss	nv-mr	dc-ap	nv-jl
	Cyperus rotundus L. ssp. rotundus	h	ped	3	wee gro rhe	sg cult		sh ss ry	jl-nv	ag-dc	ja-dc
	Fimbristylis aestivalis (Retz.) Vahl var. aestivalis	h	pd	4	gro wee	da rvf	sa	ss ry	ap-jn	my-jl	ap-dc
	Fimbristylis aphylla Zoll. ex Steud.	h	pe	3	gro	wet areas in da sg dof		ss ry	ag-nv	sp-dc	my-dc
	Fimbristylis bisumbellata (Forssk.) Bub.	h	a	3	gro wee	rvf	sa	sh ss	nv-mr	dc-ap	nv-jl
	Fimbristylis dichotoma (L.) Vahl ssp. dichotoma	h	a	3	wee gro	da cult		sh ss ry	jl-nv	ag-dc	my-dc
	Fimbristylis dipsacea (Rottb.) Cl.	h	a	3	gro wee	rvf	sa	sh ss	nv-ap	dc-my	nv-jl
	Fimbristylis disticha Boeck.	h	a	3	gro	wet areas in dof		ss ry	ag-nv	sp-dc	my-dc
	Fimbristylis fuscoides Cl.	h	pd	3	gro	dof		ss ry	ap-jn	jn-ag	ap-dc
	Fimbristylis jucunda (Cl.) Kern	h	pd	4	gro	da rvf	sa gv rk	ss ry	ap-jn	jn-ag	ap-dc
	Fimbristylis miliacea (L.) Vahl	h	pe	3	gro wee	wet areas in dof		ss ry	ag-nv	sp-dc	my-dc
	Fimbristylis obtusa (Cl.) Ridl.	h	a	3	gro	dof	rk	ss ry	ag-nv	sp-dc	my-dc
	Fimbristylis schoenoides (Retz.) Vahl	h	pd	3	gro	wet areas in dof		ss ry	ag-nv	sp-dc	my-dc
	Rhynchospora rubra (Lour.) Mak.	h	a	3	gro	wet areas in dof	rk	ss ry	ag-nv	sp-dc	my-dc
	Scirpus grossus L. f.	h	pe	3	aqu gro	ponds wet areas in dof	st	ss ry	ag-nv	sp-dc	ja-dc
	Scleria levis Retz.	h	pd	3	gro	wet areas in dof		ss ry	ag-nv	sp-dc	my-dc
	Scleria lithosperma (L.) Sw. var. linearis Bth.	h	pd	3	gro	dof		ry	ag-nv	sp-dc	my-dc
	Scleria neesii Kunth	h	a	3	gro	wet areas in dof		ss ry	ag-nv	sp-dc	my-dc
	Scleria psilorrhiza Cl.	h	pd	3	gro	wet areas in dof		ss ry	ag-nv	sp-dc	my-dc
Gramineae	*Apluda mutica L.*	h	capd	3	gro	dof		ry sh ss	nv-ja	dc-fb	jn-fb
	Arundinella setosa Trin. var. setosa	h	pd	3	gro	dof		ry	ag-oc	sp-nv	jn-dc
	Bothriochloa bladhii (Retz.) S.T. Blake	h	a	3	gro wee	da		ss ry	ag-nv	sp-dc	my-dc
	Brachiaria setigera (Retz.) C.E. Hubb.	h	a	3	gro wee	rvf		sh ss	dc-mr	ja-ap	nv-jn
	Chrysopogon aciculatus (Retz.) Trin.	h	ped	4	gro wee	da		sh ss ry	sp- nv	oc-dc	ja-dc
	Coelachne perpusilla (Arn. ex Steud.) Thw.	h	a	3	gro	wet areas in dof		ss ry	ag-nv	sp-dc	my-dc
	Cynodon dactylon (L.) Pers.	h	ape	3	gro wee	da sg rvf	sa	ss ry	ja-dc	ja-dc	ja-dc
	Dactyloctenium aegyptium (L.) P. Beauv.	h	ped	3	gro wee	da		sh ss ry	sp- nv	oc-dc	ja-dc
	Digitaria bicornis (L.) Roem. & Schult.	h	a	3	gro wee	cult rvf	sa	sh ss	nv-ap	dc-my	nv-jl
	Digitaria siamensis Henr.	h	a	3	gro	dof		ry	ag-oc	sp-nv	my-dc
	Echinochloa colona (L.) Link	h	ape	3	gro wee	da sg rvf	sa	ss ry	ja-dc	ja-dc	ja-dc
	Eleusine indica (L.) Gaertn.	h	ape	3	gro wee	da sg rvf	sa		ja-dc	ja-dc	ja-dc
	Eragrostis amabilis (L.) Nees	h	a or pe	3	gro wee	da sg rvf	sa	ss ry	ap-nv	my-dc	mr-dc
	Eragrostis luzonensis Steud.	h	a	3	gro wee	da		sh ss ry	ag-nv	sp-dc	my-dc
	Eragrostis pilosa (L.) P. Beauv.	h	a	3	gro wee	cult rvf	sa	sh ss	nv-ap	dc-my	nv-jl

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	Eremochloa ciliaris (L.) Merr.	h	a	4	gro	wet areas in dof		ss ry	ag-nv	sp-dc	my-dc
	Eriachne triseta Nees ex Steud.	h	pd	5	gro	dof		sh ss	nv-ja	dc-fb	jn-fb
	Leptochloa chinensis (L.) Nees	h	a	3	gro wee	cult rvf	sa	sh ss	nv-ap	dc-my	nv-jl
	Leptochloa malabarica (L.) Veldk.	h	pd	3	gro	rocks in dof	rk	ry	ag-oc	sp-nv	my-dc
	Lophopogon intermedius A. Camus	h	pd	3	gro rhe	rvf	gv rk	ss	dc ja fb	ja-mr	nv-jl
	Mnesithea laevis (Retz.) Kunth var. laevis	h	pd	3	gro	wet areas in dof		ss ry	ag-oc	sp-nv	my-dc
	Oryza sativa L.	h	a	5	gro wee	da sg cult		ry	mr-oc	(my) nv-dc	fb-dc
	Ottochloa nodosa (Kunth) Dandy	h	a	3	gro	dof mxf		ss ry	ag-oc	sp-nv	my-dc
	Paspalum orbiculare Forst.	h	pd	3	gro wee	wet areas in dof		ss ry	ag-oc	sp-nv	my-dc
	Phragmites vallatoria (Pluk. ex L.) Veldk.	h	pe	4	gro wee	mxf da sg cult rvf	sa	sh ss	nv-mr	dc-ap	nv-jl
	Saccharum spontaneum L.	h	pd	4	gro wee	cult rvf	sa	sh ss	nv-ap	dc-my	nv-jl
	Sacciolepis indica (L.) A. Chase	h	a	3	gro wee	wet areas in dof cult		ss ry	ag-oc	sp-nv	my-dc
	Setaria parviflora (Poir.) Kerg.	h	a	3	gro wee	da cult		ss ry	ag-oc	sp-nv	my-dc
	Sorghum mekongense (A. Camus) A. Camus	h	ape	3	gro wee	da sg rvf	sa	ss	ap-jl	my-ag	ja-dc
	Sporobolus diander (Retz.) P. Beauv.	h	ped	3	gro wee	da		ss ry	ag-nv	sp-dc	ja-dc
	Sporobolus harmandii Henr.	h	a	3	gro	wet areas in dof		ss ry	ag-oc	sp-nv	my-dc
	Thysanolaena latifolia (Roxb. ex Horn.) Honda	h	pe	4	gro wee	da sg		ry sh ss	ag-oc	sp-nv	ja-dc
Gramineae, Bambusoideae	*Bambusa bambos (L.) Voss. ex Vilm.*	h	pe	4	gro cul	da sg		ry sh ss	fb-mr	mr-ap	ja-dc
	Bambusa vulgaris Schrad. ex Wend. var. striata (Lodd. ex Penny) Gamb.	s (h)	pe	3	gro cul	da sg cult		ry sh ss	dc-ja	ja-fb	ja-dc
	Dendrocalamus longispathus Kurz	h	pe	3	gro cul	da sg cult		ry sh ss			ja-dc
	Gigantochloa albo-ciliata (Munro) Kurz	s (h)	pe	3	gro	da sg		sh ss	ja-fb	fb-mr	ja-dc
	Thyrostachys oliveri Gamb.	s (h)	pe	3	gro cul	da sg cult		ss	ja-fb	fb-mr	ja-dc
Cycadaceae	*Cycas pectinata B.H.*	l	pe	2	gro	mxf		sh ss	nv-dc	ja-fb	ja-dc
	Epicycas siamensis (Miq.) de Laub.	h	pd	3	gro	dof		ss ry		mr-my	mr-dc
Selaginellaceae	*Selaginella repanda (Desv.) Spr.*	h	a	3	gro epl	mxf		ry sh ss	sp- nv	sp-nv	jn-dc
Schizaeaceae	*Lygodium flexuosum (L.) Sw.*	v	pd	3	gro	dof sg		ry sh ss	jl-dc	jl-dc	my-dc
Davalliaceae	*Davallia denticulata (Burm. f.) Mett. ex Kuhn*	h cr	pd	3	epi	mxf		sh ss	sp- nv	sp-nv	jn-dc
Oleandraceae	*Oleandra undulata (Willd.) Ching*	h	pd	3	epi epl gro	dof		ry	sp- nv	sp-nv	jn-nv
Parkeriaceae	*Adiantum philippense L.*	h	pd	3	gro epl	dof mxf		ry sh ss	sp- nv	sp-nv	my-nv
	Adiantum zollingeri Mett. ex Kuhn	h	pd	3	gro epl	dof mxf		ry sh ss	sp- nv	sp-nv	my-nv
	Ceratopteris thalictroides (L.) Brongn.	h	a	2	gro	ponds wet areas in dof		ss ry	ag-nv	ag-nv	jn-nv
	Cheilanthes belangeri (Bory) C. Chr.	h	pd	3	gro	rocks in dof	rk	ry	ag-nv	ag-nv	jn-nv
	Cheilanthes chusana Hk.	h	pd	3	gro	wet areas in mxf da sg		ss ry	ag-nv	ag-nv	jn-nv
	Doryopteris ludens (Wall. Ex Hk.) J.Sm.	h	pe	2	gro or epl	mxf		ry	ja-dc	ja-dc	ja-dc
Pteridaceae	*Pteris heteromorpha Fee*	h	pe	2	gro	mxf		ss	ja-dc	ja-dc	ja-dc
Lomariopsidaceae	*Bolbitis hookeriana K. Iw.*	h	pe	3	gro	mxf		sh ss	sp-my	sp-my	ja-dc
Dryopteridaceae	*Dryopteris cochleata (D. Don) C. Chr.*	h	pd	2	gro	mxf		ry	oc-dc	oc-dc	my-dc
	Tectaria impressa (Fee) Holtt.	h	pe	3	gro	mxf		sh ss	ja-dc	ja-dc	ja-dc
Thelypteridaceae	*Meniscium proliferum (Retz.) Sw.*	h	pd	3	gro rhe	streams in rvf		ss	dc-ap	dc-ap	nv-jl
Athyriaceae	*Anisocampium cumingianum Presl*	h	pd	2	gro	da sg in mxf		ss	ag-nv	ag-nv	my-nv
Polypodiaceae	*Drynaria bonii C. Chr.*	h	pd	2	epl less often epi	dof mxf		ss ry	jn-dc	jn-dc	my-dc
	Drynaria quercifolia (L.) J. Sm.	h	pd	3	epi epl	da sg mxf		sh ss	sp- nv	sp-nv	jn-dc
	Pyrrosia adnascens (Sw.) Ching	h cr	pe	3	epi	da sg		sh ss	sp- nv	sp-nv	ja-dc
	Pyrrosia longifolia (Burm. f.) Mort.	h	pe	3	epi	dof mxf		ss ry	ja-dc	ja-dc	ja-dc
	Pyrrosia stigmosa (Sw.) Ching	h	pe	3	epi epl	dof mxf		ss ry	ap - dc	ap-dc	ja-dc
Marsileaceae	*Marsilea quadrifolia L.*	h	pd	3	aqu gro rhe	streams ponds in rvf	sa	ss	ja-mr	ja-mr	nv-ag

Appendix 3

Fish species at Ban Hang Khone

Compiled by Ian G. Baird

#	FAMILY	GENUS	SPECIES	LAO NAMES (as used in Khong District)	FISHERIES
1	Pristidae	*Pristis*	*microdon*	*pa salam (not yet observed but many reliable reports)*	insignificant
2	Dasyatidae	*Amphostistus*	*laosensis*	*pa fa hang/pa fa lai/pa fa (shortened)*	moderate
3		*Himantura*	*chaophraya*	*pa fa hang/pa fa lai/pa fa (shortened)*	small
4	Notopteridae	*Chitala*	*blanci*	*pa tong kai/pa tong (shortened)*	high
5		*Chitala*	*ornata*	*pa tong khouay/pa tong (shortened)*	moderate
6		*Notopterus*	*notopterus*	*Pa tong na/pa tong (shortened)*	high
7	Angillidae	*Anguilla*	*marmorata*	*Pa lat meo/pa lai fai fa*	small
8	Clupeidae	*Clupeichthys*	*aesarnensis*	*Pa keo*	insignificant
9		*Tenualosa*	*thibeaudaui*	*pa mak phang*	small
10	Engraulidae	*Lycothrissa*	*crocodilus*	*pa mak chan/pa meo*	small
11		*Setipinna*	*melanochir*	*pa meo*	moderate
12	Cyprinidae	*Aaptosyax*	*grypus*	*pa sanak gnai/pa sanak (shortened)*	small
13		*Amblyrhynchichthys*	*truncatus*	*pa ta chon/pa ta po/pa ta chouan*	moderate
14		*Bangana*	*behri*	*pa va na no/pa va na hak/pa va kham*	high
15		*Barbichthys*	*nitidus*		small
16		*Barbodes*	*altus*	*pa vian fai/pa mak mong*	high
17		*Barbodes*	*gonionotus*	*pa pak kom/pa pak (shortened)*	high
18		*Catlocarpio*	*siamensis*	*pa kaho*	small
19		*Chela*	*caeruleostigmata*		insignificant
20		*Cirrhinus*	*cirrhosus*	*pa nang chan? (introduced species)*	small
21		*Cirrhinus*	*jullieni*	*pa doke ngieu pha*	moderate
22		*Cirrhinus*	*microlepis*	*pa phone/pa phone mak koke*	high
23		*Cirrhinus*	*molitorella*	*pa keng*	moderate
24		*Cosmocheilus*	*harmandi*	*pa mak ban/pa ban (shortened)*	high
25		*Crossocheilus*	*reticulatus*	*pa toke thoi/pa khi khom*	high
26		*Crossocheilus*	*cf. cobitis*	*pa khang lai*	insignificant
27		*Crossocheilus*	*siamensis*	*pa khang lai*	small
28		*cf. Crossocheilus*	*sp. (red body)*	*pa khang lai*	insignificant
29		*Ctenopharyngoden*	*idellus*	*pa nang chan? (introduced species)*	small
30		*Cyclocheilichthys*	*apogon*	*pa doke ngieu*	moderate

#	FAMILY	GENUS	SPECIES	LAO NAMES (as used in Khong District)	FISHERIES
31		*Cyclocheilichthys*	*armatus*	*pa doke ngieu khao/pa doke ngieu (shortened)*	moderate
32		*Cyclocheilichthys*	*enoplos*	*pa chok/pa choke*	high
33		*Cyclocheilichthys*	*repasson*	*pa doke ngieu*	moderate
34		*Cyprinus*	*carpio*	*pa nai (introduced species;established in the wild)*	moderate
35		*Epalzeorhynchos*	*frenatum*	*pa dout hin*	small
36		*Esomus*	*metallicus*	*pa sieu na*	moderate
37		*Garra*	*fasciacauda*	*pa khiko/pa say tan*	high
38		*Garra*	*sp.*		small
39		*Hampala*	*dispar*	*Pa sout*	small
40		*Hampala*	*macrolepidota*	*Pa sout*	moderate
41		*Henicorhynchus*	*lineatus*	*Pa soi (lai)*	small
42		*Henicorhynchus*	*lobatus*	*Pa soi houa lem/pa soi hang leuang/pa soi (short.ed)*	high
43		*Henicorhynchus*	*siamensis*	*pa soi houa po/pa mok/pa soi (shortened)*	high
44		*Hypsibarbus*	*lagleri*	*pa pak pay/pa pak (shortened)*	high
45		*Hypsibarbus*	*malcolmi*	*pa pak nouat/pa pak kom/pa pak (shortened)*	high
46		*Hypsibarbus*	*pierrei*	*pa pak ta leuang/pa pak (shortened)*	moderate
47		*Hypsibarbus*	*wetmorei*	*pa pak kham/pa pak thong leuang/pa pak (shortened)*	high
48		*Labeo*	*erythropterus*	*pa va souang/pa va (shortened)*	high
49		*Labeo*	*rohita*	*(pla yisok thet in Thai) (introduced)*	small
50		*Labiobarbus*	*leptocheilus*	*pa lang khon*	high
51		*Leptobarbus*	*hoeveni*	*pa phong*	small
52		*Lobocheilus*	*melanotaenia*	*pa khiang khang lai*	high
53		*Luciosoma*	*bleekeri*	*pa mak vai*	moderate
54		*Macrochirichthys*	*macrochirus*	*pa hang pha*	small
55		*Mekongina*	*erythrospila*	*pa sa-ee*	high
56		*Morulius*	*cf. barbatula*	*pa phia i-tou/pa phia (shortened)*	high
57		*Morulius*	*cf. chrysophekadion*	*pa phia khi kam/pa phia (shortened)*	high
58		*Mystacoleucus*	*cf. greenwayi*	*pa lang nam/pa lang ko*	small
59		*Mystacoleucus*	*cf. marginatus*	*pa lang nam/pa lang ko*	moderate
60		*Onychostoma*	*cf. elongatum*	*pa soi ?*	moderate
61		*Opsarius*	*koratensis*	*pa sieu*	small
62		*Opsarius*	*pulchellus*		moderate
63		*Oreichthys*	*parvus*	*pa sieu*	insignificant
64		*Osteochilus*	*hasselti*	*pa khi ka pheu-i/pa khi ka pheu*	small
65		*Osteochilus*	*lini*	*pa soi ?*	small
66		*Osteochilus*	*melanopleura*	*pa nok khao*	small
67		*Osteochilus*	*microcephalus*	*pa khang lai*	moderate
68		*Osteochilus*	*waandersii*	*pa khang lai*	small
69		*Parachela*	*siamensis*	*pa tep houa beut*	small
70		*Paralaubuca*	*typus*	*pa tep*	high
71		*Poropuntius*	*deauratus*	*pa chat hang leuang/pa hang sam/pa chat (short.ed)*	moderate
72		*Probarbus*	*jullieni*	*pa eun ta deng/pa eun thong/pe eun moum/pa eun tabong*	high
73		*Probarbus*	*labeamajor*	*pa eun khao/pa eun me ngouang/pa eun kho kan*	high
74		*Puntioplites*	*falcifer*	*pa sakang*	high
75		*Puntius*	*brevis*	*pa khao*	moderate
76		*Raiamas*	*guttatus*	*pa sanak*	moderate
77		*Rasbora*	*aurotaenia*	*pa sieu ao*	moderate
78		*Rasbora*	*borapetensis*	*pa sieu khao/pa sieu (shortened)*	small
79		*Rasbora*	*tornieri*	*pa sieu ao*	small
80		*Scaphognathops*	*bandanensis*	*pa pian*	high
81		*Scaphognathops*	*stejnegeri*	*pa pian*	moderate
82		*Sikukia*	*gudgeri*	*pa ta say/pa khao na*	high
83		*Systomus*	*orphoides*	*pa pok*	small
84		*Systomus*	*partipentazona*	*pa seua (noi)*	insignificant
85		*cf. Systomus*	*sp.*	*pa khao*	moderate
86		*Tynnichthys*	*thynnoides*	*pa koum*	high
87		*Tor*	*tambroides*	*pa koua*	small
88	Gyrinocheilidae	*Gyrinocheilus*	*pennocki*	*pa ko*	high

#	FAMILY	GENUS	SPECIES	LAO NAMES (as used in Khong District)	FISHERIES
89	Balitoridae	*Hemimyzon*	*sp.*	*pa tit hin*	insignificant
90		*Hemimyzon*	*sp.*	*pa tit hin*	insignificant
91	Cobitidae	*Acantopsis*	*sp.*	*pa hak kouay*	moderate
92		*Acantopsis*	*sp.*	*pa hak kouay*	moderate
93		*Botia*	*caudapunctata*	*pa mou man/pa mou (shortened)*	moderate
94		*Botia*	*eos*	*pa mou man/pa mou hin/pa mou (shortened)*	small
95		*Botia*	*helodes*	*pa kheo kai*	high
96		*Botia*	*lecontei*	*pa mou man/pa mou (shortened)*	moderate
97		*Botia*	*modesta*	*pa mou man/pa mou (shortened)*	high
98		*Botia*	*cf. morleti*	*pa mou man/pa mou (shortened)*	moderate
99		*Pangio*	*anguillaris*	*pa si-eu*	insignificant
100		*Pangio*	*fusca*	*pa si-eu*	insignificant
101		*Schistura*	*sp.(red&black bars)*	*pa it/pa khang lai/pa kheo kai*	small
102		*Schistura*	*sp.(whitish body)*	*pa it/pa khang lai/pa kheo kai*	insignificant
103		*Schistura*	*sp.(brown&white bars)*	*pa it/pa khang lai/pa kheo kai*	insignificant
104		*Nemacheilus*	*sp.(yellow body)*	*pa it/pa khang lai/pa kheo kai*	insignificant
105	Bagridae	*Bagrichthys*	*macracanthus*	*pa mak khan mak kheu*	moderate
106		*Bagrichthys*	*macropterus*	*pa kouay souk/pa mak khan mak kheu*	moderate
107		*Heterobagrus*	*bocourti*	*pa kha gneng (chong lang gnao)*	small
108		*Hemibagrus*	*nemurus*	*pa kot leuang/pa kot youak/pa kot (shortened)*	high
109		*Hemibagrus*	*wyckii*	*pa kot mo/pa kot dam*	high
110		*Hemibagrus*	*wyckioides*	*pa kheung*	high
111		*Mystus*	*albolineatus*	*pa kha gneng*	small
112		*Mystus*	*atrifasciatus*	*pa kha gneng khang lai/pa kha gneng (shortened)*	small
113		*Mystus*	*multiradiatus*	*pa kha gneng khang lai/pa kha gneng (shortened)*	small
114		*Mystus*	*mysticetus*	*pa kha gneng khang lai/pa kha gneng (shortened)*	small
115		*Mystus*	*cf. rhegma*	*pa kha gneng*	small
116		*Mystus*	*singaringan*	*pa kha gneng kho*	small
117		*Pseudomystus*	*siamensis*	*pa khi hia*	high
118	Siluridae	*Belodontichtys*	*cf. dinema*	*pa khop*	high
119		*Hemisilurus*	*mekongensis*	*pa nang deng*	high
120		*Kryptopterus*	*bicirrhis or sp.*	*pa pik kai*	moderate
121		*Kryptopterus*	*cryptopterus*	*pa doke boua/pa pik kai*	moderate
122		*Kryptopterus*	*cf. cheveyi*	*pa pik kai*	small
123		*Kryptopterus*	*limpok*	*pa pik kai*	small
124		*Kryptopterus*	*moorei*	*pa pik kai*	small
125		*Kryptopterus*	*schilbeides*	*pa pik kai*	small
126		*Micronema*	*apogon*	*pa sa-ngoua/pa nang*	high
127		*Micronema*	*bleekeri*	*pa nang ngeun/pa kayt/pa nang (shortened)*	high
128		*Micronema*	*micronema*	*pa nang khao/pa nang (shortened)*	moderate
129		*Ompok*	*hypophthalmus*	*pa seuam*	moderate
130		*Ompok*	*sp.(long barbels)*	*pa pik kai (to phou/nouat gnao)*	small
131		*Wallago*	*attu*	*pa khao*	moderate
132		*Wallago*	*leeri*	*pa khoun*	moderate
133	Pangasiidae	*Helicophagus*	*waandersi*	*pa na nou/pa hoi*	high
134		*Pangasianodon*	*hypophthalmus*	*pa souay kheo/pa souay (shortened)*	moderate
135		*Pangasianodon*	*gigas*	*pa beuk*	small
136		*Pangasius*	*bocourti*	*pa houa mouam/pa yang*	high
137		*Pangasius*	*conchophilus*	*pa ke (small)/pa pho (large)*	high
138		*Pangasius*	*krempfi*	*pa souay hang leuang/pa souay (shortened)*	high
139		*Pangasius*	*larnaudii*	*pa peung*	high
140		*Pangasius*	*macronema*	*pa gnone thamada/pa gnone siap/pa gnone (shortened)*	high
141		*Pangasius*	*pleurotaenia*	*pa gnone thong khom/pa gnone (shortened)*	high
142		*Pangasius*	*polyuranodon*	*pa gnone hang hian/pa gnone youak/pa gnone (short)*	high
143		*Pangasius*	*sanitwongsei*	*pa leum/pa ling*	small
144	Schilbeidae	*Laides*	*hexanema*	*pa gnone thong/pa gnone (shortened)*	small
145		*Laides*	*sinensis*	*pa gnone thong/pa gnone (shortened)*	small
146	Amblycipitidae	*Amblyceps*	*mangois*	*pa douk deua*	insignificant

#	FAMILY	GENUS	SPECIES	LAO NAMES (as used in Khong District)	FISHERIES
147	Akysidae	*Akysis*	*recavus*	*pa khi hia*	insignificant
148		*Akysis*	*leucorhynchus*	*pa khi hia*	insignificant
149	Sisoridae	*Bagarius*	*yarrelli*	*pa khe*	high
150		*Glyptothorax*	*fuscus*	*pa kon*	insignificant
151		*Glyptothorax*	*cf. lampris*	*pa kon*	insignificant
152		*Glyptothorax*	*cf. laosensis*	*pa kon*	insignificant
153		*Glyptothorax*	*sp.*	*pa kon*	insignificant
154		*Glyptothorax*	*sp.*	*pa kon*	insignificant
155		*Glyptothorax*	*sp.*	*pa kon*	insignificant
156		*Glyptothorax*	*sp.*	*pa kon*	insignificant
157		*Glyptothorax*	*sp.*	*pa kon*	insignificant
158	Claridae	*Clarias*	*batrachus or spp.*	*pa douk*	high
159	Hemirhamphidae	*Dermogenys*	*cf. siamensis*	*pa kathong*	insignificant
160	Ariidae	*Arius*	*Stormi*	*pa khat ok (sop lem)*	high
161		*Hemipimelodus*	*Borneensis*	*pa khat ok*	high
162	Belonidae	*Xenentodon*	*Cancila*	*pa kathong*	small
163	Syngathidae	*Dorichthys*	*cf. martensii*	*pa lek nay*	not eaten
164	Synbranchidae	*Monopterus*	*albus*	*ian*	moderate
165	Mastacembelidae	*Macrognathus*	*siamensis*	*pa lot*	high
166		*Macrognathus*	*taeniagaster*	*pa lot*	small
167		*Macrognathus*	*sp. (long shout)*	*pa lot*	small
168		*Mastacemblus*	*armatus*	*pa lat*	high
169		*Mastacemblus*	*favus*	*pa lat*	high
170	Ambassidae	*Parambassis*	*apogonoides*	*pa khap khong*	small
171		*Parambassis*	*siamensis*	*pa khap khong*	small
172		*Parambassis*	*wolffi*	*pa khap khong*	moderate
173	Coiidae	*Coius*	*undecimradiatus*	*pa seua*	moderate
174	Polynemidae	*Polynemus*	*longipectoralis*	*pa chin*	moderate
175	Sciaenidae	*Boesemania*	*microlepis*	*pa kouang*	high
176	Toxotidae	*Toxotes*	*cf. chatareus*	*pa mong*	small
177	Nanididae	*Pristolepis*	*fasciatus*	*pa ka*	high
178	Eleotrididae	*Oxyeleotris*	*marmorata*	*pa bou*	small
179	Gobiidae	*Glossogobius*	*giuris/koragensis*	*pa bou (khao)*	small
180		*Rhinogobius*	*ocellatus*	*pa say beu ban/pa bou*	small
181		*cf. Rhinogobius*	*sp.*	*pa say beu ban/pa bou*	insignificant
182		*cf. Rhinogobius*	*sp.*	*pa say beu ban houa dam/pa say beu ban/pa bou*	insignificant
183			*general sp. undet.*	*pa bou*	insignificant
184	Anabantidae	*Anabas*	*testudineus*	*pa kheng*	moderate
185	Belontiidae	*Trichogaster*	*pectoralis*	*pa salit (found above Khone Falls)(introduced)*	insignificant
186		*Trichogaster*	*trichopterus*	*pa kadeut*	small
187		*Trichopsis*	*vittata*	*pa mat*	small
188	Osphronemidae	*Osphronemus*	*exodon*	*pa men*	moderate
189	Channidae	*Channa*	*limbata*	*pa kang*	moderate
190		*Channa*	*cf. marulius*	*pa kouan*	moderate
191		*Channa*	*micropeltes*	*pa ka do/pa meng phou*	moderate
192		*Channa*	*striata*	*pa kho*	high
193	Soleidae	*Achiroides*	*cf. leuorhynchus*	*pa pan*	moderate
194		*Brachirus*	*harmandi*	*pa pan*	moderate
195		*Synaptera*	*cf. panoides*	*pa pan (gnai)*	high
196	Cynoglossidae	*Cynoglossus*	*microlepis*	*pa lin ma/pa pan*	small
197	Tetraodontidae	*Chonerhinus*	*nefastus*	*pa pao*	not eaten
198		*Tetraodon*	*baileyi*	*pa pao thong/pa pao (shortened)*	not eaten
199		*Tetraodon*	*barbatus*	*pa pao ta/pa pao (shortened)*	not eaten
200		*Tetraodon*	*fangi*	*pa pao ta/pa pao (shortened)*	not eaten
201		*Tetraodon*	*leiurus*	*pa pao*	not eaten

Appendix 4

List of bird species observed in Khone island during 1993-97

Compiled by Peter Cunningham

#	COMMON NAME	SCIENTIFIC NAME	LAO NAME
1	Little Cormorant	*Phalacrocorax niger*	
2	Oriental Darter	*Anhinga melanogaster*	nok ka nam; nok kho ngou
3	Grey Heron	*Ardea cinerea*	nok seo khouak
4	Purple Heron	*Ardea purpurea*	nok seo khouak
5	Chinese Pond-Heron	*Ardeola bacchus*	nok chao
6	Cattle Egret	*Bubulcus ibis*	nok nyang
7	Great Egret	*Egretta alba*	nok nyang
8	Intermediate Egret	*Egretta intermedia*	nok nyang
9	Little Egret	*Egretta garzetta*	nok nyang
10	Little Heron	*Butorides striatus*	nok chao lang
11	Black Bittern	*Dupetor flavicollis*	nok chao lang
12	Black-crowned Night-Heron	*Nycticorax nycticorax*	nok chao
13	Malayan Night-Heron	*Gorsachius melanolophus*	nok choa fan
14	Cinnamon Bittern	*Ixobrychus cinnamomeus*	
15	Painted Stork	*Mycteria leucocephala*	nok ka boua
16	Wooly-necked Stork	*Ciconia episcopus*	nok kho kan
17	Greater Adjutant	*Leptoptilos dubius*	nok ka soom
18	Adjutantsp.	*Leptoptilos sp.*	nok ka soom
19	Saurus Crane	*Grus antigone*	nok kiang
20	Spot-billed Pelican	*Pelecanus philippensis*	nok hong
21	Giant ibis	*Pseudibis gigantea*	nok sob hoi nyai
22	large Ibis sp. or spp.	*Pseudibis sp. or spp.*	nok sob hoi nyai
23	Spot-billed Duck	*Anus poecilorhyncha*	pet nam
24	Osprey	*Pandion haliaetus*	leo pa
25	Black-shouldered Kite	*Elanus caeruleus*	
26	Brahminy kite	*Haliastur indus*	leo deng
27	Jerdon's Baza	*Aviceda jerdoni*	leo
28	Black Baza	*Aviceda leuphotes*	leo hone
29	Crested Goshawk	*Accipiter trivirgatus*	nok houa nam pheung
30	Shikra	*Accipiter badius*	leo nok khoa
31	Grey-headed Fish-Eagle	*Ichthyophaga ichthaetus*	leo pa; nok o-ho
32	Crested Serpent-Eagle	*Spilornis cheela*	nok khoa kou houk
33	Red-headed Vulture	*Sarcogyps calvus*	heng kho deng; heng kho kham
34	Long-billed Vulture	*Gyps indicus*	heng khi thao
35	White-rumped Vulture	*Gyps bengalensis*	heng khi tao
36	Collared Falconet	*Microhietax caerulescens*	

#	COMMON NAME	SCIENTIFIC NAME	LAO NAME
37	Peregrine Falcon	*Falco pergrinus*	
38	Red Junglefowl	*Gallus gallus*	gai pa
39	White-breasted Waterhen	*Amaurornis phoenicurus*	
40	Red-wattled Lapwing	*Venellus indicus*	nok te te
41	River Lapwing	*Vanellus duvaucelii*	nok te te
42	Little-ringed Plover	*Charadrius dubius*	
43	Curlew sp.	*Numenius sp.*	nok sob hoi noi
44	Common Greenshank	*Tringa nebularia*	
45	Green Sandpiper	*Tringa ochropus*	
46	Common Sandpiper	*Actitis hypoleucos*	
47	Pintail Snipe	*Gallinago stenura*	nok khek
48	Greater Painted-snipe	*Rostratula benghalensis*	
49	Small Pratincole	*Glareola lactea*	nk khoa sai
50	Black-winged Stilt	*Himantopus himantopus*	
51	Great Thick-knee	*Esacus recurvirostris*	no mouan
52	Brown-headed Gull	*Larus brunnicephalus*	
53	River Tern	*Sterna aurantia*	nok see da
54	White-winged Tern	*Chlidonias leucopterus*	
55	Thick-billed Pigeon	*Treron curvirostra*	mok poa
56	Yellow-footed Pigeon	*Treron phoenicoptera*	nok poa; nok moum
57	Green Imperial Pigeon	*Ducula aenea*	nok moum
58	Red Turtle-Dove	*Streptopelia tranquebarica*	nok khoa
59	Spotted Dove	*Streptopelia chinensis*	nok khao
60	Emerald Dove	*Chalcophaps indica*	nok khao
61	Alexandrine Parakeet	*Psittacula eupatria*	nok khek
62	Red-breasted Parakeet	*Psittacula alexandri*	nok khek
63	Blossum-headed Parakeet	*Psittacula roseata*	nok khek; nok chee
64	Grey-headed Parakeet	*Psittacula fischii*	nok khek; nok chee
65	Vernal Hanging Parrot	*Loriculus vernalis*	nok chee
66	Indian Cuckoo	*Cuculus micropterus*	nok jee jo
67	Plaintive Cuckoo	*Cacomantis merulinus*	
68	Violet Cuckoo	*Chrysococcyx xanthrorhyn.*	
69	Common Koel	*Eudynamys scolopacea*	
70	Green-billed Malkoha	*Phaenicophaeus tristis*	nok ghawt
71	Greater Coucal	*Centropus sinensis*	nok kot
72	Lesser Coucal	*Centropus bengalensis*	nok kot
73	Barn Owl	*Tyto alba*	
74	Brown Hawk-Owl	*Ninox scutulata*	
75	Bay Owl	*Phodilus badius*	nok ka heo; nok pee pai
76	Collared Scops-Owl	*Otus lempiji*	nok khoa noo
77	Asian Barred Owlet	*Glaucidium cuculoides*	
78	Brown Fish-Owl	*Ketupa zeylonensis*	nok khi khi
79	Spotted Wood-Owl	*Strix seloputo*	nok khoa mee
80	Great-eared Nightjar	*Eurostopodus macrotis*	nok ka ba ti lek
81	Large-tailed Nightjar	*Caprimulgus macrurus*	nok ka ba sang
82	Orange-breasted Trogon	*Harpactes oreskios*	nok lang khet
83	Pied Kingfisher	*Ceryle rudis*	nok katen khi none
84	Common Kingfisher	*Alcedo atthis*	nol katen sieu
85	Stork-billed Kingfisher	*Halcyon capensis*	nok katen louang
86	White-throated Kingfisher	*Halcyon smyrnensis*	nok katen ta louak
87	Black-capped Kingfisher	*Halcyon pileata*	nok katen kho kan
88	Chestnut-headed Bee-eater	*Merops leschenaulti*	nok kachieu
89	Blue-tailed Bee-eater	*Merops philippinus*	nok kachieu
90	Green Bee-eater	*Merops orientalis*	nok kachieu

#	COMMON NAME	SCIENTIFIC NAME	LAO NAME
91	Indian Roller	*Coracias benghalensis*	nok khap
92	Dollarbird	*Eurystomus orientalis*	
93	Hoopoe	*Upapa epops*	nok hone khouan
94	Wreathed Hornbill	*Rhyticeros undulatus*	nok kok
95	Oriental Pied Hornbill	*Anthracoceros albirostris*	nok keng
96	Lineated Barbet	*Megalaima lineata*	nok kadok
97	Blue-eared Barbet	*Megalaima australis*	
98	Coppersmith Barbet	*Megalaima haemacephala*	
99	Common Flameback	*Dinopium javanense*	nok sai
100	Laced Woodpecker	*Picus vittatus*	nok sai
101	Black-headed Woodpecker	*Picus erythropygius*	nok sai hua dam
102	Rufous Woodpecker	*Celeus brachyurus*	
103	Black-and-Buff Woodpecker	*Meiglyptes jugularis*	
104	Heart-spotted Woodpecker	*Hemicircus canente*	
105	Blue-winged Pitta	*Pitta moluccensis*	nok chet si; nok a hang
106	Asian Palm-Swift	*Cypsiurus balasiensis*	nok en fa
107	Brown Needletail	*Hirundapus giganteus*	
108	Crested Treeswift	*Hemiprocne coronata*	
109	Barn Swallow	*Hirundo rustica*	nok en
110	Wire-tailed Swallow	*Hirundo smithii*	nok en
111	Richard's Pipit	*Anthus novaeseelandiae*	
112	White Wagtail	*Motacilla alba*	leucopsis and alboides seen
113	Yellow Wagtail	*Motacilla flava*	
114	Forest Wagtail	*Dendronanthus indicus*	
115	Bar-winged Flycatcher-shrike	*Hemipus picatus*	
116	Large Wood-shrike	*Tephrodornis virgatus*	
117	Ashy Minivet	*Pericrocotus divaricatus*	
118	Common Iora	*Aegithina tiphia*	
119	Great Iora	*Aegithina lafresnayei*	
120	Golden-fronted Leafbird	*Chloropsis ayrifrons*	nok khote keo
121	Blue-winged Leafbird	*Chloropsis cochin'ensis*	
122	Black-headed Bulbul	*Pycnonotus atriceps*	nok khote luang
123	Black-crested Bulbul	*Pycnonotus melanicterus*	nok khote houan
124	Sooty-headed Bulbul	*Pycnonotus aurigaster*	nok khote
125	Stripe-throated Bulbul	*Pycnonotus finlaysoni*	nok khote
126	Yellow-vented Bulbul	*Pycnonotus goiavier*	nok khote
127	Streak-eared Bulbul	*Pycnonotus blanfordi*	nok khote
128	Black Drongo	*Dicrurus macrocercus*	nok ka seo
129	Ashy Drongo	*Dicrurus leucophaeus*	nok ka seo
130	Hair-crested Drongo	*Dicrurus hottentottus*	nok ka seo
131	Greater Racket-tailed Drongo	*Dicrurus paradiseus*	nok ga seo hang nyao
132	Black-naped Oriole	*Oriolus chinensis*	nok a meng louang
133	Black-hooded Oriole	*Oriolus xanthornus*	nok a meng louang
134	Blue Magpie	*Urocissa erythrorhyncha*	nok een khed
135	Large-billed Crow	*Corvus macrorhynchos*	ka
136	Puff-throated Babbler	*Pellorneum ruficeps*	
137	Scaly-crowned Babbler	*Malacopteron cinereum*	
138	Striped Tit-Babbler	*Macronous gularis*	
139	Grey-faced Tit-Babbler	*Mocronous ptilosus*	
140	White-crested Laughing Thrush	*Garrulax leucolophus*	nok thoua
141	White-bellied Yuhina	*Yuhina zantholeuca*	
142	Dusky Warbler	*Phylloscopus fuscatus*	
143	Radde's Warbler	*Phylloscopus schwarzi*	
144	Pale-legged Leaf Warbler	*Phylloscopus tenellipes*	

#	COMMON NAME	SCIENTIFIC NAME	LAO NAME
145	Warbler sp. or spp.	*Phylloscopus sp. or spp.*	
146	Thick-billed Warbler	*Acrocephalus aedon*	
147	Lanceolated Warbler	*Locustella lanceolata*	
148	Zitting Cisticola	*Cisticola juncidis*	
149	Plain Prinia	*Prinia inornata*	
150	Common Tailorbird	*Orhtotomus sutorius*	
151	Dark-necked Tailorbird	*Orhtotomus atrogularis*	
152	Siberian Rubythroat	*Luscinia calliope*	
153	Siberian Blue Robin	*Luscinia cyane*	
154	Oriental Magpie Robin	*Copsychus saularis*	nok jee joo
155	White-rumped Shama	*Copsychus malabaricus*	nok jee joo
156	Stonechat	*Saxicola torquata*	
157	Blue Rock-Thrush	*Monicola solitarius*	nak chao vat
158	Blue Whistling Thrush	*Myiophoneus caeruleus*	
159	Eyebrowed Thrush	*Turdus obscurus*	
160	Asian Brown Flycatcher	*Musciapa dauurica*	
161	Red-throated Flycatcher	*Ficedula parva*	
162	Little Pied Flycatcher	*Ficedula westermani*	
163	Grey-headed Flycatcher	*Culicicapa cetlonensis*	
164	Verditer Flycatcher	*Eumyias thalassina*	
165	Hainan-blue Flycatcher	*Cyornis hainana*	
166	Tickell's Blue Flycatcher	*Cyornis tickelliae*	
167	Blue flycatcher sp. or spp.	*Cyornis sp. or spp.*	
168	Black-naped Monarch	*Hypothymis azurea*	
169	Asian Paradise-flycatcher	*Terpsiphone paradisi*	
170	Brown Shrike	*Lanius cristatus*	
171	White-shouldered Starling	*Sturnus sinensis*	
172	Black-collared Starling	*Sturnus nigricollis*	nok iang
173	Vinous-breasted Starling	*Bturnus burmannicus*	nok iang
174	Common Myna	*Acridotheres tristis*	nok iang
175	White-vented Myna	*Acridotheres javanicus*	nok iang
176	Hill Myna	*Gracula religiosa*	nod seng ka; nok salika
177	Brown-throated Sunbird	*Anthreptes malacencis*	nok pi kouay
178	Ruby-cheeked Sunbird	*Anthreptes singalensis*	nok pi kouay
179	Olive-backed Sunbird	*Nectarina jugularis*	nok pi kouay
180	Crimson Sunbird	*Aethopyga siparaja*	nok pi kouay
181	Thick-billed Flowerpecker	*Dicaeum agile*	
182	Yellow-vented Flowerpecker	*Dicaeum chrysorreum*	
183	Scarlet-backed Flowerpecker	*Dicaeum cruentatum*	
184	Eurasian Tree-Sparrow	*Passer montanus*	
185	Plain-backed Sparrow	*Passer flaveolus*	
186	Baya Weaver	*Ploceus philippinus*	
187	White-rumped Munia	*Lonchura striata*	