

PROCEEDINGS

Workshop on Developing a Proposed Framework
for a Wetland Inventory, Assessment and
Monitoring System (WIAMS) in Malaysia

Cititel Mid Valley, Kuala Lumpur
18 & 19 April 2002



WETLANDS
INTERNATIONAL

Malaysia Programme

**Developing a Proposed Framework
for a Wetland Inventory, Assessment
and Monitoring System (WIAMS) in
Malaysia**

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FOREWORD

This workshop was very timely and is likely to have a major impact on wetland management both within Malaysia and far beyond. The initial intent was to develop a system for assessing wetlands in Malaysia and hence build on local interest and expertise. However, it was soon evident that the discussions being planned would have a much greater effect on wetland management in nearby countries and further afield. That is, the workshop provided the impetus for integrating information and models from other workshops, conferences and management programs. Led by knowledgeable speakers the workshop participants were able to take that extra step and expound a model that could assist in the integration of inventory, assessment and monitoring procedures that had hitherto on the whole been treated as separate processes.

The 62 workshop participants principally represented Malaysian federal and state governmental agencies, non-governmental organisations, universities, research institutions, international agencies, and private/corporate bodies. Assisted by staff from Wetlands International the participants listened to inputs and comments from experts familiar with one or other aspect of the continuum of wetland inventory, assessment and monitoring and agreed on the basic premises for a proposed framework that became known as a WIAMS for Malaysia. This was a major outcome and should serve as a valued model for Malaysia and others interested in an integrated approach to wetland management.

The model proposed will support the wise use of wetlands, whether for conservation, sustainable use or multiple use objectives. The approach involves a multi-scalar (hierarchical) approach to inventory, best practice assessment protocols within a risk management framework, and a focused monitoring program that provides feedback on performance in order to obtain outcomes. In these respects it builds on recent thinking and developments in wetland inventory, most notably the Asian Wetland Inventory that is also being developed by Wetlands International, as well as resolutions on wetland risk assessment and monitoring adopted by the Ramsar Wetlands Convention.

The outcomes of this workshop whilst worthy in themselves also represent a major outcome for the decade long push by Wetlands International and others for the development and implementation of integrated and technically sound approaches to wetland inventory, assessment and monitoring. Many discussions have been held within the technical sessions of the Ramsar Convention's Scientific and Technical Review Panel (STRP). Others were mediated by the Mediterranean wetland program known as MedWet that in effect grew from a conference organised by one of Wetlands International's forerunners – IWRB – in 1991. Thanks are due to the many scientists and conservationists who contributed to these discussions and enabled Wetlands International to hold a seminal workshop on these topics at the 2nd International Conference on Wetlands and Development, Dakar, Senegal, November, 1998. This workshop provided the impetus for many of the ideas that were subsequently accepted during the 7th Meeting of the Conference of Parties to the Ramsar Convention in San Jose, Costa Rica, in 1999. Substantial progress has been made since then and at the 8th Meeting of the Ramsar Parties planned for late 2002 a further set of resolutions will be submitted in support of the proposals that were aired and combined in the workshop in Kuala Lumpur.

The outcomes of the workshop in Kuala Lumpur are worthwhile and bring great credit to the sponsors of and participants in the Kuala Lumpur workshop. In this respect a special vote of gratitude to my colleagues in Wetlands International who organised this workshop. A further vote of appreciation to all those who over the past decade or so have supported our mutual efforts to improve wetland management and provide a better information base for their wise use. And as a concluding statement I'd like to include a note of appreciation to the late Dr G.E. (Ted) Hollis who provided many of the original ideas that challenged our thinking in the 1990s and helped us develop more integrated approaches to wetland management. We are closer to this now – thanks Ted for the harangues and guidance and for stressing that wetlands belong to us all and that we should manage them better.

Dr Max Finlayson

President, Wetlands International

Director, National Centre for Tropical Wetland Research

Darwin, Australia

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1.0 INTRODUCTION

The workshop on ‘Developing a Proposed Framework for a Wetland Inventory, Monitoring and Assessment System (WIAMS) in Malaysia’ was held on 18 & 19 April 2002 in Kuala Lumpur. A total of 62 participants from 43 agencies (government agencies - both at Federal and State, non-governmental organisations, universities, research institutions, international agencies, private /corporate bodies) attended (see Appendix II). Both the Wetlands International-Malaysia Programme and Wetlands International-Asia Regional Programme staff were present to assist in facilitating the workshop.

Relevant agencies from 6 states and several federal agencies attended. State agencies included various State Forestry Departments, Sabah Wildlife Department, Johor State Park Corporation, Natural Resources and Environment Board Sarawak (NREB) and Lembaga Urus Air Selangor (LUAS).

Federal agencies were represented by the Conservation and Environmental Management Division of the Ministry of Science, Technology and Environment (MoSTE), Forestry Division of the Ministry of Primary Industries (MPI), Federal Department of Town and Country Planning, Department of Environment (DOE), Malaysian Centre for Remote Sensing (MACRES), Department of Fisheries, Peninsular Malaysia Forestry Headquarters, Minerals and Geoscience Department and Department of Irrigation and Drainage (DID).

The workshop was organised to seek inputs and comments from the various participants on developing a proposed framework for a Wetland Inventory, Assessment and Monitoring System (WIAMS) in Malaysia. It was divided into two parts – the first day was devoted to presentations while participatory break-out sessions were held in the second day (see Appendix I for the workshop programme).



Workshop participants - seated from left to right, Dr. Sundari Ramakrishna, Dr. Zulkifli Idris and Mr. Peter Noordermeer

ACKNOWLEDGEMENTS

This document is the result of the workshop organized by Wetlands International-Malaysia Programme and funded by the Dutch Ministry of Foreign Affairs (DGIS) under the Conservation and Wise Use of Wetlands – Global Programme, administered by Wetlands International Global office based in Netherlands.

There are many people and agencies to thank for their involvement in this workshop. Special thanks to the Dutch Ministry of Foreign Affairs for without their funding assistance there would not have been such a workshop. Many thanks to the Royal Netherlands Embassy in Kuala Lumpur, namely Mr. Peter Noordermeer for kindly participating in the official opening of the workshop.

This workshop was supported by the Ministry of Science, Technology and the Environment Malaysia (MoSTE). Our heartiest gratitude is extended to Dr. Zulkifli Idris, Director, Conservation and Environmental Management Division of MoSTE for kindly addressing the official opening of the workshop.

Our gratitude also goes out to Dr. Max Finlayson, Dr. Jonathan Davies, Dr. Chris Humphrey, Prof. Ho Sinn Chye and Mr. Alvin Lopez for their inputs and useful comments during the pre- and post-workshop periods.

The Workshop Facilitating Team consisted of Dr. Sundari Ramakrishna, Murugadas TL, Sim Cheng Hua, Mohala Santharamohana and Zurahanim Fasha from Wetlands International-Malaysia Programme. Special thanks are also offered to the staff of Wetlands International - Asia Regional Programme, namely Lee Shin Shin, David Li, Flora George and Khadijah Ahmad. Our thanks also go out to Amaravathy Sivalingam for rapporteuring during the workshop as well as to Amelia Jindi and Nelson Yeoh for designing and formatting the whole proceeding document.

Our gratitude also goes out to Dr. Jonathan Davies and Dr. Chris Humphrey for agreeing to write and edit parts of this document which was not an easy task.

Most importantly, we would like to thank all the participants and speakers of this workshop for taking time out of their daily work schedule to contribute to this workshop – without them this workshop would not have been successful.

EXECUTIVE SUMMARY

This document is based on the presentations, outcomes and discussions held at a workshop hosted by Wetlands International-Malaysia Programme that was funded by the Dutch Ministry of Foreign Affairs (DGIS) under the Conservation and Wise Use of Wetlands – Global Programme based in Netherlands. The workshop was held on 18 & 19 April 2002, at Cititel Mid Valley, Kuala Lumpur.

When the idea of organising a workshop was first conceived in mid-June 2001, it was the intention of Wetlands International-Malaysia Programme to specifically ‘Develop a Framework for a Wetland Assessment System (WAS) in Malaysia’. However, the scope was broadened due to recent developments in wetland management and conservation at a global scale: it is now recognised that wetland inventory, assessment and monitoring are inseparable and essential components in a framework of knowledge for the wise use of wetlands, whether for conservation, sustainable use or multiple use objectives. Collectively known as a WIAMS (Wetlands Inventory, and Assessment, Monitoring System), it is argued that this comprehensive and integrated approach better and unambiguously articulates the framework necessary for effective wetland management and conservation than that implied in the conventional WAS (Wetlands Assessment System). It involves a multi-scalar (hierarchical) approach to inventory, best practice assessment protocols within a risk management framework, and a focused monitoring programme which provides feedback on performance in order to obtain outcomes. Hence, the workshop has been re-named in these proceedings to a Workshop on ‘Developing a Proposed Framework for a Wetland Inventory, Assessment and Monitoring System (WIAMS) in Malaysia’.

The workshop gave a broad introduction to the wetland management framework (WIAM), of which wetland inventory, assessment and monitoring are parts. The distinction between “inventory” and “assessment”, in particular, was clarified for participants; these terms are often confused and used interchangeably, yet they are two different activities under the WIAM framework. Thus, wetland inventory is the activity through which information is gathered, assessment is the activity which evaluates the information obtained while monitoring provides information to managers on the extent of any change.

Developments in WIAMS were then highlighted to the participants. It was noted that over the past two decades, WIAMS is rapidly becoming an indispensable part of the decision-making tool box for wetland managers and policy makers operating from local to global scales. It was recommended strongly that the WIAMS framework be adopted because it will, at the least, standardise terminology and provide compatible approaches for obtaining and reporting information which can then be shared with those who cannot afford the luxury of such programmes. Presenters of the WIAMS approach also stressed that while a hierarchical framework has been proposed, not all levels of detail need to be worked through and data at any level within the hierarchy may be gathered, whether or not other levels have been or will be addressed. The hierarchical approach provides the framework to gather information at different levels and detail, while demonstrating the clear linkages between scales.

The workshop was also an avenue to highlight two regionally important initiatives to the participants: The ‘Millennium Ecosystem Assessment (MA)’ and ‘The Asian

Wetland Inventory (AWI) Project'. The AWI is an initiative driven by Wetlands International and incorporates a multi-scalar approach to inventory. Two case studies, respectively from Australia and India, further elaborated upon the importance of WIAMS in the management and wise use of wetlands. Possible WIAM approaches and tools were also presented during the course of the workshop, including Remote Sensing and GIS.

The breakout, workshop sessions held after the presentations provided an opportunity for participants to apply a multi-scalar wetland inventory, assessment and monitoring approach to several case scenarios relevant to Malaysian wetlands. The outcomes of these sessions, described below, were important in highlighting practical issues and concerns that need to be addressed and/or considered, not just in implementing WIAMS but in general wetland management and conservation across the country.

The main outcomes of the workshop may be summarised as follows:

- Participants showed greater understanding of the concepts and terminology related to WIAMS.
- Generally, the participants agreed that there is a need to standardize methods of collecting and evaluating data.
- The government officers (agencies) representatives agreed that a wetland inventory should be done as the earlier directory 1987 is outdated.
- The Asian Wetland Inventory could be used as the basis for conducting a national wetland inventory for Malaysia. The inventory should focus on, and/or consider:
 - a basic data set that describes the location and size of the wetland and the major biophysical features, including variation in the areas and the water regime;
 - use of the AWI's standardised techniques, guidelines and manuals;
 - a review of gaps and coordination of data collection;
 - developing and making greater use of communication networks;
 - Included in the last two points is the need for coordination of all relevant agencies in Malaysia, including those holding existing data and those that could contribute further to data collection (eg Malaysian Centre for Remote Sensing (MACRES)).
- Once basic inventory data have been acquired and adequately stored, more management oriented information on wetland threats and uses, land tenure and management regimes, benefits and values should be added. Collectively, the biophysical and management oriented information should provide a basis for national assessment of wetlands and management priorities.
- A multi-scalar framework for gathering inventory information, such as adopted for the AWI and recommended for a national wetland inventory (described above), could be extended and applied nationally to assessment and monitoring, adopting a national WIAMS. The breakout, workshop session on assessing and reporting on the ecological character of wetlands in Malaysia showed that the country is in need of a national reporting program and techniques for WIAM at this scale. While the AWI can provide tools for inventory, other rapid (bio)assessment tools (ie cost-effective and sufficiently rapid to generate adequate 'first-pass' data over large areas) need to be developed and applied. Suitable concepts of assessment and monitoring have been addressed under the Ramsar Wetlands Convention.

- Some Malaysian participants at the workshop demonstrated considerable expertise in assessment methodologies and this highlighted further the need to coordinate and develop national frameworks for WIAMS through effective networks and partnerships.
- Participants agreed in principle that the draft framework can be used but required some fine tuning when it comes to the steps included in the process of WIAMS.

RINGKASAN EKSEKUTIF

Dokumen ini adalah berdasarkan pembentangan, rumusan dan perbincangan yang telah diadakan semasa suatu bengkel anjuran Wetlands International-Program Malaysia dengan pembiayaan daripada Dutch Ministry of Foreign Affairs (DGIS) di bawah Program Sejagat – Pemuliharaan dan Penggunaan Lestari Tanah Bencah (Conservation and Wise Use of Wetlands – Global Programme), yang berpangkalan di Netherlands. Bengkel ini diadakan pada 18 & 19 April 2002 di Cititel Mid Valley, Kuala Lumpur.

Ketika idea untuk menganjurkan suatu bengkel pertama kali diilhamkan pada pertengahan bulan Jun 2001, ia telah menjadi tujuan khas Wetlands International-Program Malaysia untuk 'Mengujudkan Rangkakerja bagi suatu Sistem Penilaian Tanah Bencah ataupun Wetland Assessment System (WAS) di Malaysia'. Walau bagaimanapun, skop rangkakerja ini telah menjadi luas disebabkan perkembangan terkini dalam bidang pemuliharaan dan pengurusan tanah bencah secara global: ia baru sahaja disedari bahawa penginventorian, penilaian dan pemantauan tanah bencah adalah merupakan komponen penting serta ianya tidak boleh dipisahkan dalam rangka pengetahuan untuk penggunaan lestari tanah bencah sama ada untuk pemuliharaan, penggunaan mapan atau tujuan pelbagai kegunaan. Diketahui secara kolektif sebagai WIAMS (Wetlands Inventory, and Assessment, Monitoring System), dipertikaikan bahawa kaedah komprehensif dan bersepadu ini lebih jelas menghuraikan rangkakerja yang diperlukan untuk pengurusan dan pemuliharaan efektif tanah bencah jika berbanding dengan kaedah yang lazim iaitu WAS (Wetlands Assessment System). Ia melibatkan pendekatan multi-skala (bersifat hierarki) untuk penginventorian, penggunaan protokol penilaian pengamalan terbaik yang dirangkumi dalam suatu rangkakerja pengurusan risiko, serta program pemantauan berfokus yang menyediakan maklum balas prestasi bagi tujuan memperoleh keputusan pelbagai. Oleh yang demikian, bengkel ini telah ditukar namanya dalam prosiding ini kepada Bengkel bagi tujuan 'Mengujudkan suatu Cadangan Rangkakerja bagi Sistem Penginventorian, Penilaian dan Pemantauan Tanah Bencah (WIAMS) di Malaysia'.

Bengkel ini memperkenalkan secara meluas rangkakerja pengurusan tanah bencah (WIAM), di mana penginventorian, penilaian dan pemantauan tanah bencah merupakan sebahagian daripadanya. Perbezaan antara 'inventori' dan 'penilaian' terutamanya dijelaskan kepada para peserta; memandangkan kedua-dua istilah ini seringkali mengelirukan dan disalahgunakan, walaupun ia merupakan aktiviti yang agak berbeza dalam konteks rangkakerja WIAM. Inventori tanah bencah adalah aktiviti pengumpulan maklumat, penilaian adalah aktiviti yang menilai maklumat yang telah dikumpulkan, manakala pemantauan berperanan untuk memberi maklumat kepada pengurus mengenai sejauh mana perubahan yang berlaku dalam sesuatu kawasan tanah bencah.

Segala perkembangan dalam WIAMS juga telah dibentangkan kepada para peserta. Suatu perkara ketara yang telah muncul sejak dua dekad yang lepas ialah bahawa WIAMS telah semakin menjadi penting dalam proses membuat keputusan khususnya bagi para pengurus tanah bencah dan peggubal dasar dari peringkat tempatan sehinggalah ke tahap global. Adalah dicadangkan dengan serius bahawa rangka WIAMS diamalkan sebab ia akan, sekurang-kurangnya, mempiawaikan istilah-istilah yang digunakan serta menyediakan kaedah yang serasi untuk memperoleh dan melaporkan maklumat yang boleh dikongsi bersama dengan pihak yang tidak mampu memperoleh program tersebut. Para

pembentang kaedah WIAMS juga menekankan bahawa walaupun rangkakerja secara hierarki telah dicadangkan, tidak kesemua tahap butiran perlu dianalisis dan maklumat pada mana-mana tahap hierarki boleh dikumpulkan, tidak mengambil kira sama ada tahap yang lain telah ataupun akan ditekankan. Kaedah hierarki ini menyediakan rangkakerja untuk mengumpulkan maklumat pada tahap serta butiran yang berlainan, sambil menunjukkan perhubungan yang ketara di antara skala-skala yang berlainan.

Bengkel ini juga merupakan suatu peluang keemasan untuk menonjolkan dua projek usaha serantau yang penting kepada para peserta iaitu: Penilaian Ekosistem Milenium (Millenium Ecosystem Assessment atau MA) dan Projek Inventori Tanah Bencah Asia (The Asian Wetland Inventory Project atau AWI). Projek AWI merupakan inisiatif Wetlands International dan menggabungkan kaedah multi-skala dalam proses penginventorian. Dua kes contoh, masing-masing daripada Australia dan India, menerangkan dengan lebih lanjut mengenai betapa pentingnya WIAMS dalam pengurusan dan penggunaan lestari tanah bencah. Beberapa pendekatan dan peralatan untuk WIAM juga disampaikan dalam bengkel tersebut, termasuk 'Remote Sensing' serta 'GIS'.

Sesi perbincangan secara berkumpulan yang diadakan selepas tamatnya penyampaian pada hari tersebut, memberi peluang kepada para peserta untuk menggunakan pendekatan penginventorian, penilaian dan pemantauan multi-skala ini bagi beberapa kes senario yang berkaitan dengan tanah bencah di Malaysia. Hasil daripada sesi-sesi ini, yang dihuraikan di bawah, adalah penting untuk menonjolkan isu praktikal yang perlu ditujukan dan/atau dipertimbangkan, bukan sahaja dalam melaksanakan WIAMS tetapi bagi pengurusan dan pemuliharaan tanah bencah secara keseluruhan di Malaysia.

Pencapaian-pencapaian utama berikutan daripada bengkel ini boleh dirumuskan secara berikut;

- Para peserta menunjukkan pemahaman yang lebih mendalam mengenai konsep dan istilah-istilah yang berkaitan dengan WIAMS.
- Pada keseluruhannya, kesemua para peserta bersetuju bahawa perlunya mempiawaikan kaedah-kaedah untuk mengumpul dan menilai data.
- Pegawai-pegawai (Agensi-agensi) kerajaan juga bersetuju bahawa suatu inventori tanah bencah sangat diperlukan disebabkan inventori 1987 yang sedia ada sudah agak lama dan perlu dikemaskinikan.
- Inventori Tanah Bencah Asia (Asian Wetland Inventory) boleh digunakan sebagai asas untuk mengadakan inventori tanah bencah kebangsaan untuk Malaysia. Inventori ini patut memberi keutamaan/pertimbangan kepada yang berikut:
 - Pengujudan suatu set data asas yang menerangkan lokasi dan saiz tanah bencah, ciri-ciri biofizikal utama termasuk variasi di kawasan tersebut serta regim airnya;
 - Penggunaan teknik piawai, garis panduan dan buku panduan AWI;
 - Kaji semula jurang dalam pengumpulan data serta mengkoordinasikan proses pengumpulan data;
 - Menghasilkan dan lebih menggunakan rangkaian-rangkaian komunikasi.
 - Termasuk dalam dua butir akhir adalah betapa perlunya koordinasi di antara semua agensi-agensi yang terlibat di Malaysia, tidak dikecualikan mereka yang sudah mempunyai maklumat sedia ada dan mereka yang boleh menyumbang dengan lebih lanjut kepada pengumpulan data (contohnya Malaysian Centre for Remote Sensing atau MACRES).

- Setelah suatu inventori asas diperolehi dan disimpan dalam keadaan yang memuaskan, maklumat yang lebih bersifat pengurusan berkenaan dengan ancaman dan guna tanah, milik tanah, regim pengurusan, manfaat serta nilai tanah bencah, perlu dilengkapkan juga. Secara keseluruhannya, maklumat yang berdasarkan biofizikal dan pengurusan patut dijadikan asas bagi mengujudkan prioriti untuk penilaian dan pengurusan tanah bencah kebangsaan
- Suatu rangkakerja multi-skala untuk mengumpul maklumat inventori, seperti yang diamalkan oleh AWI dan dicadangkan untuk inventori tanah bencah nasional (dihuraikan seperti di atas), boleh digunakan untuk penilaian dan pemantauan menggunakan pengamalan WIAMS secara kebangsaan. Sesi perbincangan untuk menilai dan melaporkan ciri-ciri ekologi tanah bencah Malaysia menunjukkan bahawa negara kita memerlukan suatu program laporan kebangsaan serta teknik-teknik untuk WIAMS pada skala ini. Meskipun AWI boleh menyediakan segala kelengkapan untuk tujuan inventori, namun kelengkapan (bio)penilaian yang lain (yang jimat kos dan pantas untuk mengeluarkan maklumat 'first pass' yang mencukupi merentasi kawasan yang luas) perlu dicipta dan digunakan. Konsep penilaian dan pemantauan yang sesuai pernah dibincangkankan melalui Konvensyen Tanah Bencah Ramsar (Ramsar Convention on Wetlands).
- Sebilangan peserta Malaysia dalam bengkel ini menunjukkan kepakaran yang mengalakkan dalam kaedah-kaedah penilaian, lantas menonjolkan lagi perlunya ada koordinasi dan perkembangan rangka WIAMS nasional melalui rangkaian dan perkongsian yang berkesan.
- Para peserta bersetuju secara prinsip bahawa draf rangkakerja ini boleh digunakan tetapi ia masih lagi memerlukan sedikit penyesuaian terutamanya berkenaan langkah-langkah yang terkandung dalam proses WIAMS.

WORKSHOP OBJECTIVES

The workshop was organised to disseminate information on WIAM and to obtain inputs from various agencies on developing a proposed framework for a WIAMS in Malaysia. The latter point was particularly important, as participatory inputs are essential to support the concept of wise use and effective management of wetlands as stipulated under the Ramsar Convention on Wetlands.

The objectives of the workshop were:

- To provide a broad introduction to the wetland management framework (WIAM) of which wetland inventory, assessment and monitoring are parts;
- To stress and elaborate upon the interdependence of wetland inventory, assessment and monitoring for effective management of wetlands;
- To demonstrate how the process can lead to more efficient conservation and management of wetlands;
- To highlight the value in gathering such information under a multi-scalar (hierarchical) framework for each of the inventory, assessment and monitoring components;
- To obtain inputs from various stakeholders with regards to a WIAMS;
- To develop a proposed framework for a WIAMS in Malaysia; and
- To make recommendations on how to implement the WIAMS for effective wetland management and conservation in Malaysia.

2.0 BACKGROUND PAPER

WETLAND CONSERVATION IN MALAYSIA

Sundari R, Murugadas TL and Meera S

Wetlands International – Malaysia Programme

1.0 INTRODUCTION

In developing countries most of the population live in or are close to wetland areas and many people in rural areas depend on wetlands for their livelihood. In addition to the central role played by wetlands in agriculture and fisheries production, a wide range of products are commonly harvested from wetlands by local people. These wetland products include food (birds, mammals and plants), medicine, clean water, timber, fuel wood, cane, reeds for thatch and matting, and resins. Affordable and readily available alternatives often do not exist for local people. In addition to supplying subsistence products for local populations, wetlands frequently also supply products that constitute an income supplement during difficult times when other sources of income are not available. Such products can make the difference between survival and failure for rural populations. Furthermore, many wetland areas have great cultural and religious significance.

Wetlands are critically important ecosystems that provide significant social, economic and ecological benefits. The importance of wetlands in Malaysia is also exemplified by the two staple food of the national diet: rice and fish. The high productivity of wetlands and their capability to produce a surplus has enabled the nation to develop economically. Eighty percent of fishery-related activities occur in the coastal wetlands of Malaysia. Wetlands contribute significantly to the economy of Malaysia; firstly through agricultural production, forestry and fisheries; secondly and increasingly for water supply (for domestic use as well as for irrigation). Other economic and ecological benefits of wetlands include groundwater replenishment, maintenance of water tables for agriculture, flood control, shoreline protection and stabilisation, climate change mitigation, sediment and nutrient retention, water purification and habitats for biodiversity. Tourism in wetlands is also becoming increasingly important.

Ten percent of the total land area of Malaysia is comprised of wetlands (AWB, 1994). Different communities live near and around these important ecosystems and have used the wetland resources for centuries. In 1994, Malaysia ratified the Ramsar Convention of Wetlands of International Importance, and soon thereafter designated Tasek Bera, a unique freshwater swamp as its first Ramsar site. The Malaysian Wetland Directory was compiled in 1987 and highlights 96 wetland sites of national importance.

Malaysia's land use policy is 'use-oriented', i.e. designed for maximum exploitation and development (MoSTE, 1997). Thus, conversion of land for urbanisation, industrial, agricultural, mining and forestry development has higher priority than that of conservation, although it is probable, in many cases, that conservation for sustainable use of resources has a higher rate of return on investment in the long term. This is because, when decision are

made on the conversion of wetlands to other land uses, the cost/benefit analyses used in these situations often do not take into account the full range of benefits of the wetland area to be converted. The National Land Code (NLC) is applicable only in Peninsular Malaysia while in East Malaysia, the Sabah Land Ordinance and Sarawak Land Ordinance form the basis of land laws and administration. The Land Capability Classification (LCC) which is applicable throughout Malaysia divides land use into five categories: mining, agriculture covering a wide range of possible crops, agriculture for a restricted range of possible crops, forestry and conservation, based on potential productivity and economic yield of the land in question. Land designated for conservation has the lowest priority in this order. Since its implementation, the LCC has introduced major land use changes which have been financially beneficial and have done much to address problems of rural poverty and social inequality. The LCC's weakness is its limited applicability to adequately addressing biological diversity and conservation issues, although conservation has been widely defined as the judicious use and management of nature and natural resources for the benefit of human society and ethical reasons. Development projects in wetland areas i.e. agriculture (whether planned or unplanned) compromises the ecological integrity of intact wetland areas and results in loss or degradation of these sensitive yet fragile ecosystems.

Most key wetland sites in Malaysia are included in the Permanent Forest Estate ¹(PFE), managed primarily as source of timber and non-timber goods. The value of wetland forests e.g. peat swamp forest, and mangrove forest, in performing various environmental or cultural services has rarely been considered in decision-making. The term PFE, however, may be misleading since it implies that the forest areas are permanent. This is not guaranteed since the Executive Council within State Governments can degazette any area of PFE for infrastructure development, agriculture, housing and other purposes (PFEs are the jurisdiction of respective state governments). Very few wetland areas in Malaysia which are designated as nature parks and wildlife sanctuaries are legally protected for conservation while, some wetland areas forming part of Stateland Forest and are essentially viewed as land earmarked for development. *See Appendix III (under Appendices) for information on the status of wetland areas in Malaysia.*

2.0 BACKGROUND INFORMATION

The Ramsar Convention stresses the importance of wetlands as rich areas of biological diversity and productivity and as life support systems for human populations. This has been a key theme in the evolving global support and political commitment for sustainable development and environmental conservation as articulated in the Ramsar Convention's Strategic Plan 1997-2002, the World Conservation Strategy, Caring for the Earth, the report of the Brundtland Commission, and Agenda 21. The role of wetlands has emerged as a key element in the conservation of natural ecosystems through the Convention on Biological Diversity and United Nations Framework Convention on Climate Change, among others. The importance of our wetlands goes beyond their status as habitats for many endangered plant and animal species. They are vital component of national and global ecosystems and economies.

¹ PFE is a term for the sum of forest reserves, areas maintained or managed for their maximum economic, social, and ecological benefits. There are four categories within the PFE: 1) Production Forest for the economic exploitation of the forest resources; 2) Protection Forest for its many ecological services, such as the maintenance of climate conditions, water resources, soil fertility, biological diversity conservation, flood mitigation, and ameliorating soil erosion and river siltation; 3) Education and Research Forest; 4) Amenity Forest.

Since the ratification of the Ramsar Convention in 1994, there has been a progressing loss and degradation of wetlands in Malaysia. One of the many wise use guidelines for wetland conservation under the Ramsar Convention is the adoption of a holistic approach to land use planning. Although the National Land Code (NLC) in Malaysia is federal legislation, land is legally administered under the respective state governments (MoSTE, 1997). The NLC has no direct bearing on biological diversity conservation, although it provides certainty in use through the land categorization system, and security in tenure in terms of ownership rights. The absence of a single central authority in charge of land administration, given the division of functions between state and federal governments, implies that the maintenance of wetland reserves for biodiversity conservation is dependent upon the decisions of policy makers of individual states. This conflict in many ways has resulted in poor implementation of the Ramsar Convention's goals and objectives in Malaysia. Malaysia launched its National Biodiversity Policy in 1998. In 1997, the Framework for the National Policy on Wetlands was established, but till today the policy is still at a draft stage. It has taken considerable time and lengthy consultation to overcome barriers such as institutional reluctance to change ways of doing business in government agencies and elsewhere.

In view of increasing threats to wetlands and their biological diversity, the National Land Council (which is the advisory council of the NLC) needs to integrate the major issues of unsustainable land use practices into its long term land use planning, in addition to administrating land use laws. Land use patterns and priorities have undergone drastic changes since the 1960s, therefore the LCC should be replaced with an integrated and holistic approach to land use planning (MoSTE, 1997).

3.0 THREATS TO WETLANDS

Despite the importance of wetlands to Malaysia's ecological and economic health and vitality, the last century has witnessed their continued loss and degradation. Since 1900, Malaysia's total wetland areas has been reduced through reclamation, drainage and conversion or lost to other land uses. Significant portions have been seriously degraded or are at imminent risk. The loss and degradation of wetlands still continue unabated. The following are perceived as major threats to wetlands in Malaysia:

i. Conversion/Reclamation of wetland areas for other land uses. The rapidly increasing population in the region and resulting rate of urbanisation puts a strong pressure for acquisition of land for development. Wetlands are often converted, or reclaimed, as sites for agriculture including aquaculture, industry, human settlements and other uses.

A holistic land use approaches or guidelines which successfully integrate wetlands into multiple land use planning are inadequate at the moment. Hence, this has led to the loss of important wetland benefits. Without the adoption of appropriate land use approaches, wetlands as functioning ecosystems providing many types of benefits will be lost and this will mean that important contributions to development are lost.

ii. Changes to wetland hydrology. Surface water flows are modified for several purposes such as for flood control and water supply. Seasonal surface water flows may also be disrupted through clearance of vegetation from catchment areas. This

leads to increased surface flows in the wet season and decreased flows in the dry season. Regulation of flows by weirs and dams results in disrupting natural fluctuations in supply of water to wetlands. This affects ecosystem processes and may cause an impact on life cycles of both flora and fauna. Additionally many watercourses in urban areas have been converted to concrete drains and embankments, with loss of instream, fringing wetlands and riparian vegetation. Thus, this has also had an impact on the biodiversity.

Drainage of wetland areas especially peat swamps, for agriculture purposes has shown to have very adverse impacts. The loss of peat swamps results in loss of water storage capacity and lowering of water tables. Reduced water table in peat swamps will increase the incidence of peat and forest fires. Severe degradation of peatlands in Malaysia is resulting in a decline in the capacity of these wetlands to serve as carbon sinks and the resulting carbon emissions are contributing to global climate change.

iii. Pollution Pollution is a serious threat as pollutants tend to accumulate in wetlands. Pollution arising from solid waste dumping, pesticides and herbicide residues from land and coastal based agricultural activities, untreated effluent/discharges from industries and domestic areas, silt, soil erosion and oil spills are major threats to wetlands.

4.0 JUSTIFICATION FOR A WIAMS IN MALAYSIA

Inventory, assessment and monitoring are vital components of effective wetland management. Together they provide the essential data and information that support management decisions. Furthermore, they provide feedback for management actions and for implementation of principles and frameworks to ensure that they deliver the information necessary for managers and other decision makers. With the recognition that inventory, assessment and monitoring are important for effective management, increasing attention has focussed on the design and implementation of an integrated assessment programme.

Many national wetland inventories in the Asian region have been published in last decade or so which pioneered systematic and relevant data collection on wetlands, but the data collected were fairly limited, with emphasis on identifying wetlands of importance for conservation purposes rather than for their importance for direct uses, functions and services. A need has been recognized for a more systematic, comprehensive approach to wetland assessment and inventory. Protocols for planning a wetland inventory have been developed and used in the past and are readily available e.g. the Mediterranean Wetland Initiative (MedWet).

Most wetlands in Malaysia are multiple use ecosystems, therefore developing a WIAMS will not only benefit associated biodiversity but also local human populations that make use of the goods and services that wetlands provide. In addition, the lack of a WIAMS has made it impossible to assess the extent, changes and degree of degradation of wetland areas across Malaysia. A Malaysian Wetland Directory published in 1987 provided summary information on the conservation status, threats and biodiversity significance of 96 wetland sites in Malaysia. Since its publication, no national updates have been produced. The need to develop and establish a user-friendly WIAMS to assist wetland stakeholders (government agencies at federal, state and local government levels, private land owners,

non-governmental organisations (NGOS), community based organisation (CBOs) and local community groups) to inventorise, assess and monitor the ever-changing status of Malaysian wetlands and to make rational and informed decisions in their management and conservation is therefore clearly essential.

5.0 BENEFICIARIES

The following groups have been identified as potential main beneficiaries and users of a WIAMS:

- Government agencies responsible for wetland conservation and management both at Federal, State and Local Government levels.
- Research institutions and universities conducting research in wetland areas.
- NGOs and CBOs conducting activities in wetland areas with local communities.
- Local communities depending on wetland areas for their livelihood and economic opportunities.
- Private land owners who manage wetland areas for tourism and recreation, and for uses such as agriculture and aquaculture.

6.0 WIAMS STRATEGY IN MALAYSIA

The approach for the successful development and implementation of a WIAMS should be participatory at all levels. This approach is very important for the success of a WIAMS due to the relatively large number of stakeholders who are involved in the use of wetland areas throughout Malaysia.

It is envisaged that developing a framework will be a step towards realising the larger goal in establishing and implementing a WIAMS in Malaysia. The Ministry of Science, Technology and the Environment Malaysia (MoSTE) is keen to develop a Malaysia Wetland Inventory under the 8th Malaysia Plan (2001-2005). The Asian Wetland Inventory (AWI) model for natural resource inventory is being offered to the MoSTE for consideration. A Wetland Inventory is vital to policy-makers and planners in developing a Malaysian-wide network of ecologically representative protected wetlands and in encouraging their wise use. It is hoped that this workshop will encourage the adoption of a standardised WIAMS for Malaysia.

7.0 REFERENCES

AWB. 1994. Priorities in Wetland Conservation in South-east Asia: Selected recommendations for Action. Ramsar South-east Asia Regional Workshop, 29 March-1 April 1994, Indonesia. Asian Wetland Bureau, Kuala Lumpur. p.12.

MoSTE. 1997. Assessment of Biological Diversity in Malaysia. Malaysia: Country Study on Biological Diversity. Ministry of Science, Technology and the Environment, Malaysia, Kuala Lumpur. pp.186.

3.0 WORKSHOP

TECHNICAL SESSION I – Introduction to Wetland Inventory, Assessment and Monitoring Processes

Invited Paper No. 1

WETLAND INVENTORY, ASSESSMENT AND MONITORING: AN INTRODUCTION

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ABSTRACT

Wetlands remain poorly known and undervalued ecosystems, yet they provide many benefits such as direct uses (e.g. fisheries, water supply), functions (e.g. flood control, groundwater recharge) and attributes such as biodiversity. Often, information is lacking on wetlands, yet it is essential for the wise management of these ecosystems. Wetland inventory and assessment is the process by which this information is gathered and evaluated.

The aim of this paper is to provide a broad introduction to the process of which wetland inventory, assessment and monitoring are parts. The terms “inventory” and “assessment” are often used interchangeably, yet they are two different activities in the same process. Wetland inventory is the activity through which information is gathered. Assessment is the activity which evaluates the information obtained. From the collection of the relevant information and its evaluation, management of the wetland can be implemented. During the management phase, monitoring is an important activity and may be defined as “Regular collecting of information on the site using characteristics of the site or its catchment which, for which any change may produce a negative impact on the site”.

Information should be collected in a “top down” manner, starting off with the river basin/catchment, then focusing down on the sub-catchment, the wetland site or complex and finally the habitats contained within the wetland. Data should be collected in a standardised manner and should be directed primarily towards that which is relevant to subsequent management. This includes basic geographical, physical, chemical and biological information, with emphasis on data relating to the benefits that the wetland provides and the threats operating on the wetland.

The data collected should be easily accessible, in such a form as to be easily interpreted and to be easily up-dated. As such, the information should be held in a computerised database linked to a GIS.

The Med Wet project, a regional initiative in inventory of the countries surrounding the Mediterranean Sea, and the Asian Wetland Inventory project, are briefly discussed as examples of standardised wetland inventory projects.

1.0 INTRODUCTION

Sufficient, relevant, up-to-date data are a prerequisite for the effective management of all types of ecosystems including wetlands, yet there is still insufficient information on wetlands in the Asian region upon which to base sound management (Finlayson & Davidson 2001). Thus, there is a need for activities involving the collection and interpretation of information on wetlands for management purposes.

The first attempt at compiling information on wetlands in a systematic manner was with the Directory of Asian Wetlands (Scott 1989). The information collated was focused mainly on the biological importance of wetlands, especially for bird populations.

Many national wetland inventories in the Asian region have been published in the last decade or so which pioneered systematic and relevant data collection on wetlands, but the data collected were fairly limited, with an emphasis on identifying wetlands of importance for conservation purposes rather than for their importance for direct uses and for functions and services. The scope and the detail of data collected were also limited fundamentally by lack of funds and trained manpower.

Most of these inventories were published as printed documents, not in electronic format, which makes updating very difficult and time-consuming. This is understandable since electronic formats such as databases and GIS were not user friendly.

With the ever-increasing recognition that wetlands are important ecosystems and that they require sound management, a need has been recognised for a more systematic, comprehensive approach to wetland inventory (Finlayson & Davidson 2001). The development of more “user-friendly” databases and GIS means that this information can be easily held, interpreted and updated.

This paper gives a brief introduction to the activities involved in wetland inventory, assessment and monitoring, with an emphasis on inventory and assessment; and briefly describes two examples of wetland inventory projects: the Mediterranean Wetland Initiative (MedWet) and the Asian Wetland Inventory Programme (AWI).

The generally accepted Ramsar definition of wetlands is used throughout this paper:

“Wetlands are areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres.”

2.0 WETLAND INVENTORY, ASSESSMENT AND MONITORING – THE PROCESS

The diagram below (Figure 1) shows the process of wetland inventory, assessment and monitoring and the activities involved.

These terms should be defined since the terminology is often confused - the terms inventory and assessment are often used interchangeably, but they refer to different stages in the process:

- **Inventory:** The activity of gathering information on wetlands and their catchments to produce a listing of sites. The information is collected in a standardised manner and includes location, size, physical, chemical and biological features, human activities, protection/management status, threats and benefits provided by the wetlands.
- **Assessment:** To assess something is to judge the worth or importance of it, in this case, the activity involves evaluating the information gathered on wetlands to judge their value. The end result may be a prioritised list of wetlands in terms of their importance. Wetlands are normally assessed in terms of the benefits they provide and the threats which re operating on them.
- **Monitoring:** This is an activity which is carried out during the management phase. It is the regular collection of information on the wetland or its catchment which is targeted at variables which may negatively affect the wetland. Examples are monitoring human activities in the catchment, monitoring the level of resource exploitation within the wetland etc.

Thus, simply put, data are collected, these data are assessed/analysed and used in management. A monitoring programme is developed within the management regime to monitor any potential deleterious changes in the variables affecting the wetland and also to monitor the effectiveness of management. Monitoring is a tool whereby the management regime can be modified to take into account any change in variables operating within the wetland or its catchment.

STEP IN PROCESS	MAJOR ACTIVITIES
PREPARATION/ PLANNING	Rationale, objectives, scope, time and funds available. Data sheets, data collection methods, wetland classification scheme and wetland assessment methods should be finalised. Liaison with stakeholders, identification of inventory team. Development of database/GIS
INVENTORY	
DESK STUDY	Review of previous information on the wetlands, map and photo procurement
PREPARATION FOR FIELD WORK	Specific planning for fieldwork: Timing of survey. Contacting and liasing with government agencies, local communities, NGOs. Arrange logistics: places to stay, transport. Pilot testing and validation of methodology
FIELDWORK	Ensure all necessary data collected on wetland inventory forms
PRESENTATION OF DATA	Data held in database and linked GIS
ASSESSMENT	Interpretation of data: evaluation of wetlands mainly in terms of their values and the threats facing them.

OUTPUTS	Published of draft document with ranking of wetlands for their importance and urgency for management with justification. Workshop with stakeholders to fine-tune results. Development of action plan. Development of monitoring programme.
IMPLEMENTATION: MANAGEMENT & MONITORING	

Figure 1. Overview of the wetland inventory, assessment and monitoring process

2.1 Preparation

It is essential to adequately prepare for a wetland inventory. The rationale and objectives for the project must be established first. Usually the rationale is that wetlands are valuable ecosystems, but are being destroyed and degraded rapidly and that there is a lack of relevant data on which to base sound management. A well-thought out rationale is essential to attract funding for the project.

Inventory objectives normally are to:

- Identify the type, location and size of wetlands,
- To collect data relevant to management in a standard systematic manner,
- To establish a baseline for the subsequent monitoring programme.

Preparation also involves developing a framework within which the project will be carried out- funds have to be secured; and standard data collection sheets, a wetland classification system and a standard wetland assessment methodology need to be finalised.

Most wetland classification systems in use at the moment are based on that of the Ramsar Bureau which in turn was derived from Cowardin's wetland and deepwater habitat classification for the United States (Cowardin et al. 1979). These classifications start off from the major wetland systems (lacustrine, palustrine, riverine, estuarine and marine) and then use hydroperiod, land form, substrate and vegetation to subdivide these major systems. However, a modified classification systems is being developed which classifies wetlands initially by a combination of landform type and hydroperiod (Finlayson, pers.comm.) This type of classification is more logical in that landform and hydroperiod are the fundamental determinants of wetland character.

A computerised database, if possible linked to a GIS should also be developed, with the database fields being complementary to the fields in the filed data collection sheets for ease of input.

It is also necessary to identify stakeholders in the project and collaborating partners.

Stakeholders include:

Relevant government agencies concerned with natural resource management, research institutions,/universities, NGOs, funding agencies, local government units at wetland sites and local communities living in and around the wetlands.

2.2 Collecting the Information: The Inventory Phase

As a guiding rule, collection of information should not be solely aimed at the wetland sites. It is also necessary to collect information on the river basin/catchment area in which the wetland lies, and the sub catchment. This is desirable for two major reasons:

1. Wetland sites are greatly influenced by the nature of the catchment and human activities within it.
2. Collection of data at the catchment and sub catchment level avoids needless repetition of data on wetlands within the same catchment/subcatchment. Wetlands can then be grouped together by catchment/river basin since they are hydrologically linked to each other and most likely share similar water quality characteristics.

The inventory team should be assembled at this stage – it should ideally be multi-disciplinary, with the members drawn from the disciplines of geography/geology/soils; hydrology; socio-economics and ecology. All members should be familiar with rapid assessment techniques in their disciplines: e.g. rapid rural appraisal for the socio-economics member. A database/GIS expert should also be present.

It is also desirable, before embarking on the major part of the information gathering, to test the methodology and fine tune it.

2.2.1 Desk Study

This is an activity which is often not carried out comprehensively before collecting data in the field. Desk study; i.e., review of previously published information, can be a great help in identifying where there are large gaps in the information base and it will give an idea of the basic characteristics of the wetlands to be surveyed. There are four main sources of information:

1. Written publications and reports
2. Maps
3. Remote images: photographs, both aerial and ground shots and satellite images
4. Expert opinion: it is useful to consult people who have been to the sites to be surveyed since they can provide much useful information on features of the wetland on and logistical considerations such as accessibility of the area and the best season for surveys.

Collection of this data is also useful because there should be an indication of how the wetlands have changed since these sources became available. As part of the desk study, all relevant information should be held in one place for ease of access – thought should be given to setting up a resource centre for wetland information.

A start can be made on filling in the data collection form at this stage with information gathered from the desk study; e.g. geology, soils, climate, location, area, and socio-economic and management information.

2.2.2 Field Survey

Timing

An important consideration for field survey is the timing of the field survey. For example, what time of year would be best to get the most information from the visit? In many floodplains, most often habitats may be under water at certain times of the year making description of habitats well nigh impossible. How is access influenced by the seasons/ Is it easier during the wet or the dry season? Are there any migratory species that use the area? If so, it would be desirable that the survey coincide with the peak migratory period.

With wetlands that have a seasonally variable water regime, it may be best to make at least two visits in a year – one at minimum water level and one at high water.

The data collection sheet

As mentioned before, a standard wetland data collection sheet should be used in the field. This shows the core data that needs to be collected. The core data is the minimum data that need to be collected in order to characterise the wetland, to establish its benefits and to provide information for subsequent management.

Data are normally collected under the following headings:

GEOGRAPHICAL

Name
Location
Climate
Altitude
Area

PHYSICAL AND CHEMICAL

Landforms/geomorphology
Geology
Soils
Origin
Hydrology (inflows, outflows, hydroperiod)
Water Quality

WETLAND BENEFITS *

Direct Uses
Functions/Services
Attributes (e.g. biodiversity, cultural values)

LAND USE AND HUMAN ACTIVITY IN CATCHMENT

THREATS TO THE WETLAND AND CATCHMENT

MANAGEMENT INFORMATION

Land tenure/ownership
Agencies involved in management and resource use
Conservation and other management measures

REFERENCES/SOURCES OF DATA AND RESOURCE PERSONS

The above is a summary of the information to be collected during the inventory phase. It should be remembered that the information is collected at several levels from the catchment focusing down on the habitats within the wetland and data sheets are needed for each level since the exact type of information and the level of detail will vary at the different levels.

* The benefits of wetland have been divided into three types according to Claridge (1991).

The term direct uses refers to aspects of a wetland which are harvested directly such as fishes, timber and water. These direct uses are easy to quantify in economic terms.

Functions (also called services) are those aspects of a wetland which are beneficial to humans such as flood control, shoreline stabilisation etc. Although these functions may have a great economic value; e.g. a marsh may prevent flood damage and associated economic costs downstream by reducing flood peaks, they are harder to quantify in economic terms than direct uses.

Attributes are those aspects of a wetland which do not necessarily have an economic value, but which are valued by society, or some sectors within society. Examples are cultural and spiritual values associated with sites; and biological attributes such as species richness, rarity, endemism etc..

2.2.3 Post-Survey Phase: Presentation of the Data

A published document should be produced showing the results of the inventory as a bare minimum. However, it is desirable to enter the information into a computerised database, from which data can be easily used for interpretation purposes and which will be easy to up-date on a regular basis. Moreover, for the accurate delineation and location of wetlands, it is essential that good, large-scale maps of the wetlands and the catchments be produced. Ideally a GIS should be linked to the database to show the data in spatial form and to facilitate the interpretation of the data.

2.3 Assessment

After the data have been collected and presented in an easily accessible form, the wetlands can be evaluated for their “importance”. Importance usually means evaluation in terms of the degree of benefits that wetlands provide; e.g. biological importance, socio-economic importance and provision of functions/services. The degree of threat is also important to evaluate.

The actual methodology used in assessment varies. Most of the techniques used are fairly subjective in their approach since there may be a lack of quantitative data, at least initially, on which to base objective decisions.

- Multi-criteria evaluation techniques have been used to assess the ecological importance of sites (e.g. Spellerberg 1992). Criteria to be used are first selected. These may include biological criteria such as species richness, species diversity, habitat diversity, habitat distribution, and presence of rare, endangered and endemic species. Other criteria normally include socio-economic importance (value for direct uses), importance for functions, the degree of threat, degree of disturbance and management viability. For each criterion, a range of scenarios is given; e.g. for degree of disturbance, these could

range from undisturbed through slightly disturbed, moderately disturbed to heavily disturbed/degraded. Points are allocated to each scenario, with undisturbed sites having a higher points allocation. Similarly, for the criterion of species richness, those sites with higher species richness will score more points than those with poor species richness. Spellerberg (1992) gives several examples of these multi-criteria evaluation methods. The end result would be a comparative ranking of sites in terms of their importance for direct uses, functions and attributes, the degree of threat and management viability.

- Indicators may also be used to assess a wetland's importance. Biological indicators; e.g. bird species richness may be used as an rapid indicator of a site's biodiversity value and degree of disturbance. Degree of intactness is also a good indicator of ecological importance.
- Other indicators have been used to assess the importance of some functions and services provided by wetlands (e.g. Larson et al. 1989). For example simple indicators can be obtained from maps and/or field surveys to assess the potential importance of a wetland for flood control. The reader is referred to Larson et al. (1989) for more details.
- Expert opinion is another option for assessment, with a range of experts familiar with the sites giving their advice on the important wetlands.

However, there is no substitute for good quantitative data which can be tested statistically to produce an objective listing of important wetlands, but it should be realised that the amount of data available on most Asian wetlands precludes this for the time being.

A GIS helps enormously in interpreting the location, area and distribution of habitats and is therefore very important in identifying rare and endangered habitats.

2.4 Outputs of the Assessment Phase

At the end of this phase, it is useful to convene a workshop in order to discuss the results and fine-tune them. This workshop should include all stakeholders, including local community representatives.

The output of this phase should be a listing of wetland sites prioritised for their importance. This means that the most important wetlands in terms of the three categories of benefits should be ranked in relation to each other. Wetlands should also be ranked according to the type and degree of threat operating on them. This is very important since urgent management measures can then be directed towards important wetlands which are under the greatest threat of destruction or degradation.

2.5 Management and Monitoring

The ultimate goal of the inventory and assessment process should be sound management of wetlands. What type of management regime is recommended for a particular wetland depends on the results of the assessment phase. For example, some wetlands may be found to have a very high value in terms of direct uses such as fisheries utilised by local people. In this case, the emphasis would be on development of a fisheries management plan to safeguard the fishery resource for local people, with the Fisheries Department being the lead agency. In other cases, a site may be found to have a very high biodiversity with several rare or endangered species. This site is more appropriate to be designated as a protected area with the conservation agency as the lead agency.

As mentioned before, monitoring is not just a regular collection of data which were gathered in the initial inventory exercise. Monitoring is a targeted activity and monitors those variables which may cause changes in the wetland and the benefits it provides. Any monitoring programme should provide feedback into a management plan so that management actions can be taken to minimise any negative impacts identified through monitoring. For example, hydroperiod (the water regime and how it varies seasonally) is one of the fundamental determinants of the character of a wetland. Any change in the hydroperiod will cause a dramatic change in the character of the wetland e.g. the vegetation. Therefore, any activities which may cause a change in the hydroperiod should be monitored closely. As a first step, base line data on the hydroperiod such as monitoring of water levels seasonally should be gathered. Monitoring of development plans and activities such as river flow modification in the catchment of the wetland would also be needed. It should be noted that monitoring in this case can be proactive; i.e. by monitoring plans and by seeking to be involved in the planning process, one can have a say in the decision-making process to minimise or remove any adverse effects before they occur.

Other examples of common monitoring programmes are those which look at levels of resource utilisation in the wetland such as exploitation of fishery resources. By monitoring the intensity of fishing (e.g. catch data, numbers of fishermen and numbers and types of gears), one can devise management strategies to ensure that resource utilisation is on a sustainable basis and that the fishery resources are available in undiminished quantity in future years.

3.0 EXAMPLES OF WETLAND INVENTORY PROJECTS

3.1 Mediterranean Wetland Initiative (MedWet)

This is a regional project launched in 1991, the first objectives of which were to assess the existing information on Mediterranean wetlands in order to identify gaps and assess the methodologies used; and to develop a standard methodology for wetland inventory in the Mediterranean region (Costa et al. 2001). The first stage was a three-year preparatory project to develop a standard set of tools to be used in the inventory process. These tools consisted of a reference manual, sets of inventory data sheets, a habitat description system and a computerised database to hold the information. Information in this project is collected at three levels: at the catchment level, the wetland site level and the habitat level.

There are three major phases to the MedWet project: review of existing information, simple inventory and then detailed inventory (Costa et al.1996). The review of existing information was seen as a necessary prerequisite for the simple and /or detailed inventory phases. If resources are limited initially; a simple inventory may be undertaken first, with the production of simple maps for each wetland and filling in of information gaps identified from the review. As more resource become available, a detailed inventory can be undertaken with the production of detailed maps, ideally using a GIS and compilation of detailed information on each site. This phase is particularly important for developing a management regime for individual wetlands and providing a baseline for monitoring programmes. If sufficient resources are available from the start, a detailed inventory can be carried out straight away after the review phase.

After the three year preparatory phase, the methodology was tested in pilot studies in five countries and refined. Subsequently, the methodology had been used to develop wetland inventories in most of the Mediterranean countries. An important point here is that the methodologies are not “set in stone” but are continually being refined and improved as more and more experience is gained in their use.

3.2 Asian Wetland Inventory (AWI) Programme

The “Global review of wetland resources and priorities for wetland inventory” (Finlayson & Davidson 1999), carried out by Wetlands International on behalf of the Ramsar Convention, concluded that the existing information base for Asian wetlands was inadequate. As a result of this, the AWI was launched in 1999 with the endorsement of the Ramsar Convention. The AWI aims to develop a standardised protocol for wetland inventory across the Asian region. Information is collected at four levels: 1. River basin, 2. Sub basin, 3. Wetland site or complex and 4. Habitat. Thus, attention is focused down progressively from the catchment level to the habitat level. Information can from the top two levels can be used in overall land use planning whilst information collected at levels 3 and 4 can be used for site specific management of wetland sites and complexes. The information gathered is to be held in a computerised database linked to a GIS. AT present, the tools are being developed, including a manual, data sheets, a database and GIS. Pilot testing of the protocol will begin in the near future. More details on the project are given in Lopez (2002) (this volume).

4.0 CONCLUSION

There are several ingredients for a successful wetland inventory and assessment project – there must be adequate preparation of the methodology and pilot testing; there should be an extensive period of desk study prior to collection of new information from field surveys; a multi-disciplinary team should be used and there should be adequate time allocated to assessment of the information collected. Any envisaged wetland inventory and assessment project should conduct a review of previous projects to benefit from their experiences and to build on them.

5.0 REFERENCES

Claridge, G.F. (1991) An overview of wetland values: A necessary preliminary to wise use. PHPA/AWB Sumatra Wetland Project Report No. 7, AWB, Bogor, Indonesia

Costa, L.T., Farinha, J.C., Thomas Vives, P, Hecker, N. & Silva, E.P. (2001) Regional wetland inventory approaches: The Mediterranean example.

In: Finlayson, C.M., Davidson, N.C. & Stevenson, N.J. (Eds.)(2001)

Wetland inventory, assessment and monitoring: Practical techniques and identification of major issues. Proceedings of Workshop 4, 2nd International Conference on Wetlands and Development, Dakar, Senegal, 8-14 November 1998, Supervising Scientist report 161, Supervising Scientist, Darwin, Australia.

Costa, L.T., Farinha, J.C., Hecker, N. & Thomas Vives, P. (1996)

Mediterranean Wetland Inventory: A Reference Manual.

MedWet/Instituto da Conservacao de Natureza/Wetlands International Publication, Volume I

Cowardin, L.M., Carter, V., Golet, F.C. & LaRoe, E.T. (1979) Classification of wetlands and deepwater habitats of the United States.

U.S. Fish and Wildlife Service FWS/OBS-79/31. Washington D.C.

Davies, J. & Claridge, G.F. (Compliers) (1993) Wetland Benefits. The potential for wetlands to support and maintain development.

Asian Wetland Bureau Publication No.87; IWRB Special Publication No.27; Wetlands for the Americas Publication No.11

Finlayson, C.M., & Davidson, N.C. (1999) Summary Report.

In: Finlayson, C.M. & Spiers, A.G. (Eds.) (1999) Global review of wetland resources and priorities for wetland inventory.

Supervising Scientist Report 144. Supervising Scientist, Canberra, pp. 1-13.

Finlayson, C.M., Davidson, N.C. & Stevenson, N.J (2001) Wetland inventory, assessment and monitoring – practical techniques and identification of major issues: Summary. In: Finlayson, C.M., Davidson, N.C. & Stevenson, N.J. (Eds.) (2001) Wetland inventory, assessment and monitoring: Practical techniques and identification of major issues. Proceedings of Workshop 4, 2nd International Conference on Wetlands and Development, Dakar, Senegal, 8-14 November 1998, Supervising Scientist report 161, Supervising Scientist, Darwin, Australia.

Larson, J.S., Adamus, P.R. & Clairian, E.J. Jnr. (1989) Functional assessment of freshwater wetlands: A manual and training outline. WWF and Environmental Institute, University of Massachusetts, Amherst, U.S.A.

Lopez, A. (this volume)

Scott, D.A. (Compiler) (1989) A directory of Asian wetlands.

IUCN, Gland, Switzerland and Cambridge, U.K.

Spellerberg, I.F. (1992) Evaluation and assessment for conservation.

Chapman & Hall, London.

Invited Paper No. 2

DEVELOPMENTS IN WETLAND INVENTORY, ASSESSMENT AND MONITORING

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ABSTRACT

The main challenge that wetland managers and policy makers face today is to make choices that are sensible, pragmatic and defensible, particularly against a background of ecological and socio-economic complexity and uncertainty, due in large part to a lack of reliable knowledge. However, recent developments in wetland inventory, assessment and monitoring methods may provide an essential framework of knowledge for the wise use of wetlands, whether for conservation, sustainable use or multiple use objectives. Collectively known as a WIAMS (Wetlands Inventory, and Assessment, Monitoring System), we argue that this approach is more comprehensive and, hence, more effective than the conventional WAS (Wetlands Assessment System). It involves a multi-scalar (hierarchical) approach to inventory, best practice assessment protocols within a risk management framework, and a focused monitoring programme which provides feedback on performance in order to obtain outcomes.

Wetlands throughout the world are under increasing threats and pressures from both local and global changes. Hence, over the past two decades, WIAMS are rapidly becoming an indispensable part of the decision-making tool box for wetland managers and policy makers operating from local to global scales. We first review past recommendations and considerations for wetlands inventory, monitoring and assessment, and then identify practical steps for developing effective programmes to obtain reliable information in a cost-effective and timely fashion. We recommend strongly that the WIAMS framework be adopted because it will, at the least, standardise terminology and approaches for obtaining and reporting information which can then be shared with those who cannot afford the luxury of such programmes. We recommend also, that this robust working framework be constantly reviewed and improved.

INTRODUCTION

Wetland inventory, assessment and monitoring have been increasingly addressed in international and national fora in recent years. Much of the international effort has been directed towards supporting the concept of wise use of wetlands advocated under the Ramsar Wetlands Convention and supported by Wetlands International and its partners (Finlayson & Davidson 2001). This has resulted in a number of international meetings and agreements on priorities for wetland inventory, assessment and monitoring. These are reported below as the basis for developing a holistic approach for wetland management through the provision of accurate and reliable information. Such information has been identified as a crucial step for effective wetland management (Dugan 1990, Finlayson 1996a).

In presenting this information we propose the acceptance of standardised terminology and the adoption of comparable approaches for obtaining and reporting information necessary for effective wetland management. In doing this we draw heavily upon information obtained from a number of international wetland projects. Foremost amongst these are:

- a global review of wetland inventories (GRoWI) for the Ramsar Convention (Finlayson & Davidson 1999, Finlayson et al 1999);
- a framework for conducting wetland risk assessment as an integral component of management planning processes (van Dam et al 1999);
- frameworks for monitoring adopted under the Ramsar Convention (Finlayson 1996b) and the Mediterranean wetland initiative (MedWet) (Finlayson 1996c, Grillas 1996, Tomas Vives & Grillas 1996); and
- a framework for a hierarchical approach to wetland inventory in Asia (Finlayson et al 2002a,b).

In support of this proposal we first review past recommendations and considerations for wetland inventory, assessment and monitoring and identify practical steps for developing effective programmes that can supply information in a timely manner for wetland managers. The latter builds on outcomes of workshops held during the 2nd International Conference on Wetlands and Development, Dakar, Senegal, November 1998 (Finlayson et al 2001a).

PREVIOUS CONFERENCE RECOMMENDATIONS

Finlayson & Davidson (2001) provide a summary of the recommendations on wetland inventory, assessment and monitoring agreed in major wetland conferences during the last two decades. These conferences included the following:

- Managing Waterfowl Populations (Matthews 1990) – IWRB, Astrakhan, Russia (former USSR), 2–5 October 1989;
- Managing Mediterranean wetlands and their birds for the Year 2000 and beyond (Finlayson et al 1992) – IWRB, Grado, Italy, 3–10 February 1991;
- Old world and new world wetlands (Mitsch 1994; Finlayson and van der Valk 1995) – Intecol Wetland Conference, Columbus, USA, 13–8 September 1992;
- Waterfowl and wetland conservation in the 1990s – A global perspective (Moser et al 1993) – IWRB, St Petersburg Beach, Florida, USA, 12–19 November 1992; and
- International conference on wetlands and development (Prentice & Jaensch 1997) – Wetlands International, Kuala Lumpur, Malaysia, 9–13 October 1995.

Recommendations from these meetings were broadly consistent and covered six common themes and/or requirements:

- Collection of long term data on wetlands;
- Standardisation of techniques, guidelines and manuals;
- Provision of training;
- Reviewing gaps and co-ordination of data collection;
- Developing and making greater use of communication networks; and
- Developing means to audit existing effort.

The consistency of the recommendations was attributed in part, to a degree of consistency of attendance and participation of personnel from or associated with Wetlands International (Finlayson & Davidson 2001). However, as the conferences were held in different locations it is likely that many other interests were also represented. Further, the nature of the meetings became much broader with an initial focus on waterbirds extending to waterbirds and their habitats, and then to wetlands and their management. Thus, the outcomes most likely represent a decade of a developing and expanding interest in wetlands and an increasing awareness that wetland inventory, assessment and monitoring was either needed or, where it existed, was inadequate.

Finlayson & Davidson (2001) also reported that there was little evidence that these recommendations had been widely implemented. Whilst many of the recommendations were worthy, they had apparently proved to be unrealistic and possibly over-ambitious given the past and present levels of institutional capacity and capability on the ground. Unfortunately it seemed that the rhetoric and *bon homie* of the conferences (and their workshops) had been difficult to translate into on-the-ground action after the conference. A major exception to the general lack of implementation was provided by the Mediterranean wetlands programme MedWet, which has now contributed substantively to standardising techniques for wetland inventory (Costa et al 1996) and monitoring (Tomas Vives 1996).

The success of the MedWet programme is heartening, but it should not shield the reality that this success has not been widely replicated. Other regional conferences and workshops have not succeeded in this manner and further wetland inventory, assessment and monitoring are still urgently needed. This was shown by the regional reviews of the Ramsar Convention's inventory project (see reports in Finlayson & Spiers 1999). Thus, if we are to see further improvement in wetland inventory, assessment and monitoring we need to also identify processes that can translate recommendations into action.

The workshops held in Dakar, Senegal, 1998 (Finlayson et al 2001a) took this problem into account and attempted to present some practical outcomes that could assist in the development of more effective wetland inventory, assessment and monitoring programmes. Thus, as well as hearing about a number of current and recent initiatives on wetland inventory and assessment, the workshop provided an opportunity to test the ideas emerging from earlier workshops. The outcomes of this workshop as presented by Finlayson et al (2001b) are discussed below along with some more recent advances.

CURRENT STATE OF WETLAND INVENTORY, ASSESSMENT AND MONITORING

Finlayson et al (1999, 2001b) report that there is a wealth of wetland inventory, assessment and monitoring activity under way at a great variety of scales – from global through regional and national scales to wetland site-based work. Broad-scale initiatives include:

- a global review of wetland resources that compiled and analysed information from national wetland inventory resources and evaluated the size and distribution of the global wetland resource (undertaken by Wetlands International for the Ramsar Convention – Finlayson & Spiers 1999, Finlayson et al 1999);
- a pilot project designed to recommend and develop standard wetland inventory and assessment tools to meet the needs of sustainable wetlands management worldwide

- (undertaken by Wetlands International through the Biodiversity Conservation Information System (BCIS) network – Davidson 1999);
- the first phase of a project towards a Pan-European wetlands inventory (Wetlands International and the RIZA institute, Netherlands – Nivet & Frazier 2001);
 - continuing development and testing of wetland inventory and assessment tools through the MedWet initiative (Costa et al 2001);
 - development of a draft framework for wetland inventory by the Scientific and Technical Review Panel of the Ramsar Wetlands Convention based on a resolution adopted by the Convention in 1999 (reproduced in Finlayson & Davidson 2001); and
 - development of the Asian Wetland Inventory using approaches derived from the recommendations presented at the workshops held in Dakar and supporting the concepts outlined in the Ramsar framework (Finlayson et al 2002a,b).

The global review of wetland resources identified large gaps in the global wetland inventory effort, with many discrepancies in data management, inadequate documentation, inconsistencies in methods and poor communication of information. Papers presented in Finlayson et al (2001a) also illustrate the extent and limits of wetland inventory, assessment and monitoring in some countries.

DISTINCTIONS BETWEEN WETLAND INVENTORY, ASSESSMENT AND MONITORING

It is important to distinguish between inventory, assessment and monitoring when designing data gathering exercises, especially since they require different categories of information. The distinctions are often confused. Working definitions reported by Finlayson et al (2001b) are:

Wetland Inventory: the collection and/or collation of core information for wetland management, including the provision of an information base for specific assessment and monitoring activities.

Wetland Assessment: the identification of the status of, and threats to, wetlands as a basis for the collection of more specific information through monitoring activities.

Wetland Monitoring: Collection of specific information for management purposes in response to hypotheses derived from assessment activities, and the use of these monitoring results for implementing management. The collection of time-series information that is not hypothesis-driven from wetland assessment is here termed *surveillance* rather than monitoring.

The relationship between these concepts is shown in Figure 1. The approach and the scope of activity for inventory, assessment and monitoring as separate components of the management process differ substantially, but these are not always well distinguished in implementation projects. Importantly, wetland inventory and wetland monitoring require differing types of information and, whilst wetland inventory provides the basis for guiding the development of appropriate assessment and monitoring, wetland inventories repeated at given time intervals do not constitute monitoring.

Basically wetland inventory is used to collect information to describe the ecological character of wetlands; assessment considers the pressures and associated risk of adverse

change in ecological character; and monitoring, which could include survey and surveillance (Finlayson 1996b,c), provides information on the extent of any change. As all three steps – inventory, assessment and monitoring – are important data gathering exercises we propose that any “Wetland Assessment System (WAS)” comprises components of each. The extent of each component would be determined by individual management needs and the extent of existing information. We also propose, in light of the definitions given above from Finlayson et al (1999, 2001b) that the term “Wetland Assessment System” is redundant and should be replaced with a Wetland Inventory, Assessment and Monitoring System (WIAMS).

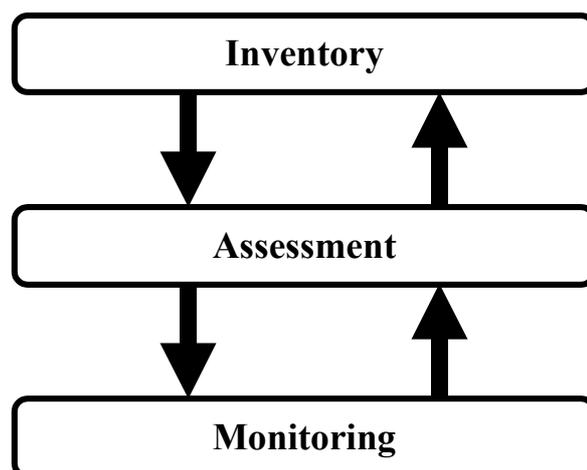


Figure 1. Concepts of wetland inventory, assessment and monitoring (taken from Finlayson et al 1999, 2001b) and proposed for acceptance within the technical guidelines adopted by the Ramsar Wetlands Convention.

PRACTICAL STEPS FOR IMPROVED INVENTORY, ASSESSMENT AND MONITORING

As noted above, recommendations covering practical steps for improving wetland inventory, assessment and monitoring have been proposed at many conferences. A summary of these is presented below along with outcomes of the major activities also reported above.

1. All countries that have not yet conducted a national wetland inventory should do so, preferably using an approach that is comparable with other large-scale wetland inventories already underway or complete. These should focus on a basic data set that describes the location and size of the wetland and the major biophysical features, including variation in the areas and the water regime.
2. Once the basic data have been acquired and adequately stored, more management oriented information on wetland threats and uses, land tenure and management regimes, benefits and values can be added. When such information is recorded it should be accompanied by clear records that describe when and how the information was collected and its accuracy and reliability. This information should provide a base for national assessment of wetlands and management priorities.
3. Each inventory and assessment programme should contain a clear statement of its purpose and the range of information that has been collated or collected. This extends to

defining the habitats being considered and the date the information was obtained or updated.

4. Priority should be given to improving the global inventory for wetland habitats that are currently poorly covered in most parts of the world, notably seagrasses, coral reefs, saltmarshes and coastal tidal flats, mangroves, arid-zone wetlands, rivers and streams and artificial wetlands.
5. The effectiveness of all aspects of wetland inventory and assessment should be addressed through a standardised framework and a generic wetland inventory database, designed to be as flexible as possible for use in all regions of the world and to accommodate various inventory and assessment objectives.
6. Models for effective wetland inventory, using appropriate remote sensing and ground techniques should be compiled and widely disseminated. These should outline useful habitat classifications (eg those based initially on landform and not vegetation parameters), methods and means of collating and storing the information, in particular Geographic Information Systems (GIS) for spatial and temporal data that could be used for monitoring purposes.
7. Wetland monitoring systems should build upon the information provided in wetland inventory and assessment activities. Specific monitoring should be based on a hypothesis derived from the assessment data and be contained within a suitable management structure.

Although we recommend these seven essential steps, we stress the value of: maximising the use and availability of existing information; developing standard frameworks and mechanisms, made as simple and versatile as possible and based on clear evaluation of purpose and need; and using these approaches to support filling of the extensive gaps in existing information.

The Ramsar Convention has to date adopted guidelines for the development of effective wetland risk assessment (van Dam et al 1999) and monitoring programmes (Finlayson 1996a). Guidelines for inventory are available in a draft form and will be debated late in 2002 at the 8th Meeting of the Conference of Parties to the Convention. These guidelines can be combined and used to develop a wetland inventory, assessment and monitoring system (WIAMS) that reflects local needs and conditions. A summary of existing guidelines is provided below.

GUIDELINES FOR DEVELOPING WETLAND INVENTORY PROGRAMME

In response to recommendations made in the global review of wetland inventory (Finlayson & Spiers 1999, Finlayson & Davidson 1999, Finlayson et al 1999) the Ramsar Wetlands Convention adopted resolution VII.10 Priorities for Wetland Inventory. Amongst other issues this contained a request to:

“... review and further develop existing models for wetland inventory and data management, including the use of remote sensing and low-cost and user-friendly geographic information systems.”

The guidelines presented below were developed by the Scientific and Technical Review Panel of the Convention with input from Wetlands International's Specialist Group on Wetland Inventory and Monitoring, and the Environmental Research Institute of the Supervising Scientist (Australia). The draft guidelines², will be debated at the 8th Meeting of the Conference of Contracting Parties to the Convention in November 2002.

The guidelines include 13 steps (Table 1) for assisting interested parties design an inventory that is suited to their needs. It basically comprises a framework for developing an inventory using information provided or obtained by the proponents. It is not a recipe for a specific inventory. As a guide to developing individual inventories information is provided in the draft guidelines on existing inventory methods and habitat classifications, types of remotely sensed data and a procedure for determining which is most appropriate for a particular inventory.

A key feature of the proposed framework is the adoption of the concept of a core or minimum data set sufficient to describe the wetland(s). It is noted that the specific details of this data set are inseparable from the level of complexity and the spatial scale of the inventory. Thus, it is recommended that sufficient information (the core, or minimum, data set) should be collected so as to enable the major wetland habitats to be delineated and characterized for at least one point in time by describing i) the biophysical features of the wetland; and/or ii) the major management issues of the wetland. The decision about whether or not to undertake an inventory based only upon core biophysical data or also to include data on management features will be based on individual priorities and resources. Recommended core data fields for the collection of biophysical and management features of wetlands are listed in Table 2.

GUIDELINES FOR DEVELOPING A WETLAND ASSESSMENT PROGRAMME

The concepts of assessment have also been addressed under the Ramsar Wetlands Convention with an initial emphasis on providing guidance for wetland risk assessment. This was developed to assist with predicting and assessing change in the ecological character of wetlands. A framework that provides guidance on how to go about predicting and assessing change in the ecological character of wetlands and promotes, in particular, the usefulness of early warning systems, was adopted by resolution VII.10 on Wetland Risk Assessment.

The basic model prepared for wetland risk assessment, modified from a generalised ecological risk assessment model, is shown in Figure 2. It outlines the six steps based on the concepts presented by van Dam et al (1999).

1. *Identification of the problem* - identify the nature of the problem and develop a plan for the remainder of the assessment, including the objectives and scope.
2. *Identification of adverse effects* – determine the types of adverse ecological and/or socio-economic effects caused by the problem.
3. *Identification of the extent of the problem* – estimate the extent to which the problem may or does occur.
4. *Identification of the risk* – integrate the results from the above steps.

² Available at URL, http://www.ramsar.org/key_sc26_docs_cop8_07.htm.

5. *Risk management and reduction* – make decisions to minimize the risks without compromising other societal, community or environmental values.
6. *Monitoring* – verify the effectiveness of the risk management decisions.

The application of the above risk assessment model has been demonstrated in specific case studies for invasive species (Finlayson et al 2001c, van Dam et al 2001) and altered water allocations within a river basin (Begg et al 2001). It is anticipated that further assessment procedures will be developed or expanded to support this risk assessment model. Importantly it is noted that the risk assessment model builds on information obtained through the inventory procedure and links this with monitoring, shown as the last step in the model.

Table 1. A structured framework and step-wise checklist for planning a wetland inventory

No.	Step	Guidance
1	State the purpose and objective	State the reason(s) for undertaking the inventory and why the information is required, as the basis for choosing a spatial scale and minimum data set.
2	Review existing knowledge and information	Review the published and unpublished literature and determine the extent of knowledge and information available for wetlands in the region being considered.
3	Review existing inventory methods	Review available methods and seek expert technical advice to: a) choose the methods that can supply the required information; and b) ensure that suitable data management processes are established.
4	Determine the scale and resolution	Determine the scale and resolution required to achieve the purpose and objective defined in Step 1.
5	Establish a core or minimum data set	Identify the core, or minimum, data set sufficient to describe the location and size of the wetland(s) and any special features. This can be complemented by additional information on factors affecting the ecological character of the wetland(s) and other management issues, if required.
6	Establish a habitat classification	Choose a habitat classification that suits the purpose of the inventory, since there is no single classification that has been globally accepted.
7	Choose an appropriate method	Choose a method that is appropriate for a specific inventory based on an assessment of the advantages and disadvantages, and costs and benefits, of the alternatives.

8	Establish a data management system	<p>Establish clear protocols for collecting, storing and retrieving data, including archiving in electronic or hardcopy formats. This should enable future users to determine the source of the data, and its accuracy and reliability.</p> <p>At this stage it is also necessary to identify suitable data analysis methods. All data analysis should be done by rigorously tested statistical or other quantitative methods, and all information documented. The data management system should support, rather than constrain, the data analysis.</p> <p>A meta-database should be used to: a) record information about the inventory datasets; and b) outline details of data custodianship and access by other users.</p>
9	Establish a time schedule and the level of resources that are required	<p>Establish a time schedule for: a) planning the inventory; b) collecting, processing and interpreting the data collected; c) reporting the results; and d) regular review of the programme.</p> <p>Establish the extent and reliability of the resources available for the inventory. If necessary make contingency plans to ensure that data are not lost due to insufficiency of resources.</p>
10	Assess the feasibility & cost effectiveness	<p>Assess whether or not the programme, including reporting of the results, can be undertaken within the current institutional, financial and staff situation.</p> <p>Determine if the costs of data acquisition and analysis are within budget and that a budget is available for the programme to be completed.</p>
11	Establish a reporting procedure	<p>Establish a procedure for interpreting and reporting all results in a timely and cost effective manner.</p> <p>The report should be succinct and concise, indicate whether or not the objective has been achieved, and contain recommendations for management action, including whether further data or information is required.</p>
12	Establish a review and evaluation process	<p>Establish a formal and open review process to ensure the effectiveness of all procedures, including reporting and, when required, supply information to adjust or even terminate the programme.</p>
13	Plan a pilot study	<p>Test and adjust the method and specialist equipment being used, assess the training needs for staff involved, and confirm the means of collating, collecting, entering, analysing and interpreting the data. In particular, ensure that any remote sensing can be supported by appropriate “ground-truth” surveys.</p>

Table 2. Core (minimum) data fields for biophysical and management features of wetlands

Biophysical features

- Site name (official name of site and catchment)
- Area and boundary (size and variation, range and average values) *
- Location (projection system, map coordinates, map centroid, elevation) *
- Geomorphic setting (where it occurs within the landscape, linkage with other aquatic habitat, biogeographical region) *
- General description (shape, cross-section and plan view)
- Climate – zone and major features (average rainfall, temperature range, relative humidity, prevailing winds)
- Soil (structure and colour)
- Water regime (natural or artificial, periodicity, extent of flooding and depth, source of surface water and links with groundwater)
- Water chemistry (salinity, pH, colour, transparency, nutrients)
- Biota (vegetation zones and structure, animal populations and distribution, special features including rare/endangered species)

Management features

- Land use – local, and in the river basin and/or coastal zone
- Pressures on the wetland – within the wetland and in the river basin and/or coastal zone
- Land tenure and administrative authority – for the wetland, and for critical parts of the river basin and/or coastal zone
- Conservation and management status of the wetland – including legal instruments and social or cultural traditions that influence the management of the wetland
- Ecosystem values and benefits (goods and services) derived from the wetland – including products, functions and attributes (see Resolution VI.1) and, where possible, their services to human well-being (see Resolution VI.23 and VII.8) and whether or not the benefits derived from wetlands are sustainable.
- Management plans and monitoring programmes – in place and planned within the wetland and in the river basin and/or coastal zone (see Resolutions 5.7, VI.1, VII.17, [and VIII.xx])

* These features can usually be derived from topographical maps or remote sense images, especially aerial photographs.

GUIDELINES FOR DEVELOPING A WETLAND MONITORING PROGRAMME

A framework for assisting with the design of a monitoring programme was developed in unison for the Ramsar Wetlands Convention (Finlayson 1996b) and for the Mediterranean Wetland Programme (MedWet) (Finlayson 1996c). The concepts that support the

framework are outlined in resolution VI.1 which addressed a number of issues including monitoring change in the ecological character of wetlands.

The framework applies to all forms of monitoring (eg changes in the area of a wetland, the ecological health of a wetland or the underlying reasons behind the loss of wetlands). As such it is not prescriptive and it does not provide a recipe for a particular type of problem wetland type. It presents a series of steps for designing a monitoring programme which can be tailored to individual needs.

In presenting this framework it is stressed that not all monitoring programmes are effective. For example, monitoring programmes that are data rich and information poor are not likely to be effective. Effectiveness is further reduced if the programme provides misleading information. At the outset the likely outcomes of the monitoring programme should be considered, including an assessment of the likely threshold of change that can be tolerated (both system and social tolerance), or the likely responses that may be needed (van Dam et al 1999).

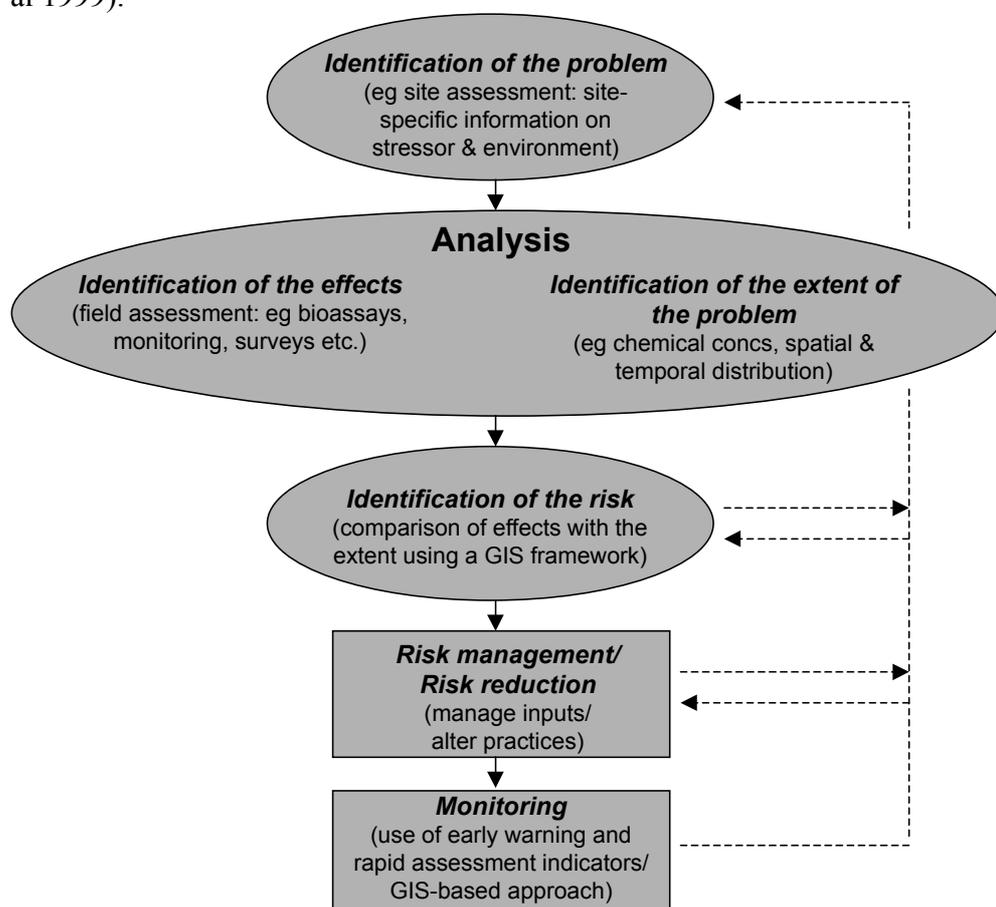


Figure 2. Wetland risk assessment model recommended by the Ramsar Wetlands Convention resolution VI.1, after van Dam et al (1999)

Key aspects of the framework are described below, adapted from material presented by Finlayson (1996b,c) and from background sources. A summary of the points to consider when using the framework is given in Table 3.

The framework outlined above was developed for the Ramsar Wetland Convention and has been specifically tested in the MedWet programme (Tomas Vives 1996).

DEVELOPMENT AND IMPLEMENTATION OF MULTI-SCALAR APPROACHES FOR WETLAND INVENTORY, ASSESSMENT AND MONITORING

The above guidelines have been agreed as the basis for developing coherent approaches for wetland inventory, assessment and monitoring. That is, the guidelines provide the basis of a holistic approach to determining the status of and extent of change (if any) in wetlands. In the process of developing these guidelines the issue of scale was regularly raised. This has been possibly most clearly articulated for inventory (Finlayson et al 2001b), but could equally apply to assessment and monitoring.

That is, the purpose or objective for wetland inventory, assessment or monitoring is inseparable from the spatial scale of the analysis. Phinn et al (1999) notes that wetland inventory has been carried out at a number of spatial scales, with specific objectives at each scale. For example:

Table 3. Summary of key points to consider when designing a wetland monitoring programme

Identify the nature & extent of the problem(s) or the issue(s)	State clearly and unambiguously in relation to the known extent and most likely cause, identify the baseline or reference situation that exists or is required, and establish the most likely threshold of change that could be socially acceptable.
Set the objective	Based on the step above and provides the basis for collecting the information through attainable and achievable time periods for monitoring and to support managerial responses.
Establish the working hypothesis(es)	Supports the objective and can be tested by the methods adopted, including statistical analyses in line with acceptable levels of change identified before the monitoring commences.
Choose the methods & variables	Specific for the problem and able to provide sufficient information to test the hypothesis(es) need to detect the presence of, and assess the significance of, any change. Thus, they are suitable for obtaining the results necessary to identify or clarify any change and for showing the most likely cause or need for further investigation.
Assess the feasibility & cost effectiveness	Determine whether or not the programme (including reporting of the results) can be done regularly and continually within the context of the management planning processes and financial resources available. Assess factors that influence the sampling programme such as: availability of trained staff; access to sampling sites; availability and reliability of specialist equipment; means of analysing and interpreting the data; usefulness of the data and information. Determine if the costs of data acquisition and analysis are within

	the budget and that the budget is available and/or renewal as appropriate.
Conduct a pilot study	Test and fine-tune the method and specialist equipment being used, assess the training needs for staff involved, and confirm the means of analysing and interpreting the data. This does not imply that all likely conditions and variations that may be experienced over an extended period are assessed, but it does imply that the operators have confidence in the procedures and their ability to respond to adverse conditions.
Collect the samples	Staff should be trained in all sampling methods before the project begins, including the necessary documentation required. For example, date and location, names of staff, sampling methods, equipment used, means of storage or transport of samples, all changes to the methods and general observations. Samples should be processed within a timely period and all data documented such as: date and location; names of staff; processing methods; equipment used ; and all changes to the protocols.
Analyse the samples	Sample and data analysis should be done by rigorous and tested methods and all information documented such as: date and location; names of analytical staff; methods used; equipment used; data storage methods.
Report the results	Interpret and report all results in a timely and cost effective manner. The report should be written in a clear and concise manner and indicate whether or not the hypothesis(es) has been supported. It contains recommendations for management action, including further monitoring.
Evaluate the project	Formally and openly review the effectiveness of all procedures and where necessary adjust or even terminate the programme. The latter should not be seen as a failure if it is shown to be done for valid reasons.

- global – presence/absence in specific continents and islands,
- continental – distribution of regions within continents or islands dominated by wetlands,
- regional – scale of predominance of specific wetland types,
- local – individual wetlands, and
- site – variability within wetlands.

These ideas have been further developed and expressed in a draft protocol for wetland inventory in Australia (Finlayson 1999) and extended with protocols for an Asian wetland inventory (Finlayson et al 2002a,b). The basis of the latter is outlined below.

The Asian Wetland Inventory (AWI) has been developed with multiple goals in mind. These take into account the need for information at multiple scales (ie local to global) and include the need to (after Finlayson et al 2002a,b):

- develop standardised field data collection sheets;
- provide core data/information on Asian wetlands to support international conventions and treaties on wetlands, climate change, biodiversity, migratory species and desertification, and their implementation by governments;
- analyse long-term trends in Asian wetlands and their natural resources;
- enable regular revisions and updates of information on wetlands of national and international importance in Asia; and
- disseminate these analyses for wider consideration and use in sustainable development and conservation of wetland resources.

The key feature of the AWI is the production of hierarchical and map-based outputs at four levels of detail. The level of detail is related to the scale of the maps that are contained within a standardised GIS format with a minimum core data set. The hierarchical approach comprises a progression in scale from river basins to individual sites (Figure 3). The initial analysis (level 1) comprises delineation of geographical regions (major river basins & islands) in Asia and encompasses a description of the geology, climate and ecology of each based on existing information sources. Level 2 analysis comprises delineation of wetland regions within each geographic region. This is done on the basis of similar climatic, geologic, hydrologic and vegetation features. Level 3 analysis comprises grouping and description of wetland complexes within each region on the basis of more detailed information. Finally, Level 4 analysis comprises detailed description of individual wetland habitats. The above approach results in the production of more detailed information on wetlands as the inventory progresses from Levels 1 to 4.

At all levels of analysis the usefulness of existing information is assessed and used as a basis for determining whether or not further analysis or collection of information is necessary. It is likely that the analyses will be undertaken as described below:

- **Level 1** – desk study to describe the broad geologic, climatic and ecological features of each geographic region using existing datasets, such as those nowadays available on the world wide web;
- **Level 2** – desk study to identify the wetland regions within each geographic region using information already collated on geology, climate, hydrology and vegetation;
- **Level 3** – fieldwork and analysis to identify the physical, physico-chemical and biological features of wetland complexes within each wetland region; and
- **Level 4** – detailed fieldwork and analysis to describe the physical, physico-chemical and biological features of each wetland habitat within each wetland complex. This includes information on plant and animal assemblages and species, land and water use and wetland management.

Data collection and analysis is based on standardised procedures, although flexibility is not discouraged where deemed useful, and data management formats. Proforma data sheets for each level of analysis have been developed and are accompanied by guidelines for collecting the required information (Finlayson et al 2002c).

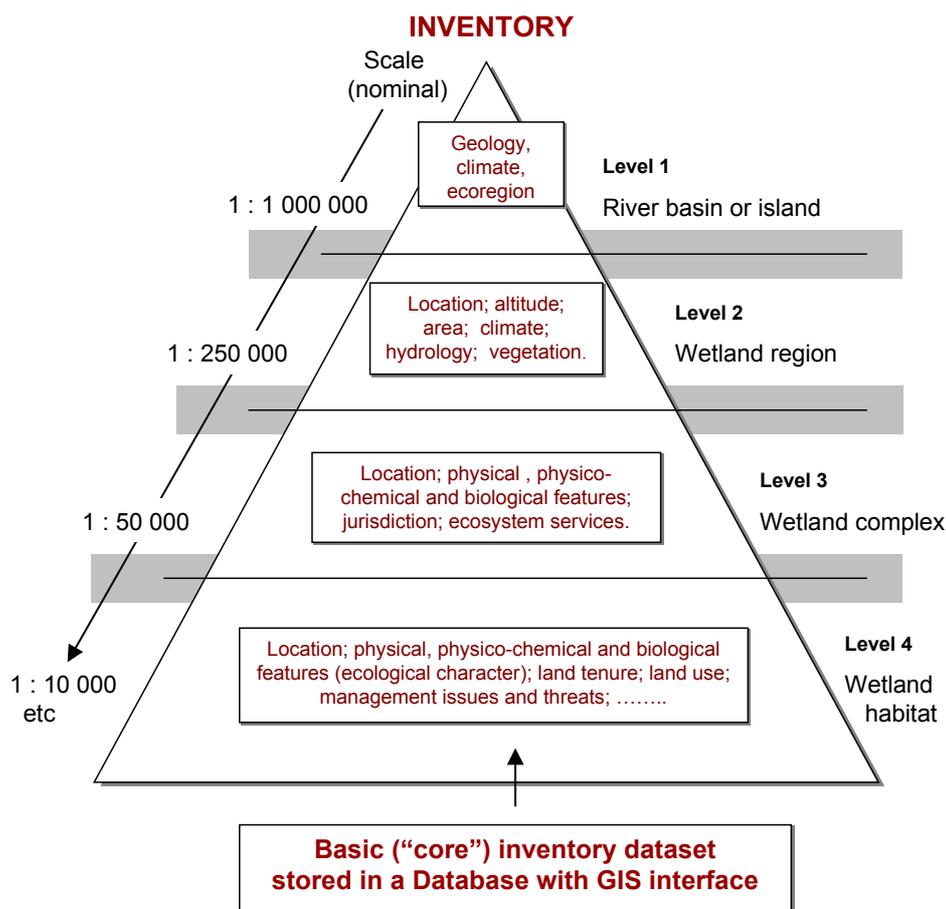


Figure 3. Hierarchical approach to wetland inventory

The hierarchical or multi-scalar approach can also be linked with other data collecting exercise such as those proposed in the Millennium Ecosystem Assessment (Reid 2000). It is important to realise that while a hierarchical framework has been proposed it is not essential to work through all levels of detail. The hierarchical approach has been developed in response to existing needs to obtain information at different levels and detail, and also serves to demonstrate the clear linkages between scales. It is possible to obtain data at any level within the hierarchy whether or not other levels have been or will be addressed. A key point of this approach, however, is the adoption of compatible data fields and data management procedures to allow maximum use of the data whether this is immediately planned or not. The global review of wetland inventory demonstrated that a large amount of data was reused, often without sufficient attention to its limits or constraints on interpretation (Finlayson et al 1999, Finlayson & Spiers 1999).

It is anticipated that similar multi-scalar procedures will be developed for wetland assessment and monitoring. These procedures will likely build on the multi-scalar information collected under the inventory process and provide managers and others with analyses suitable for the scale of investigation. A concept for a multi-scalar, interrelated wetland inventory, assessment and monitoring scheme is provided in Figure 4. The concept is an extension of those provided in Figures 1 and 3, acknowledging that assessment and monitoring also require information gathered at different scales.

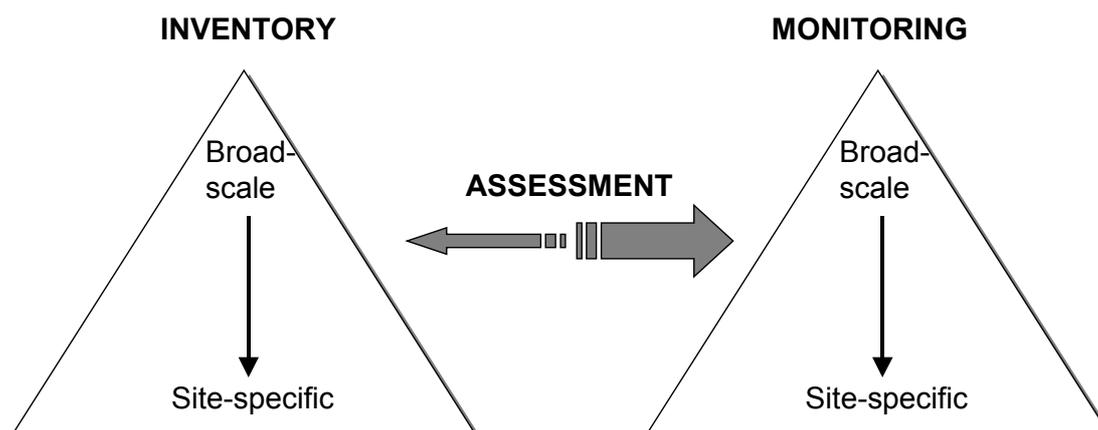


Figure 4. Concept of a multi-scalar, interrelated wetland inventory, assessment and monitoring system

Assessment and monitoring at broad scales may be required to:

1. evaluate larger, landscape level features or effects, and/or
2. provide assessments over catchment, regional or larger scales.

Landscape-level effects may result as a consequence of wetland loss due to fragmentation of the landscape, climate change, fire, or widespread invasion by weeds and feral animals. Thiesing (2001) criticised the lack of assessment methods available at the landscape level for wetlands in the USA, noting that wetlands interact with one another, provide refugia for wetland animals within the landscape and seed banks for wetland vegetation. They also serve as sources for species dispersal and migration to other wetlands within the landscape, providing habitat for migratory species such as waterbirds or fish, as well as maintenance and support of biodiversity. Indeed, for biodiversity and conservation assessments at the site-specific level, landscape-level studies are essential to provide contextual information (distribution and abundance).

Additionally, assessments over catchment, regional or larger scales are an essential management requirement. For example, in Australia and New Zealand they are applied in national water quality assessment programmes for:

- rapid, cost-effective and adequate first-pass determination of the extent of a problem or potential problem (eg as applied to broad-scale land-use issues, diffuse-source effluent discharges or information for State of Environment Reporting or audits);
- screening of sites to identify locations needing more detailed investigation; and/or
- remediation programmes being conducted over broad geographical areas (catchment, regional or larger scales) (see ANZECC & ARMCANZ 2000).

Assessment and monitoring of course, will also be required at specific sites where, in general, stronger inference and greater sensitivity to disturbance become more important requirements. Humphrey et al (2002) discuss these applications further, providing attributes and examples of monitoring techniques used for broad-scale and site-specific assessments.

Detailed monitoring at broad scales is usually not possible because of excessive costs and so monitoring at this scale must be cost-effective and sufficiently rapid to generate

adequate first-pass data over large areas. The data may be adequate for management purposes or they may help managers to decide what type of further information may be required and from where (ANZECC & ARMCANZ 2000). Typically, rapid assessment methods are applied at broad scales, including rapid biological assessment and remote sensing. For specific sites, however, more detailed, quantitative monitoring may be required, utilising designs that provide stronger inference about a putative impact (Humphrey et al 2002). Parker (2001) describes a number of study designs for monitoring wetlands, each applicable to a particular spatial scale of a study.

REFERENCES

ANZECC & ARMCANZ 2000. *Australian and New Zealand guidelines for fresh and marine water quality*. National Water Quality Management Strategy Paper No 4, Australian and New Zealand Environment and Conservation Council & Agriculture and Resource Management Council of Australia and New Zealand, Canberra.

Begg GW, van Dam RA, Lowry JB, Finlayson CM & Walden DJ 2001. *Inventory and risk assessment of water dependent ecosystems in the Daly basin, Northern Territory, Australia*. Supervising Scientist Report 162, Supervising Scientist, Darwin NT.

Costa LT, Farinha JC, Tomas Vives P & Hecker N 1996. *Mediterranean wetland inventory: A reference manual*. MedWet Publication. Instituto da Conservacao da Natureza, Lisboa, and Wetlands International, Slimbridge, UK.

Costa LT, Farinha JC, Tomas Vives P, Hecker N & Silva EP 2001. *Regional wetland inventory approaches – the Mediterranean example*. In *Wetland inventory, assessment and monitoring - Practical techniques and identification of major issues: Introduction and review of past recommendations*, eds CM Finlayson, NC Davidson & NJ Stevenson (eds), Supervising Scientist Report 161, Supervising Scientist Division, Environment Australia, Darwin, Australia. pp 31-39.

Davidson NC 1999. *Wetlands and biodiversity. Creation of global assessment tools for conservation, status, needs and priorities*. BCIS/NORAD. Wetland pilot project. Phase I progress report, February 1999, unpublished report, Wetlands International, Wageningen, The Netherlands.

Dugan PJ (ed) 1990. *Wetland conservation: A review of current issues and required action*. IUCN, Gland, Switzerland.

Finlayson CM 1996a. *Information required for wetland management in the South Pacific*. In *Wetland conservation in the Pacific islands region*, Proceedings of the regional workshop on wetland protection and sustainable use in Oceania, R Jaensch (ed). Port Moresby, Papua New Guinea, June 1994, Wetlands International-Asia/Pacific, Canberra, 185–201.

Finlayson CM 1996b. *The Montreux Record: A mechanism for supporting the wise use of wetlands*. In *Proceedings of the Sixth Meeting of the Conference of the Contracting Parties of the Convention on Wetlands, Technical Sessions: Reports and presentations*, Ramsar Convention Bureau, Gland, Switzerland, 32–37.

Finlayson CM 1996c. *Framework for designing a monitoring programme*. In *Monitoring Mediterranean wetlands: A methodological guide*, ed P Tomas Vives, MedWet publication, Wetlands International, Slimbridge, UK and ICN, Lisbon, Portugal, 25–34.

Finlayson CM 1999. Protocols for an Australian national wetland inventory. In CM Finlayson & AG Spiers (eds), *Techniques for Enhanced Wetland Inventory, Assessment and Monitoring*. Supervising Scientist Report 147, Supervising Scientist Group, Canberra. 119-145.

Finlayson CM & Davidson NC 1999. Summary report. In *Global review of wetland resources and priorities for wetland inventory*, eds CM Finlayson & AG Spiers, Supervising Scientist Report 144, Supervising Scientist Group, Environment Australia, Canberra, 1–13.

Finlayson CM & NC Davidson 2001. Wetland inventory, assessment and monitoring—Practical techniques and identification of major issues: Introduction and review of past recommendations. In CM Finlayson, NC Davidson & Stevenson NJ (eds) 2001a. *Wetland inventory, assessment and monitoring: Practical techniques and identification of major issues*. Proceedings of Workshop 4, 2nd International Conference on Wetlands and Development, Dakar, Senegal, 8–14 November 1998, Supervising Scientist Report 161, Supervising Scientist, Darwin. pp 1-10.

Finlayson CM & Spiers AG (eds) 1999. *Global review of wetland resources and priorities for wetland inventory*. Supervising Scientist Report 144, Supervising Scientist Group, Environment Australia, Canberra.

Finlayson CM & van der Valk AG 1995. *Classification and inventory of the world's wetlands*. Advances in Vegetation Science 16, Kluwer Academic Press, Dordrecht, The Netherlands.

Finlayson CM, Hollis T & Davis T (eds) 1992. *Managing Mediterranean wetlands and their birds*. Proceedings of an IWRB International Symposium, Grado, Italy, February 1991. IWRB Special Publication No. 20, Slimbridge, UK.

Finlayson CM, Davidson NC & Stevenson NJ (eds) 2001a. *Wetland inventory, assessment and monitoring: Practical techniques and identification of major issues*. Proceedings of Workshop 4, 2nd International Conference on Wetlands and Development, Dakar, Senegal, 8–14 November 1998, Supervising Scientist Report 161, Supervising Scientist, Darwin.

Finlayson CM, Davidson NC & Stevenson NJ 2001b. Wetland inventory, assessment and monitoring – Practical techniques and identification of major issues: Summary. In CM Finlayson, NC Davidson & NJ Stevenson (eds) 2001a. *Wetland inventory, assessment and monitoring: Practical techniques and identification of major issues*. Proceedings of Workshop 4, 2nd International Conference on Wetlands and Development, Dakar, Senegal, 8–14 November 1998, Supervising Scientist Report 161, Supervising Scientist, Darwin.

Finlayson CM, Davidson NC, Spiers AG & Stevenson NJ 1999. Global wetland inventory – Status and priorities. *Marine and Freshwater Research* 50, 717–727.

Finlayson M, van Dam R, Walden D & Storrs M 2001c. Risk assessment for managing the tropical weed *Mimosa pigra*. In: *Assessment and Management of Alien Species that Threaten Ecosystems, Habitats and Species*. Abstracts of keynote addresses and posters presented at the sixth meeting of the Subsidiary Body on Scientific, Technical and Technological Advice, Montreal, Canada, 12-16 March 2001. CBD Technical Series No. 1. Secretariat of the Convention on Biological Diversity, Montreal, Canada. pp. 17-19.

Finlayson CM, Howes J, Begg G & Tagi K 2002a. A strategic approach for characterising wetlands – the Asian wetland inventory. Proceedings of Asian Wetland Symposium, Penang, Malaysia, 27-30 August, 2001. (in press).

Finlayson CM, Howes J, van Dam R, Begg G & Tagi K 2002b. The Asian Wetland Inventory as a tool for providing information on the effect of climate change on wetlands in Asia. Workshop on climate change and wetlands, Kushiro, Japan, 20-21 September 2001. In press.

Finlayson CM, Howes J, Begg GW, Tagi K & Lowry J 2002c. A manual for an inventory of Asian wetlands. Asian Wetland Inventory regional workshop, Phnom Penh, Cambodia, 8-9 April 2002. In draft.

Grillas P 1996. Identification of indicators. In *Monitoring Mediterranean wetlands: A methodological guide*, ed P Tomas Vives, MedWet publication, Wetlands International, Slimbridge, UK and ICN, Lisbon, Portugal, 35–59.

Humphrey CL, Bayliss P & Finlayson CM 2002. Possible approach towards developing a wetland inventory, assessment and monitoring scheme in Australia: A case study from the wet-dry tropics. In: *Murugadas TL (Compl) 2002. Proceedings of workshop on developing a proposed framework for a wetland inventory, assessment and monitoring system (WIAMS) in Malaysia (eds. Sundari R, Davies J and Humphrey C)*, Kuala Lumpur, Malaysia, 18-19 April, 2002, Wetlands International – Malaysia Programme (in press)

Matthews GVT (ed) 1990. *Managing waterfowl populations*. Proceedings of an IWRB Symposium, Astrakahn, USSR, 2–5 October 1989. IWRB Special Publication No. 12, Slimbridge, UK.

Mitsch WJ (ed) 1994. *Global wetlands – Old world and new*. Elsevier, Amsterdam.

Moser M, Prentice RC & van Vessem J (eds) 1993. *Waterfowl and wetland conservation in the 1990s – A global perspective*. Proceedings of an IWRB Symposium, St Petersburg Beach, Florida, USA, 12-19 November 1992. IWRB Special Publication No. 26, Slimbridge, UK.

Nivet C & Frazier S 2001. *A review of European wetland inventory information*. Preliminary (incomplete) report prepared in the framework of ‘A Pilot Study towards a Pan-European Wetland Inventory’, a cooperative project between Wetlands International – Africa, Europe, Middle East and the Dutch Institute for Inland Water Management and Waste Water Treatment (RIZA).

Parker AK 2001. *Methods for evaluating wetland condition: Study design for monitoring wetlands*. EPA 822-R-01-007d. US Environmental Protection Agency, Office of Water, Washington, DC.

Phinn S, Hess L & Finlayson CM 1999. An assessment of the usefulness of remote sensing for wetland monitoring and inventory in Australia. In *Techniques for enhanced wetland inventory, assessment and monitoring*, eds CM Finlayson & AG Spiers, Supervising Scientist Report 147, Supervising Scientist Group, Canberra, 44–82.

Prentice RC & Jaensch RP (eds) 1997. *Development policies, plans and wetlands*. Proceedings of Workshop 1 of the International Conference on Wetlands and Development, Kuala Lumpur, Malaysia, 9–13 October 1995, Wetlands International, Kuala Lumpur.

Reid WV 2000. Ecosystem data to drive hard choices. *Issues in Science and Technology* XVI, 37-44.

Thiesing MA 2001. An evaluation of wetland assessment techniques and their applications to decision making. In CM Finlayson, NC Davidson & NJ Stevenson (eds) 2001a. *Wetland inventory, assessment and monitoring: Practical techniques and identification of major*

issues. Proceedings of Workshop 4, 2nd International Conference on Wetlands and Development, Dakar, Senegal, 8–14 November 1998, Supervising Scientist Report 161, Supervising Scientist, Darwin, 87-96.

Tomas Vives P (ed) 1996. *Monitoring Mediterranean wetlands: A methodological guide*, MedWet publication, Wetlands International, Slimbridge, UK and ICN, Lisbon, Portugal.

Tomas Vives P & Grillas P 1996. Techniques for monitoring. In *Monitoring Mediterranean wetlands: A methodological guide*, ed P Tomas Vives, MedWet publication, Wetlands International, Slimbridge, UK and ICN, Lisbon, Portugal, 61–72.

Van Dam RA, Finlayson CM & Humphrey CL 1999. Wetland risk assessment: A framework and methods for predicting and assessing change in ecological character. In *Techniques for enhanced wetland inventory, assessment and monitoring*, eds CM Finlayson & AG Spiers, Supervising Scientist Report 147, Supervising Scientist Group, Environment Australia, pp 83–118.

Van Dam R, Walden D, Begg G & Finlayson M 2001. Ecological risk assessment of the cane toad, *Bufo marinus*, in Kakadu National park, Australia. In *Assessment and Management of Alien Species that Threaten Ecosystems, Habitats and Species*. Abstracts of keynote addresses and posters presented at the sixth meeting of the Subsidiary Body on Scientific, Technical and Technological Advice, Montreal, Canada, 12-16 March 2001. CBD Technical Series No. 1. Secretariat of the Convention on Biological Diversity, Montreal, Canada. pp. 21-23.

Invited Paper No. 3

ASIAN WETLAND INVENTORY (AWI) - A PLANNING AND MANAGEMENT TOOL FOR WETLAND CONSERVATION AND WISE USE THROUGH MULTI-STAKEHOLDER INVOLVEMENT

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Abstract

Reliable knowledge is the basic resource on which all decisions concerning the conservation, management and wise use of wetlands should be made. Inventory, assessment and monitoring are vital components of effective wetland management. A wetland inventory can assist Governments and the public to identify wetlands of national and international importance and serve as a basis for prioritising conservation and development initiatives in conjunction with sustainable management of natural resources.

Although there were numerous recommendations from past conferences on the need for standardization in inventory approaches, Finlayson and Davidson (2001) noted that there is little evidence of implementation of these recommendations.

This paper introduces the Asian Wetland Inventory as an effort to provide a standardized approach to wetland inventory through a hierarchical approach. It briefly reviews the need for wetland inventory and discusses the approaches taken in development of a multiple stakeholder tool for wetland inventory. The hierarchical approach taken in the Asian Wetland Inventory would provide information to assist in the development of conservation actions and policies from regional to site management level.

Introduction

Wetlands represent a large variety of inland and coastal habitats which share a common characteristic: namely land where saturation with water permanently, seasonally, daily or episodically, is the dominant factor determining their ecological character. Wetlands are critically important ecosystems that provide local and globally significant social, economic and ecological benefits. They have a multitude of functions, all of which provide goods and services of inestimable value to society. Wetlands provide many economic and ecological benefits - through wetland products, functions and attributes in the form of fisheries and shellfish, groundwater replenishment, maintenance of water tables for agriculture, forestry and pastoral activities, water storage and flood control, shoreline protection and stabilisation, climate change mitigation, sediment and nutrient retention, water purification, habitats for biodiversity and opportunities for recreation and tourism. They are of cultural and economic importance to many local and indigenous communities.

Although wetlands in Asia support some of the world's most significant biodiversity and are a globally important resource for billions of people, their destruction and degradation continues unabated. In the last 50 years it is estimated that over 60% of all wetlands in the

region have been degraded. With recent rapid population growth in Asia, there are serious water management problems throughout the region. These include diminishing water supplies, water contamination, accelerated erosion and sedimentation, groundwater depletion, flood damage and climate change. According to the Stockholm Environment Institute, 48 countries in the world will suffer from acute water shortages by 2025. With global warming starting to have a significant influence on wetlands (Finlayson *et al.* 2002a) large scale flooding of coastal plains, such as those in China, India and Bangladesh could increase. Thus, improved water management is becoming increasingly essential for preventing or minimizing the consequences of large scale changes in the water regime of wetlands, many of which are already under pressure from other human activities.

Improved management of these habitats will depend upon, in part, the acquisition of reliable knowledge of wetland functions and the ecological processes that support those functions. In fact, reliable knowledge is the basic resource on which all decisions concerning the conservation, management and wise use of wetlands should be made and such knowledge can be collected in a wetland inventory.

Whilst an extensive wetland ‘inventory’ effort has occurred in the past two decades in particular, there has been little agreement on what constitutes an inventory and how (or if) it is distinct from a wetland directory (Finlayson 2001). Finlayson (1996) differentiated between a wetland inventory and a wetland directory as follows: ‘A directory and an inventory are used to compile the same type of information but the former is limited to current information and may not be comprehensive. An inventory generally includes investigative steps to obtain more information and thereby presents a comprehensive coverage of sites’.

Wetland inventory provides a basis for making informed decisions concerning the conservation and wise use of wetlands. A wetland inventory can assist Governments and the public to identify wetlands of national and international importance and serve as a basis to prioritising conservation and development initiatives in conjunction with management of natural resources, in particular, water, fisheries, forestry and development of land for agriculture, industry and human settlement.

The Asian Wetland Inventory (*AWI*) aims to develop a broadly supported standardised inventory protocol that can provide information for the assessment, evaluation and monitoring of wetlands. The *AWI* protocol builds on past inventory protocols that have been successfully developed for use elsewhere in the world (Finlayson *et al.* 1999). It is also based on the recommendations made in the global review of wetland inventory conducted by Wetlands International on behalf of the Ramsar Convention Bureau (Finlayson & Spiers 1999) and supports the provisions used in the Ramsar Convention framework for wetland inventory. In this paper, the need for wetland inventory is once again briefly revisited and role of the *AWI* as a multiple-stakeholder tool for wetland conservation and wise use is discussed.

Inventory, Assessment and Monitoring

Before proceeding further we consider it is important to emphasise that wetland inventory, assessment and monitoring are different processes and require different categories of information. The distinctions between these procedures are often confused. The working definitions provided by Finlayson *et al.* (2001) are used here:

- Wetland Inventory:
 - the collection and/or collation of core information for wetland management, including the provision of an information base for specific assessment and monitoring activities.
- Wetland Assessment:
 - the identification of the status of, and threats to, wetlands as a basis for the collection of more specific information through monitoring activities.
- Wetland Monitoring:
 - Collection of specific information for management purposes in response to hypotheses derived from assessment activities, and the use of these monitoring results for implementing management. (Note that the collection of time-series information that is not hypothesis driven from wetland assessment should be termed *surveillance* rather than monitoring.)

The aim of this workshop is to develop a wetland assessment system (WAS) for Malaysia. Finlayson *et al.* (this volume) proposes a “Wetland Inventory, Assessment and Monitoring (WIAM)” approach be adopted instead of the traditional Wetland Assessment System due to the fact that the latter comprises components of all three steps. However, due to the scope of this paper, discussions will only focus on wetland inventory and the Asian Wetland Inventory.

The Need for Wetland Inventory

The Ramsar Convention on Wetlands promotes wetland inventory as a tool for identifying the functions and values of wetlands, including ecological, social and cultural values. Finlayson & van der Valk (1995) also emphasize the value of wetland inventory for establishing a baseline for measuring future change in wetlands, for identifying their functions and services, for locating where wetlands are and which of these are the priority sites for conservation. Wetland inventory is also required for planning and managing wetlands at both practical and/or political levels and to enable comparisons between wetlands and management procedures to be made at different levels of government (local, national and international). In short, wetland inventory is not an end in itself, but rather an essential step in the decision-making process affecting land use, the conservation of natural resources and water allocation.

At the 2nd International Conference on Wetlands and Development (Dakar, Senegal, 10-14 November 1998), a workshop was held to review past and current projects, and to develop recommendations for further implementation of wetland inventory, assessment and monitoring (see Finlayson *et al.* 2001). Box 1 summarises some of the conclusions of this workshop. It was noted that the importance of wetland inventory and the need for standardised approaches has been called for at various international forums. Finlayson and Davidson (2001) summarized recommendations of some of the major conferences in the past 10 years for improved wetland inventory. The relevant conferences are listed below.

- Managing Waterfowl Populations (Matthews 1990) - IWRB, Astrakhan, Russia (former USSR), 2-5 October 1989
- Managing Mediterranean wetlands and their birds for year 2000 and beyond (Finlayson et al 1992) - IWRB, Grado, Italy, 3-10 February 1991
- Old world and new world wetlands (Mitsch 1994) - Intecol Wetland Conference, Columbus, USA, Sept 1992

- Waterfowl and Wetland Conservation in the 1990s - A global perspective (Moser et al 1993) - IWRB, St Petersburg Beach, Florida, USA, 12-19 November 1992
- International Conference on Wetlands and Development (Prentice & Jaench 1997) - Wetlands International, Kuala Lumpur, Malaysia, 9-13 October 1995
- International Conference on Wetlands and Development (Finlayson et al 2001), Dakar, Senegal, 8-14 November 1998

Although there were numerous recommendations that arose from the conferences above, Finlayson and Davidson (2001) clearly stated there is little evidence that these have been widely implemented. They further noted that the development of methods for the MedWet Mediterranean wetland programme (Tomas Vives 1996) has contributed significantly to standardising techniques etc.

The Global Review of Wetland Resources and Priorities for Wetland Inventory (GRoWI) (Finlayson and Spiers 1999) was commissioned by the Ramsar Convention to assess the current global situation and need for wetland inventory. This can be seen as the first attempt to review gaps and means to audit existing effort and to provide further guidance on standardisation of techniques. GRoWI showed that the existing wetland inventory base was inadequate for assessing the distribution and different types of wetlands, the extent of likely impacts and vulnerability, the role of wetlands in climate change and the loss of wetland related economic and ecological values (Finlayson & Spiers 1999). The outcomes of this review led to renewed calls for standardisation of wetland inventory procedures whilst recognising the many purposes of inventory. This was formalized in resolution VII.20 from the 7th Meeting of the Conference of Contracting Parties of the Ramsar Convention. The Asian Wetland Inventory is one response to this call.

Box 1: Conclusions about wetland inventory at the global level during the workshop at the 2nd International Conference on Wetlands and Development (Dakar, Senegal 1998) (Finlayson *et al.* 2001).

1. There is extensive past, current and planned wetland inventory activity worldwide, but for global purposes the state of wetland inventory is best described as a dismal situation, with information particularly poor in Oceania, South and Central America, Africa, Asia and eastern Europe (although there are notable exceptions in these regions).
2. The coverage of most inventories is restricted (e.g. to only some wetland types, or to important sites only): comprehensive wetland inventory exists for very few countries. Some wetland habitats are particularly poorly covered by existing inventories.
3. As well as the global lack of basic comprehensive national wetland inventory information, wetland loss and degradation has not been adequately assessed, and information on economic values of wetlands has seldom been collected (and where it has is usually inadequate).
4. The purpose and use of wetland inventory activities is often unclear, and leads to over-ambitious and time-consuming wetland inventory programmes that lack focus and that have seldom produced the information required for management purposes.
5. Much of the wetland inventory information collected to date has been largely descriptive, and/or stored in formats which cannot easily be manipulated to provide answers to fundamental questions such as the spatial extent of wetlands and how many wetlands exist.

6. Presentation of inventory data is often poor, and essential information such as the context, aims and objectives, dates, and methods are frequently omitted from inventory documentation and other outputs.
7. There are many different wetland inventory methodologies and techniques in use: a widely accepted basic standardised approach and standardised methodologies are not available. This creates difficulty in comparing information across national and international scales and limits global assessment of wetland extent, status, trends and management.
8. Some standard regional methodologies, notably that developed by MedWet for the Mediterranean region, are available and the MedWet tools are already being adapted for use in other parts of the world - there is good potential for further development of standards derived from MedWet and other available tools.
9. Complex wetland inventory data collection methods (such as information derived from satellite imagery and airborne video techniques) are increasingly frequently utilised, but are not always properly targeted, or used effectively.
10. Insufficient use of allied sources of information (e.g. waterbird, fisheries, water quality and agricultural information bases; and local peoples' information and knowledge) is made in most wetland inventory.
11. Dissemination of wetland inventory data is often very limited, with poor or restricted access, so that it is not readily accessible to those involved in the decision making process: improved access to data management tools, and the establishment of 'clearing house' mechanisms for wetland management information is needed.
12. Although wetland inventory is an essential prerequisite for wetland management, the methods used for most existing inventories will not, if repeated over time, yield monitoring information, since they do not collect the data elements necessary for monitoring.

The Asian Wetland Inventory

The overall goal of the *AWI* is to establish a standardized, systematic and regionally applicable approach to and mechanism for an inventory of wetlands as a basis for sound planning, wise-use, sustainable management and monitoring of wetlands.

As in all wetland conservation and management programmes, the need for an integrated approach has been identified as being absolutely critical for the *AWI*. Since its advent in 1999 (with financial assistance from the Ministry of Environment Japan), the *AWI* has evolved into a regional conservation and development programme. The objectives of the *AWI* project are to provide an Asia-wide standard methodology for wetland inventory. Some of the main outcomes to be achieved through the *AWI* include:

- Increased awareness on the importance of wetlands and the need for a standardised inventory among relevant national government agencies across Asia.
- A dynamic and standardised Geographical Information System (GIS) integrated database providing core data/ information on Asian wetlands to guide and support planning and conservation efforts by national governments, International Conventions, NGOs and others.
- A strengthened network of trained personnel in techniques and skills required for implementation of the *AWI* at national and local level.
- Established national inventory programmes and databases in all participating nations.

- Established network of regional training programmes in wetland inventory
- A monitoring programme for regular revision and updating information on wetlands of national and international importance in Asia.

In terms of geographic coverage, the countries/territories that will be included within "Asia" will include those countries covered in the *Directory of Asian Wetlands* as well as those in Central Asia, Russia eastwards of the Ural Mountains and any countries/territories that fall within a contiguous geographical region (river basins and major islands). Thus, "Asia" is taken to include part or all of the following countries: - Russia (eastwards of the Urals), Japan, P.D.R of Korea, Republic of Korea, Mongolia, China, the Philippines, Vietnam, Cambodia, Lao P. D. R., Thailand, Malaysia, Singapore, Brunei, Indonesia (including West Papua), East Timor, Myanmar, Bangladesh, Bhutan, Nepal, India, Sri Lanka, Maldives, Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, Uzbekistan, Afghanistan, Pakistan, Iran. It also includes some of those countries in western Asia, including Iraq, Saudi Arabia, Oman, Qatar, Kuwait, Bahrain, UAE (United Arab Emirates), Yemen Arab Republic, Yemen, Azerbaijan, Armenia.

The AWI Methodology

A principal purpose of the AWI is to delineate and map the wetland resources of Asia, taking into account wetland habitats from the intertidal zone to the uppermost reaches of all major river basins, and to store this information on a GIS (Finlayson *et al.* 2002b). This exercise is to be undertaken at different scales with the amount of detail being dependent on the explicit purpose of the inventory and the size and importance of the wetland. The first two levels will provide the contextual basis for the inventory and provide the framework for further detailed wetland inventory and assessment. The third level will provide more information on core data attributes of wetland complexes and larger sites, while the fourth level will provide more information at the site/ habitat level. The hierarchy proposed is presented below (and illustrated in Figure 1).

- **Level 1:** Geographic regions with a map at a scale of 1:5 000 000 to 1:1 000 000
A broad-based geographical regionalisation of Asia developed on the basis of river basins. Region wide assessments of geology, land cover and climate will be included.
- **Level 2:** Wetland regions with maps at a scale of 1:1 000 000 to 1: 250 000
A broad, map-based, geographic inventory for each subregion of the identified river basin. On the assumption that wetlands within each subregion will share common characteristics, such as underlying geology, climate and rainfall, this will provide the baseline in which similar wetlands or "complexes" can be identified and categorised.
- **Level 3:** Wetland complexes with maps at a scale of 1:250 000 to 1:50 000
A detailed inventory of specific wetland "complexes" identified within each subregion. As each wetland complex will exhibit different hydrological features, such as rainfall, water flow, regulation and seasonality of inundation, similar information will be collected for all wetlands within a complex.
- **Level 4:** Wetland habitats with maps at a scale of 1:50 000 to 1:25 000
A site specific wetland inventory designed to identify all discrete wetland areas within each complex. Wherever possible, map-based representations will be compiled. Detailed information on each wetland will include ecological units (habitats and biodiversity usage), threats, conservation status, human uses and criteria fulfilled under Conventions.

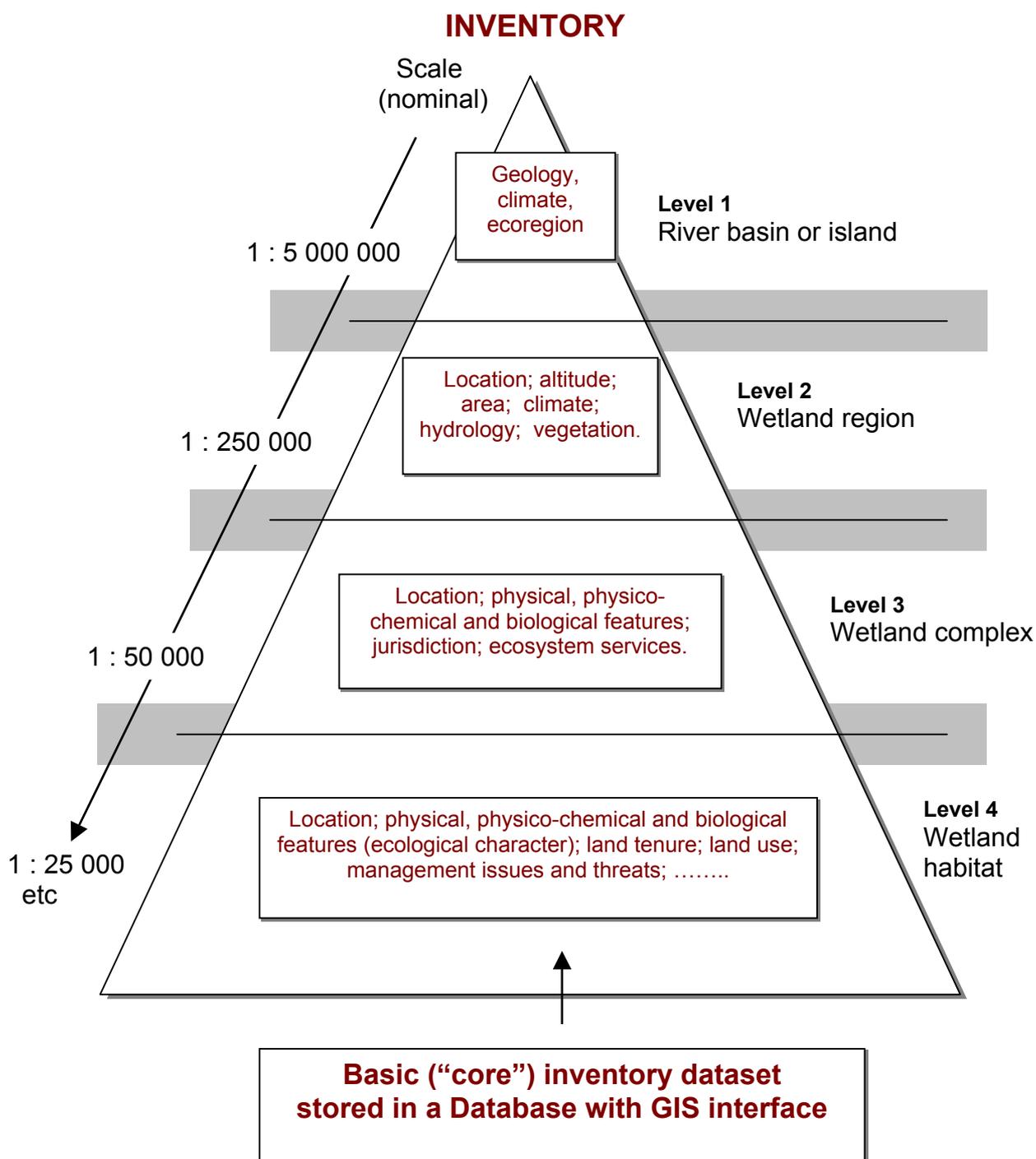


Figure 1: The hierarchical map-based approach used in the Asian Wetland Inventory

The Manual for an Inventory of Asian Wetlands

Guidelines on implementation of inventory using the multi-scalar approach proposed in the AWI are provided in the Manual for inventory of Asian Wetlands (Finlayson *et al.* 2002c). Relevant government implementing agencies and other stakeholders will be able to obtain a copy of the manual through request from Wetlands International. It is also expected that this manual will be made available on the website.

The Asian Wetland Inventory as a multiple stakeholder tool

Reliable information acquired through wetland inventory will enable further assessment and monitoring of wetlands. In the realm of conservation and development, there exist a range of stakeholders with varying level of interest in the information that is required for the wise use and management of wetland resources. For example, the information requirements for wetland management and policy development may differ depending on the remit of the organisations involved. The interest of international organisations and conventions will also differ significantly from site management authorities. Some of the key stakeholders identified for the AWI are listed below.

1. Conventions, organisations and initiatives operating at a global scale
 - a. The Ramsar Convention on Wetlands has recognised wetland inventory is a tool for identifying the function and values of wetlands, including ecological, social and cultural values. It is required for establishing a baseline for measuring future change in wetlands, for identifying their functions and values; for locating where wetlands are, and which are the priority sites for conservation. This has been discussed earlier and formalized through various recommendations and resolutions (namely Resolution VII.20). Information from the AWI will also assist the Convention in providing more accurate and reliable estimates of the status overviews of wetlands.
 - b. The United Nations Framework Convention on Climate Change (UNFCCC) - Wetland inventory can be an important tool to assess the extent of likely impacts and vulnerability of ecosystems to climate changes, evaluate the role of different wetland types in global cycles (e.g. tropical forested peat lands and the vast seasonally inundated savanna plains of Africa, Australia, Asia and South America); and appraise future losses of socio-economic and ecological values on humans and biodiversity.
 - c. Other organizations and global initiatives operating at the global scale that could benefit from the AWI include other environmental conventions, International Development Agencies, the Millennium Ecosystem Assessment (MA), Global International Waters Assessment (GIWA), Man and Biosphere Programme (MaB), Global Peatland Initiative (GPI), Asian Waterfowl Census (AWC) and the Migratory Waterbird Conservation Strategy (MWCS).
2. Organisations and initiatives operating at a regional scale

At the regional level stakeholders that could benefit from the AWI include supra-national organisations concerned with trans-boundary wetland management issues. In Asia an example is the Mekong River Commission (MRC) that is currently looking at conservation and development activities/initiatives in the Mekong region. The AWI is particularly useful given the river basin/ catchment approach that it adopts in undertaking wetland inventory. Whilst wetland inventory in the Mekong basin may be carried out by individual national authorities we anticipate that the information will be useful at a basin-wide scale for further natural resource management.

One of the major environmental issues currently affecting Asia, particularly Southeast Asia is the occurrence of haze resulting from forest fires, including peatlands. The Association of Southeast Asian Nations (ASEAN) is attempting to address this regional problem through implementation of a Regional Haze Action Plan (RHAP). Through the utilisation of remote sensing, the AWI could function as an effective tool for the

inventory of peatlands. This would provide useful information for assessment and monitoring activities that is crucial for wetland management purposes.

3. Organisations and initiatives operating at the national level

At the national level, relevant stakeholders will include identified government agencies responsible for wetland conservation and management, research institutions and non-governmental organisations. The AWI provides a framework for planning and implementing national wetland inventories. Some nations currently host national wetland databases (e.g. Indonesia). The AWI process promotes data collection in a standardised approach. In addition to facilitating the collection of new information (referred to as core data), the AWI will capitalise on existing information that provides the core data for the inventory. The AWI will also function as a stimulus in establishing standardised national wetland databases.

4. Organisations and initiatives operating at the site level.

Stakeholders at the wetland site level include district planning authorities, site management bodies and local people who are directly or indirectly associated with the wetland site. Wetlands provide numerous goods and services (see Table 1), both tangible and intangible. These are not only of local importance, but many goods and services of wetlands are of regional and global significance as well. Level 3 and 4 of the manual will provide standard guidance for inventory at the site level. Based on the information obtained through site level wetland inventory, further assessment and monitoring activities will contribute to sound management of wetlands.

Table 1: Goods and services derived from wetlands

Goods and services	Influence
Climate change mitigation – through regulation of global carbon cycles.	Regional and global
Freshwater supplies – through groundwater/aquifer recharge.	Local and regional
Freshwater supplies & drought relief – through water storage and streamflow regulation.	Local and regional
Means of water transport .	Local and regional
Toxicant removal, water quality improvement & agricultural production – through sediment accretion.	Local and regional
Erosion control, storm protection & coastal defence – through shoreline / bank stabilisation.	Local and regional
Flood peak reduction & erosion control – through flood attenuation.	Local and regional
Water quality improvement – through denitrification, pathogen removal and waste assimilation.	Local and regional
Agricultural (crop) production & pasture production – through impeding drainage of soil.	Local and regional
Energy requirements – through peat formation.	Local
Biological diversity – through food chain support.	Local, regional and global.
Harvestable resources (eg fisheries; timber; reeds etc); recreational opportunities (ecotourism); educational	Local and regional

opportunities (life sciences) & cultural values – through habitat creation and food chain support.	
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Outcomes of the AWI Regional Workshop - Phnom Penh, 8-9 April 2002

The most recent positive development on the Asian Wetland Inventory was the success of the Regional workshop in Phnom Penh. The workshop received active participation from 32 participants from 13 countries. Governments of a total of 8 Asian countries were represented at this workshop. The workshop had the following aims:

- To introduce the need for inventory and the AWI to a wider range of identified stakeholders and to identify stakeholder interest.
- To demonstrate the AWI technical tools and present case studies.

The workshop identified stakeholder interest and the action plans at the country level to progress this initiative. Other key outputs of the workshop included the Phnom Penh Statement on wetland inventory (Annexe 1).

The workshop also recognised:

- The importance of wetland inventory
- The need for standardized methodology and reporting process.
- The identification of multiple stakeholders
- The need to build national/sub-national capacity
- The importance of improving networking amongst government agencies, institutions and other organizations.
- The importance of developing national inventories in national languages
- The need to fine tune the AWI manual based on input from the workshop.
- The need for financial assistance from international and other donors

Conclusion

The AWI is a positive response to the various calls for wetland inventory in particular the Convention on Wetlands. The benefits are not only local or regional but global. Stakeholders have much to benefit and will play an important role in ensuring the success of this effort. Technical guidelines for implementation of the AWI are provided in the manual which is near completion.

The need for active government participation and inter-governmental cooperation is vital to ensure the success of this initiative. In response to the AWI initiative, Malaysia is encouraged to participate in pilot testing the Asian Wetland Inventory approach through national level implementation based on national priorities.

Acknowledgements

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References

- Finlayson, C. M. 1996. *Information required for wetland management in the South Pacific*. **In** Wetland conservation in the Pacific islands region, Proceedings of the regional workshop on wetland protection and sustainable use in Oceania, Port Moresby, Papua New Guinea, June 1994, ed R. Jaensch. Wetlands International – Asia Pacific, Canberra, pp.185-201.
- Finlayson, C. M. 2001. *Considerations for undertaking a wetland inventory*. **In**: C. M. Finlayson, N. C. Davidson & N. J. Stevenson (eds), Wetland Inventory, Assessment and Monitoring: Practical techniques and identification of major issues. Proceedings of Workshop 4, 2nd International Conference on Wetlands and Development, Dakar, Senegal, 8-14 November 1998, Supervising Scientist Report 161, Supervising Scientist, Darwin.
- Finlayson, C. M., Hollis, T. & Davis, T. (eds) 1992. *Managing Mediterranean wetlands and their birds*. Proceedings of an IWRB International Symposium, Grado, Italy, February 1991. IWRB Special publication No. 20, Slimbridge, UK.
- Finlayson CM, Davidson NC, Spiers AG & Stevenson NJ 1999. *Global wetland inventory – Status and priorities*. Marine and Freshwater Research 50, 717–727.
- Finlayson, C. M., Davidson, N. C. & Stevenson, N. J. 2001. *Wetland inventory, assessment and monitoring – practical techniques and identification of major issues: Summary*. **In**: C. M. Finlayson, N. C. Davidson & N. J. Stevenson (eds), Wetland Inventory, Assessment and Monitoring: Practical techniques and identification of major issues. Proceedings of Workshop 4, 2nd International Conference on Wetlands and Development, Dakar, Senegal, 8-14 November 1998, Supervising Scientist Report 161, Supervising Scientist, Darwin. Pp 130-136.
- Finlayson, C. M. & Spiers, A. G. (eds) 1999. *Global review of wetland resources and priorities for wetland inventory*. Supervising Scientist Report 144/ Wetlands International Publication 53, Supervising Scientist, Canberra.
- Finlayson, C. M. & van der Valk, A. G. 1995. *Wetland classification and inventory: A summary*. Vegetatio 118, 185-192.
- Finlayson, C.M, Howes J, van Dam R, Begg G & Tagi K 2002a. *The Asian Wetland Inventory as a tool for providing information on the effect of climate change on wetlands in Asia*. Workshop on climate change and wetlands, Kushiro, Japan, 20-21 September 2001. (in press).
- Finlayson, C.M., Howes, J., Begg, G. & Tagi, K. 2002b. *A strategic approach for characterising wetlands – the Asian wetland inventory*. Proceedings of Asian Wetland Symposium, Penang, Malaysia, 27-30 August, 2001. (in press).
- Finlayson, C.M., Howes, J., Begg, G. W., Tagi, K. 2002b. & Lowry, J. 2002c. *A manual for an inventory of Asian wetlands*. Asian Wetland Inventory regional workshop, Phnom Penh, Cambodia, 8-9 April 2002. In draft.

Finlayson, C.M., Begg, G. W., Humphrey, C. L. & Bayliss, P. (this volume). *Developments in wetland inventory, assessment and monitoring*.

Matthews, G. V. T. (ed) 1990. *Managing waterfowl populations*. Proceedings of an IWRB Symposium, Astrakhan, USSR, 2-5 October 1989. IWRB Special Publication No. 12, Slimbridge, UK.

Mitsch, W. J. 1994. *Global wetlands – old world and new*. Elsevier, Amsterdam.

Moser, M. Prentice, R. C. & van Vessem, J (eds) 1993. *Waterfowl and wetland conservation in the 1990s: A global perspective*. Proceedings of an IWRB Symposium, St. Petersburg Beach, Florida, USA, 12-19 November 1992. IWRB Special Publication No. 26, Slimbridge, UK.

Prentice RC & Jaensch RP (eds) 1997. *Development policies, plans and wetlands*. Proceedings of Workshop 1 of the International Conference on Wetlands and Development, Kuala Lumpur, Malaysia, 9–13 October 1995, Wetlands International, Kuala Lumpur.

Scott, D. A. (compiler) 1989. *A Directory of Asian Wetlands*. IUCN, Gland, Switzerland and IWRB, Slimbridge, United Kingdom.

Scott, D. A. & Poole, C. M. (compiler) 1989. *A status overview of Asian Wetlands*. Asian Wetland Bureau, Malaysia.

Tomas Vives P (ed) 1996, *Monitoring Mediterranean wetlands: A methodological guide*, MedWet publication, Wetlands International, Slimbridge, UK and ICN, Lisbon, Portugal.

Watkins, D. and Parish, F. 1999. *Review of wetland inventory information in Asia*. **In:** C. M. Finlayson & A.G Spiers. 1999. Global review of wetland resources and priorities for wetland inventory.

Annexe 1: The Phnom Penh Statement on Wetland Inventory, 9th April 2002

Wetlands International and the Ministry of the Environment, Kingdom of Cambodia have organised a regional workshop to introduce the Asian Wetland Inventory (AWI) programme in Phnom Penh, Cambodia between 8 and 9 April 2002.

Thirty-two participants including government representatives from Cambodia, China, Lao P.D.R., Malaysia, Philippines, Thailand and Vietnam, the Mekong River Commission, ASEAN Regional Centre for Biodiversity Conservation (ARCBC), Danish International Development Agency (Danida), ICLARM – The World Fish Centre, Swedish International Development Agency (SIDA), World Wide Fund for Nature (WWF)-Indochina, National Centre for Tropical Wetland Research (NCTWR), Australia and Wetlands International participated in the workshop. The workshop was funded by the Dutch Ministry of Foreign Affairs (DGIS) and AEON Foundation.

The workshop aimed to:

1. Introduce the need for wetland inventory and the Asian Wetland Inventory to a wider range of identified stakeholders and to identify stakeholder interest.
2. Demonstrate the AWI technical tools and present case studies.

The workshop recognised:

- The importance of inventories of wetlands, as an important information base for the wise use and conservation of wetlands.
- The need for standardized methodology and reporting process for wetland inventory.
- The identification and involvement of multiple stakeholders and users of inventory information.
- The need to build national/sub-national capacity to implement wetland inventory and ensure long-term sustainability of inventory activities at the national level.
- Importance of improving networking amongst government agencies, institutions and organisations concerned with biodiversity and wetland inventory and management, to facilitate access to available information and technologies.
- The importance of developing national inventories in national languages to ensure greater accessibility and ownership.
- The manual for inventory on Asian wetlands needs to be fine-tuned to incorporate suggestions and input from the workshop.
- The need for financial assistance from international and other donors to implement national inventories, including training and capacity building.

The workshop requested for Wetlands International to complete the manual and to take steps to formally accept the Asian Wetland Inventory as a regional approach for wetland inventory.

Wetlands International and its partners aim to respond to requests on a case-by-case basis to provide:

- Additional information on the AWI and linkages to other wetland/biodiversity inventory initiatives.

- Assistance in review/development of proposals for implementation of national wetland inventories.
- Advising on potential funding sources to implement the AWI at the national level.
- Technical advice and skills required to undertake the development and implementation of the inventory at the national/sub-national level.
- Technical advice required to develop and undertake demonstration of the AWI model at the pilot scale.
- Assistance in implementation the AWI at the national/sub-national level or river basin level.

TECHNICAL SESSION II – Wetland Inventory, Assessment and Monitoring – possible approaches and tools

Invited Paper No. 1

WETLAND ASSESSMENT SYSTEM IN CHILIKA LAGOON, INDIA- A CASE STUDY

Ajit K. Pattnaik

Chilika Development Authority

Introduction

Chilika is the largest lagoon along the east coast of India, situated between latitude 19° 28' and 19° 54' N and longitude 85° 05' and 85° 38' E. The Lagoon is a unique assemblage of marine, brackish and fresh water eco-system with estuarine characters. It is one of the hotspot of biodiversity and shelters a number of endangered species listed in the IUCN red list of threatened species. The lagoon is an avian grandeur and the wintering ground for more than one million migratory bird and is a Ramsar site. The highly productive eco-system of the lagoon with its rich fishery resources sustains the livelihood of more than 0.15 million-fisher folk who live in and around the lagoon. Some of them live at the subsistence level.

Threats and management issues

Zoological Survey of India, while comparing the baseline data from the pioneering studies on Chilika done during the year 1915 to 1924, with the data generated by way of extensive survey carried out by them after 60 years i.e during 1985-87, concluded that the lagoon ecosystem is tending towards a fresh water ecosystem and warrants urgent restoration measures. The lagoon had been encountering the problems like – siltation, shrinkage of area, choking of the inlet channel as well as shifting of the mouth connecting to the sea, decrease in salinity, proliferation of invasive fresh water species, decrease in fish productivity, various anthropogenic pressure and an over-all loss of biodiversity. Due to the change in the ecological characters of the lagoon, it was placed in the montreux record in the year 1993.

Restoration measures

As per the recommendations of CWPRS, Pune, based on their model studies a new mouth of 100M width and 2.5M below the lowest lagoon water level was opened on 23rd September 2000. Considering the sensitive ecosystem of the lagoon before the intervention the environment impact assessment was carried out by National Institute of Oceanography, Goa, and after the opening they carried out the monitoring of the lagoon to assess the

impact on the lagoon ecosystem. The other restoration measures taken were the treatment of the catchment in a participatory manner on a micro watershed basis, restoration of Nalabana bird Sanctuary and improvement of its habitat with the active participation of the community. Awareness and environmental education, development of a visitor center. Improvement of the communication network and a research centre on wetland management.

Monitoring and assessment

Wetland functions are defined as a process or series of processes that take place within a wetland. "While wetland functions are natural processes of wetlands that continue regardless of their perceived value to humans, the value people place on those functions in many cases is the primary factor determining whether a wetland remains intact or is converted for some other use" (National Audubon Society, 1993). The development of a single method for assessing the functions of wetlands or for assigning values to the functions of wetlands is not a simple task; indeed, probably no single method will perhaps satisfy all the needs. However, assessing each function of a wetland and then assigning a value to each function helps in understanding a wetland system for its better management. Furthermore, an evaluation system that provides the basis for comparing wetlands would facilitate mitigation for unavoidable wetland losses. It would also provide a tool for determining the success (or failure) of various interventions intended to protect or restore the wetland resources. In any management operation monitoring is an essential part of the process of evaluating the effectiveness of the strategies employed. In wetlands it involves the repetitive assessment of the status of various attributes of the wetland ecosystem, which is then compared with baseline for evaluation. It is used to detect environmental impacts and to assess the effectiveness of mitigation measures. The design of monitoring programmes is extremely important to ensure that the information obtained can provide a meaningful evaluation. The inclusions of an adequate baseline and/or control (reference) data are essential elements of a monitoring programme.

In case of Chilika no structured assessment approach is being followed rather it is a combination of studies conducted to generate the baseline information and monitoring to assess the effectiveness of the various interventions made to restore its ecosystem.

Hydrological modelling

The salinity level of the lagoon was observed to be decreasing alarmingly due to the choking of the inlet channel and the opening to the sea, which was affecting the exchange of water between the sea and the lagoon. The unique spatial and temporal salinity gradients that exist in Chilika give it the unique characteristics of an estuarine eco-system, exercising a continuous selective influence on its biota. To address this problem, CDA commissioned the services of the premier institutes of the country like National Institute of Oceanography (NIO), Goa to do the detail study of the wave climate of the inlet, long shore sediment transport along the shore, bathymetry of the inlet channel. The services of Central Water and Power Research Station (CWPRS), Pune was commissioned for the hydrological and two dimensional mathematical model studies. From the findings of their model studies, they concluded that the tidal influx into the lagoon was being considerably reduced because of the shoal formation along the inlet channel, continuous shifting of the inlet mouth that was 32 kms from the lake proper, resulting in significant hydraulic head loss. So they recommended that a straight cut should be made to bring the mouth closer to the lagoon by

18 Kilometers by which there will be improvement of tidal flux by 45% and salinity flux by 40%.

Hydrobiological monitoring of the lagoon

Hydro geomorphology is perhaps the most dominant factor governing the ecological process and functions of a wetland. A hydrologic modification affects both the biotic and many a biotic factors. Changes in the hydrological regimes, particularly during last few decades seem to be the root-cause for the degradation of the lagoon ecosystem. Hydrologically, Chilika is influenced by three sub systems viz. Mahanadi delta, western catchment and Bay of Bengal. The constructions of the hydraulic structures within the Mahanadi river basin are responsible for the alteration in the flow pattern in to Chilika. This has significantly changed the flushing pattern and affected the natural recruitment of biological species through the opening to the sea and the river flowing in to the lagoon. The reduction in the velocity and volume of water accelerated siltation within the lagoon as well as in the inlet channel and it's mouth. Within the World Bank funded Orissa Water Resources Consolidation Project (WRCP) a barrage across the Kathajori branch of the Mahanadi River, is proposed to replace the present Naraj weir. So to ascertain the adequate environmental flow to the lagoon under WRCP a hydro biological monitoring is carried out by Chilika Development Authority in collaboration with the Wetlands International South Asia with a river basin approach to understand the changes in the hydrological regimes, water quality and biota with respect to the change in the flow pattern from the river basin and the catchment. The degradation of the western catchment due to the changes in the land use pattern is responsible for the silt flow to a tune of .617 million tones. Other consequences is water logging resulting in the submergence of the paddy fields in northwestern periphery of the lagoon leading to crop loss affecting the livelihood of the people. The objectives of the monitoring programme was as follows: i) identify key hydrological parameters and install equipments to monitor changes of these parameters on a long-term basis. ii) identify high erosion prone areas of the catchment. iii) to monitor the water quality of the lagoon and assess the impacts of changes in hydrological regimes on water quality. iv) develop hydrological model based on inflows, outflows, hydro period, water balance and other key hydrological factors to predict changes in hydrological regimes. v) determine the effectiveness of various management interventions on Chilika Lagoon, particularly with reference to salinity gradient. vi) monitor the biodiversity of the lagoon.

Close monitoring of the lagoon

Considering the fragile ecosystem of the Chilika lagoon, a close monitoring of the lagoon is carried out to assess the impact of various management interventions on the lagoon, at an interval of thirty days from 30 fixed stations covering all the four ecological zones. The monitoring programme commenced from 1996. Hydro physical parameters monitored are watercolour, atmospheric and water temperature, water depth, transparency and total suspended solids. Hydro chemical parameters like pH, Alkalinity, Conductivity, Salinity, hardness (Ca^{+2} & Mg^{+2}) dissolved oxygen, Biological Oxygen Demand (BOD), Sodium, Potassium, Nitrate, and ortho-phosphate were monitored. For sediment the parameters monitored are pH, conductivity, organic carbon, nitrogen, sodium and potassium. The total suspended solid and the parameters like, pH, alkalinity, Nitrate, and ortho-phosphate of the water samples from 52 rivers/rivulets draining in to the lagoon are also analyzed.

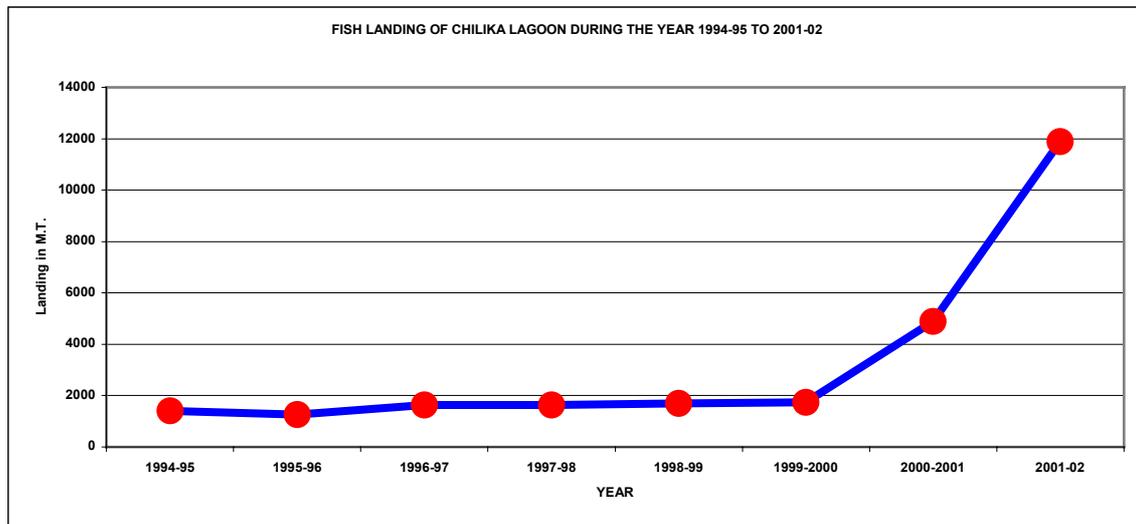
Assessment of phytodiversity

An extensive phyto-diversity survey was carried out for collection and identification of the hydrophytes, island plants and shore line plants(littoral zone) of Chilika. 720 numbers of higher plants were collected and identified from the lagoon. Besides phytoplankton, algae, pteridophytes, and grasses were also collected during phyto diversity survey. Island wise enumeration of the vegetation, with intensive ground truthing by use of total station and G.P.S. Ratio of vegetated areas to open water, number of plant species , biomass. Gross Primary Production (GPP) and Net Primary production (NPP) of phyto plankton is carried out every month in all four ecological sectors of the lagoon. From the monitoring it was revealed that the islands of the lagoon without habitation are the excellent sites for speciation. The other interesting out come were occurrence of the interesting species like *Cassipourea ceylanica*, *Macrotyloma ciliatum*, *Neptunia triquetra*, *Halophila ovalis*, *H.beccarii*, *Ruppia maritima*, *Najas graminea*, *N.minor*, *Potamogeton octandrus*, *P.crispus*, *Diplachne fusca* etc. which were reported only from Chilika lagoon and not found in any other locality of Orissa (the province where the lagoon is located).

Monitoring of the fish landing and fish stock assessment

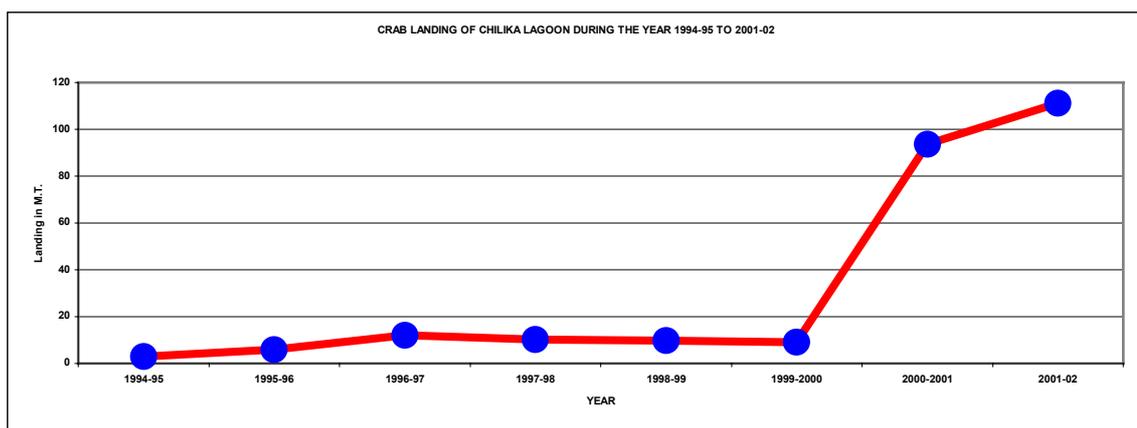
The species composition of fish in Chilika lagoon is complex in the sense that it includes fresh water, brackish, marine as well as the catadromous and anadromous species, this is due to the salinity gradient of the lagoon. A large percentage of the commercial fish species are migratory (either catodromous or anadromous). Jhingran (1963) estimated that 63-75% of the annual fish production was contributed by migratory species. The siltation leading to the choking of the outer channel is resulting in the decrease in salinity and obstruction of the migratory route of the fish. This is one of the reasons for decline of the fishery resource. The total fish landing on an average was 6,000 metric tons during 1980s where as the fish landing during 1997-98 declined to mere 1641.5 metric tons. (Source - fishery and animal resource development dept Govt of Orissa). This decline can be attributed to the composite factors like over fishing beyond carrying capacity, obstruction of migratory route of economic species (due to chocking of mouth and outer channel), juvenile poaching, and encroachment for shrimp culture etc. Fish landing information is collected from all the four sectors of the lagoon, which includes, fish, prawn and crab composition, spatial distribution and landing information including the craft and the fishing gears used for the fishing. For collection of the annual and the seasonal fish landing, sampling of the boat at the landing center, collection of market arrival data from island villages, consumption by active fisherman, local sale of fish and shrimp in small unit in village market are carried out. The gradual reduction in the salinity from the lagoon mouth to the lagoon interior after the opening of the mouth is providing the desirable sense of direction for the eurohaline forms to enter into the lagoon from the sea. This is facilitating the auto-recruitment of the fish, prawn and crab juvenile in to the lagoon. After opening of the new mouth, the distance between the lagoon and the opening to the sea is decreased by 18 km (the distance between old mouth and new mouth) this is facilitating the migration of the catadromous and anadromous species in to the lagoon. As against the annual average fish landing of 1600 metric tons, recorded during the past six years, the fish landing during the year 2000-2001 improved to 4889.21 MTs and the seven months landing after the opening of the new mouth i.e., from October 2000 to March 2001 alone was 3718.44 metric tons. From April 2001 to March 2002 the fish landing is recorded to be 11877.81 M.T, which indicates a significant improvement over the previous year. During the year 2001-2002, from April to

March 2002 i.e. within one year the landing is recorded to be 11,877.81 metric tones, which is all time high record production in the history of Chilika.



Crab landing:

The crab landing was recorded to be 79 metric tons during 1985-86 but it decreased sharply to 3 metric tons during the year 1994-95. After the opening of the mouth i.e. during the year 2000-01 due to the abundant recruitment of the crab juvenile into the lagoon the crab landing touched 93.54 MTs, which is the all time high for past one decade, during the month of January, February & March, 2001, the crab landing was to a tune of 9.9, 23.61 MT & 41.13 M.T. The crab landing during 2001 i.e., from April 2001 to March 2002 is 111.07 M.T.



Application of remote sensing and GIS

“Geomorphological Studies in and around Chilka Lake and its Environs using high-resolution satellite data”

The issues related to management of natural resources development involving complex decision can be tackled by remote sensing and Geographical Information System (GIS). remote sensing technology contemplates collection of spatial, spectral and temporal data of earth's surface using air and spacecraft. Data acquired from these satellites are being used for various applications like monitoring of ocean parameters, mapping of land features and understanding the earth's dynamic processes in exploration and exploitation of natural resources. Indian Remote Sensing satellites IRS-1A and 1B have provided excellent information earlier and are being used for different applications by various users. The recent satellites IRS1C/1D, and IRS-P4 with their improved spatial resolution, spectral range and increased repetivity provide significant information for ocean and coastal related studies. Merging of PAN and LISS-III data has a tremendous promise for delineating land features and mapping in finer scale. Geographical Information System (GIS) is an information system that is designed to work with data referenced by spatial or geographical co-ordinates. The other advantage of this tool is that large extent of the area which are in assessable can be monitored by this technique.

This tool was used for comparing the changes and transformations in the land use and land cover in the catchment during past one decade i.e. the year 1991 and 2001. Preparation of the geomorphology maps. Preparation of the watershed management plan.

Assessment and classification of the aquatic vegetation (macrophytes) by use of remote sensing tool and generation of classified aquatic vegetation map

The remote sensing tool was found to be very handy to assess the extent of spread of aquatic macrophytes in the lagoon, their distribution pattern, abundance and seasonal variation. For the species wise classification of the macrophytes in the Chilika the digital data of Indian Remote Sensing Satellite (IRS) 1D LISS III was used with a spatial resolution of 23.5m. The repeat coverage happens every 24 days. The digital data indented from the National Remote Sensing Agency (NRSA), Hyderabad were imported into the system using ERDAS imagine image processing software. The data were geo-rectified and both the scenes were mosaiced and the landmass of the islands were masked out before classifying the hydrophytes. The classification was done using ERDAS imagine Software. The digital data generated were analysed for generating the vegetation map of the hydrophytes, the twenty classes were finally grouped into four broad groups i.e. i) the emergent species ii) free floating iii) submerged-I (Potamogeton pectinatus, Halophilla beccari) iv) submerged-II (Najas, Hydrilla, vallisseria, potamogeton nodosus, potamogeton crispus, potamogeton octandrus). By use of the imagery of the different season like post monsoon, summer and winter the weed spread area during different season was assessed. The analysis was done to understand the seasonal dynamics , the impact of various physico chemical parameters on the macrophytes etc.

Type of Weed	Before Opening of new mouth	After Opening of new mouth
Emergent	86.07	71.62
Free Floating	110.74	51.81
Submerged	326.22	227.67
Weed free area	333.82	505.82
Total	856.83	856.83

Habitat evaluation of Chilika lagoon with special reference to the birds as a bioindicators

The Bombay Natural History Society being sponsored by the Chilika Development Authority with the following objectives is carrying out a long term monitoring of the avifauna of Chilika lagoon:

- i) To monitor and assess the species-wise population of waterfowl and waders in different sectors of the lagoon and their relationships with habitat factors.
- ii) To study the population dynamics of migratory species using bird-banding techniques.
- iii) To prepare the complete checklist of birds of lagoon.
- iv) To document the endangered, endemic and vulnerable species and their conservation needs.
- v) To establish the co-relation between birds congregation and the benthic flora and fauna, aquatic flora and fauna, and physico-chemical parameters.
- vi) To suggest habitat improvement measures for the Nalaban sanctuary.
- vii) To suggest the effective environmental education and awareness programme for the stakeholders and other groups including the programme for the school.

Economic Valuation of Chilika lagoon

It is proposed to do the economic valuation of the lagoon in collaboration with the Wetlands International South Asia with the following objectives:

- i) Assessment of economic contributions of products, functions and attributes of Chilika lagoon to evaluate the ecological and economic benefits derived from the wetland.
- ii) Assessment of community dependence and resource linkages of stakeholder groups and optimizing resource use.
- iii) Evaluate the impacts of developmental activities and ecological interventions on livelihood security and sustainability
- iv) Develop strategies for ecologically and economically efficient resource management with emphasis on livelihood security of local communities .

Community consultation

Since more than 0.12 million people depend on the lagoon, while formulating the management plan stakeholders consultation is done by holding village level meeting, the suggestions and the recommendations are incorporated in to the management action plan. The linkages with the community through the village level institutions, women self help groups, Community based organizations, networking of the NGOs is a mandate of the CDA. The treatment of the catchment is being done with an objective to facilitate a community based co-management strategy, for an integrated terrestrial and aquatic resource management programme with major emphasis, on the capacity building at the community level through series of training and exposure visit, to pave the way for preparation of the micro plan blended with indigenous knowledge, for optimum utilization of the natural resources to increase the productivity. The watershed community also shares the part of the cost of the treatment. This is also creating an enabling situation for the local community to take decision and to understand the problem in a better manner. A bimonthly newsletter in local (Oriya) language is published in collaboration with a local NGO, the basic objective of the newsletter is to explain to the community about how the wetland function, it's interaction with their surroundings can benefit the society. It contains most of the articles by the community who are encouraged to come up with the local issues. It also contains the articles on wise use and good practices.

Conclusion

Wetlands have come under intensive scientific study only during the last two decades. Techniques of wetland evaluation will improve as scientists gather more information about the processes that take place in wetlands and about the similarities and differences among the functions of different types of wetlands. In order to develop public support and to encourage enlightened policy decisions and regulations, it is critical to create and maintain a database of wetland characteristics in which the data are reliable, comparable, and repeatable at periodic intervals in order to monitor long-term trends. More than one approach to wetland evaluation is possible, as is done in case of Chilika.

Invited Paper No. 2

TOWARDS DEVELOPING A WETLAND INVENTORY, ASSESSMENT AND MONITORING SCHEME IN AUSTRALIA: CASE STUDIES FROM THE WET-DRY TROPICS

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ABSTRACT

Our concept of a wetland inventory, assessment and monitoring scheme (WIAMS) uses the working definitions of these terms adopted by the Ramsar Convention on Wetlands. While Australia has not yet developed a national WIAMS, a framework is available through the Asian Wetland Inventory (AWI) and Ramsar inventory schemes. The AWI is developing a four-tiered hierarchical landscape approach to inventory, from river basins, to wetland regions, to wetland complexes, to wetland habitats. We extend this hierarchical approach to assessment and monitoring, recognising that different levels of detail are required depending upon whether broad-scale or site-specific assessments are required. This complements analogous scalar approaches to monitoring and assessment that consider timeliness of data gathering and reporting, and the degree of ecological relevance of data – concepts also supported by a Ramsar resolution on ecological risk assessment, incorporating early detection capability.

We present case studies from the wet-dry tropics of northern Australia, applying our concept of a WIAMS, operating at different spatial scales and for selected pressures that may potentially affect wetlands within the Alligator Rivers Region, including Kakadu National Park. At the smaller, point-source scale, assessments of potential impact arising from uranium mining are discussed. At a broader scale, we demonstrate assessment approaches that must be considered for migratory or mobile species and which have been applied to pressures such as climate change, fire and invasive plants and animals, that operate on a wide front across the broader landscape.

Introduction

Wetlands in Australia: Inventory and Classification

The Ramsar Wetlands Convention defines wetlands as:

Areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish, or salt including areas of marine water, the depth of which at low tide does not exceed 6 metres.

This all-encompassing definition has attracted a large amount of debate and dissatisfaction within Australia and internationally (see discussion in Finlayson 1999a). However, it must be recognised that any definition must suit the needs of the users. Therefore, the Ramsar

definition has gained greater acceptability with appropriate qualification. This was the approach adopted in the Asian Wetland Inventory (Finlayson et al 2002a) where wetland delineation in this important programme did not extend to the truly marine wetlands included with the Ramsar definition.

The first major inventory of Australian standing waters was undertaken by Paijmans et al (1985). As summarised by ANZECC & ARMCANZ (2000), the work of Paijmans and co-workers clearly indicated that permanent freshwater lakes (>1 m deep) and permanent freshwater swamps (<1 m deep) are restricted to southwestern and southeastern Australia and predominantly coastal regions in eastern and northern Australia. Intermittent freshwater swamps are widespread in eastern and northern Australia while episodic freshwater lakes (mostly dry) are a feature of inland regions. Williams (1983) noted that the outstanding feature of standing waters in Australia was the lack of deep, permanent lakes and the commonness of ephemeral waters.

Further wetland inventory has occurred within Australia with the publication of a directory of important wetlands, now in its 3rd edition (Environment Australia 2001). While the 3rd edition has certainly increased our understanding of Australian wetlands, the comments made earlier by Spiers and Finlayson (1999) about the 2nd edition (Phillips 1996) are still relevant in that there are many gaps and as yet there is no comprehensive analysis of these wetlands. The latter was also pointed out by Watkins (1999) when quantifying the number and area of wetlands in Australia as part of an international assessment of wetland inventory. The wetland areas cited in the 2nd and 3rd editions (see information from the 3rd edition below) should only be seen as an indicative and lower figure. Many wetlands are not included, particularly from northern Australia where, despite a valued wetland resource, effective wetland mapping and inventory is far from complete.

Because they are dynamic systems with water levels changing throughout the year from completely dry to flooded, and with plant and animal communities changing in response, wetlands have been difficult to manage. This dynamic nature often makes it difficult to apply a single, all-encompassing definition, yet defining and classifying wetlands has become increasingly important because accurate description is needed to ensure protection and conservation of wetland habitats (ANZECC & ARMCANZ 2000). Finlayson (1999b) has recommended the adoption of a classification based on the fundamental features of a wetland – the water regime and the underlying landform. Semeniuk & Semeniuk (1997) have developed such a scheme for inland wetlands while further analysis is required for coastal wetlands. Regardless, the Asian Wetland Inventory is proposing that wetlands are classified by such fundamental features and that the information upon which a particular wetland scheme can be developed is collected as part of the core data for the inventory.

The status of Australian, including northern tropical, wetlands

ANZECC & ARMCANZ (2000) summarise the status of Australian wetlands generally. The first national State of the Environment Report (DEST State of the Environment Advisory Council 1996) recognised that Australia has a wide variety of wetlands, many of which have unique features and are of high ecological value. On the basis of six criteria, Environment Australia (2001) listed 851 wetlands of national importance in Australia representing an area of approximately 57 829 522 ha. Fifty six of these wetlands are presently listed as Wetlands of International Importance under the Ramsar Convention. Since European settlement of Australia, many wetlands have been lost primarily by

draining or infilling to create dryland for agriculture or urban development. A recent scoping review by Bunn et al (1997) noted that of the wetlands that remain many have been degraded by a variety of impacts including changes in water regime, modification of habitats, a variety of pollutants including eutrophication and salinisation, and invasion by weeds and feral animals.

Wetlands in northern Australia are considered valuable and in comparison to those elsewhere in Australia, are also considered to be generally intact and in good condition (Storrs & Finlayson 1998, Finlayson et al 1998). We do not contend that this general impression is wrong, but we caution against an overly optimistic view and stress that wetlands in northern Australia are in need of greater attention (Finlayson 1995, Finlayson & Rea 1999). One common response to such concerns has been the development of wetland policies by provincial governmental agencies (Government of Western Australia 1997, Parks & Wildlife Commission of the Northern Territory 2000, Queensland Department of the Environment 1996). Further, local communities and non-governmental organisations have taken an increased interest in wetland management and policy.

General analyses and reviews over the past two decades have identified a suite of pressures faced by wetlands in northern Australia (see Finlayson et al 1998). These reviews have focussed mainly on biophysical pressures that are or are likely to affect the ecological condition of the wetland. More recently some attention has been diverted towards the underlying or socio-economic reasons behind these pressures (Finlayson & Rea 1999).

The major biophysical pressures upon northern wetlands include invasive species, hydrologic modification, clearance and drainage, over-harvesting, and pollution (Bunn et al 1997) with some attention also being given to climate change (Bayliss et al 1997, Eliot et al 1999). These issues have been explored in many site-based analyses and comprehensive databases exist for some (Storrs & Finlayson 1998), whilst others are only now being assessed in a systematic manner (eg invasive cane toads – van Dam et al 2002, the weed, *Mimosa pigra* – Finlayson et al 2001b, environmental flows – Begg et al 2001). It is anticipated that further attention will be directed towards invasive species and environmental allocation of water for wetlands. There is increasing recognition that hydrological regulation of rivers will have a major impact on many northern wetlands, as it has elsewhere in Australia.

Finlayson & Rea (1999) contend that in addition to addressing the apparent and highly visible biophysical causes, the underlying and less visible causes must be addressed. These include: lack of public and political awareness of wetland values; lack of political will for wetland conservation and restoration; over-centralized planning processes; historical legacies of land tenure and use; and sectoral organisation of decision making. The extent to which these causes operate within northern Australia has not been specifically assessed.

Objectives of this paper

The increasing attention being directed at wetland inventory, assessment and monitoring in recent years, at national and international levels, is in response to support required for the concept of wise use and effective management of wetlands. For this, Finlayson et al (2002a) describe international developments towards a holistic wetland inventory-assessment-monitoring scheme (WIAMS) for wetland management through the provision of accurate and reliable information. While Australia has not yet developed a national

WIAMS, a framework for doing this is potentially available through the Asian Wetland Inventory (AWI) and Ramsar inventory framework.

In an accompanying paper, we show how the AWI's hierarchical landscape approach to inventory may be extended to assessment and monitoring, recognising that different levels of detail are required depending upon whether broad-scale or site-specific assessments are required (Finlayson et al 2002a). In this paper, we expand upon our concept of a WIAMS by way of case studies arising from the wet-dry tropics of northern Australia. In these case studies, we apply a WIAMS to different spatial scales and for selected pressures that may potentially affect wetlands within Kakadu National Park – a location with world-renowned intrinsic natural (including biodiversity and conservation) and cultural values. Through these case studies, relevant to (i) assessment of potential impacts of mining upon streams and wetlands, and (ii) waterbirds, we aim to demonstrate:

- the interdependence of wetland inventory, assessment and monitoring for effective management;
- the value in gathering such information under a multi-scalar (hierarchical) framework for each of the inventory, assessment and monitoring components;
- study design considerations, including limitations, when gathering information under a multi-scalar framework; and
- lessons that may be gained in developing and applying a WIAMS more generally in Australia.

A model for a multi-scalar approach to wetland inventory, assessment and monitoring

Working definitions of the terms inventory, assessment and monitoring are reported by Finlayson et al (2001a):

Wetland Inventory: the collection and/or collation of core information for wetland management, including the provision of an information base for specific assessment and monitoring activities.

Wetland Assessment: the identification of the status of, and threats to, wetlands as a basis for the collection of more specific information through monitoring activities.

Wetland Monitoring: Collection of specific information for management purposes in response to hypotheses derived from assessment activities, and the use of these monitoring results for implementing management.

Finlayson et al (2002a) describe the relationships between these components, and the scope of activity for each of these as separate elements of the management process. They provided a concept for a multi-scalar, wetland inventory, assessment and monitoring scheme, reproduced here in Figure 1. The concept acknowledges that inventory, assessment and monitoring are more often interrelated, with a particularly strong feedback loop between monitoring and assessment – indicated in Figure 1. Each component will often require information gathered at different scales. Where put into practice, this interrelated, multi-scalar concept would be termed, a Wetland Inventory, Assessment and Monitoring Scheme, or 'WIAMS' (Finlayson et al 2002a).

Finlayson et al (2002a) described two roles for assessment and monitoring that may be required at broad scales:

1. evaluation of larger, landscape level features or effects, and/or
2. provision of assessments over catchment, regional or larger scales.

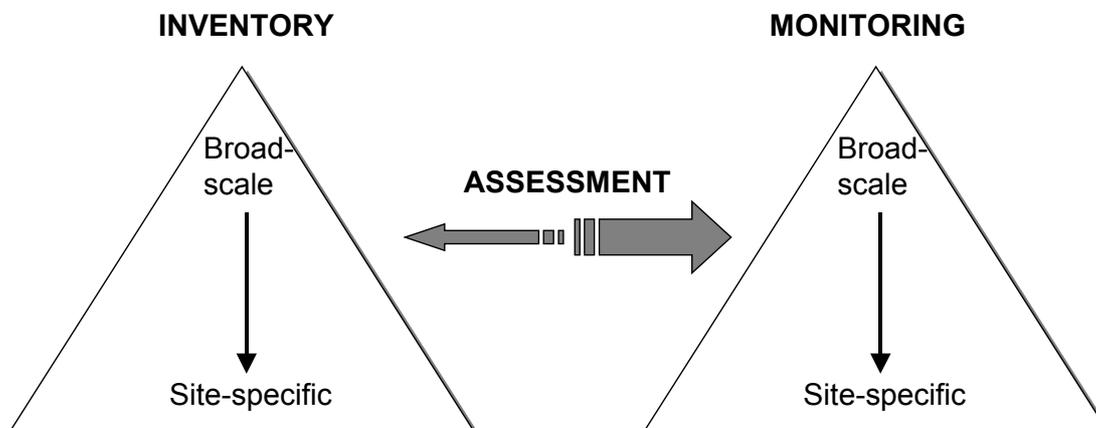


Figure 1. Concept of a multi-scalar, interrelated wetland inventory, assessment and monitoring system. (From Finlayson et al 2002a)

In the former case, there may be a requirement to assess and monitor ecosystem to habitat-level features (eg retreat of a wetland boundary) or alternatively, landscape-level effects resulting from wetland loss and fragmentation, climate change, fire, or invasive species. In the second case, assessments over broad scales – typically as part of national or regional assessments, audits and reporting – may be the subject of management focus. A summary of where broad- and site-specific assessment and monitoring may be applied, as well as attributes and examples of any techniques applied across this spatial spectrum, are provided in Table 1. A number of these applications and examples will be discussed in the case studies below.

Table 1. Comparison of assessment and monitoring at broad- and site-specific spatial scales

Spatial scale	Applications	Attributes	Examples
Broad-scale	<ul style="list-style-type: none"> • Ecosystem to habitat level • State of Environment • Land & water audits • Remediation at large scales • Diffuse-source pollution • Screening of sites • Migratory species • Landscape-level pressures 	<ul style="list-style-type: none"> • Quick • Low cost • ‘First-pass’ data • Higher taxonomic orders 	<ul style="list-style-type: none"> • Remote sensing (land cover, change detection) • Rapid biological assessment • Large-scale maps for planning & management (eg land capability assessment)

	<ul style="list-style-type: none"> • Resource integration • Biodiversity, conservation (contextual)
Site-specific	<ul style="list-style-type: none"> • Specific sites e.g. point-source • Detecting subtle or obscure impacts • Screening for biodiversity, conservation values • More detailed • More quantitative • Lower taxonomic orders (e.g. species-level) • Remote sensing (change detection) • Detailed assessments • Monitoring wetlands of international importance (eg Ramsar, World Heritage)

Wetland inventory, assessment and monitoring conducted in the Alligator Rivers Region

The Alligator Rivers Region

The Alligator Rivers Region (ARR) of tropical northern Australia incorporates Kakadu National Park, an area renowned for its rich cultural and natural heritage values. Ecosystems of the Park are recognised under international conservation conventions including World Heritage listing, and the Ramsar Wetlands Convention. The ARR also contains economically-important mineral reserves, including uranium, which has been mined and milled in the Region since 1979. Concern about environmental impact of mining led the Australian Federal Government in 1978 to enact environmental protection legislation specific to the Region. The Office of the Supervising Scientist for the ARR and the Environmental Research Institute of the Supervising Scientist (*eriss*) were established to ensure protection of the environment. Programmes of research and monitoring have been established in the Region, focusing on the avoidance of detrimental changes resulting from mining in relatively unmodified World Heritage ecosystems (Humphrey et al 1999). Apart from research activities associated with mining, *eriss* is also a partner of the National Centre for Tropical Wetland Research (NCTWR), a consortium that in part, conducts general research that may assist in the sustainable use and management of tropical wetlands (www.nctwr.org.au).

Another Australian Federal agency, Parks Australia North (PAN), and Aboriginal landowners jointly manage Kakadu National Park. Management directions for Kakadu National Park are largely established in the 4th Plan of Management (1999-2004), which includes national and international obligations (eg lease agreements with Aboriginal landowners, maintenance of World Heritage values, Ramsar and JAMBA/CAMBA) (Anon 1999). The recent Environmental Protection and Biodiversity Conservation (EPBC) Act (1999) provides more explicit requirements for monitoring and reporting on the conservation of World Heritage properties. Through its staff and consultants, PAN in consultation with landowners, conducts its own research and monitoring. Results of PAN studies, as well as those from *eriss*, are being used to assess the extent to which the World

Heritage values of the Park are being maintained. The World Heritage values include cultural values as well as natural values encompassing (i) outstanding and diverse landscape, ecosystem and habitat features, and (ii) high diversity and abundance of plant and animal species including threatened species, those of conservation significance and those of outstanding universal value (Press et al 1995). Apart from mining, the values of the Park may be potentially threatened by tourism, climate change, fire and invasive plants and animals, with many of these factors operating on a wide front across the broader landscape.

Research, including inventories and assessments, is also conducted in the Park as part of broader national biodiversity and conservation programmes. These investigations have included rainforest surveys, weed and feral animal control programmes, rare and threatened species programmes and fire management programmes (Anon 1999).

From the programmes described above, *eriss* (through its mine research and monitoring and wetland roles), PAN and other workers have acquired much inventory, assessment and monitoring data for the ARR (Finlayson 1995, Gardner et al 2002). Exemplary case studies are provided in the following sections.

Case study 1. Mining in the Region: WIA&M of potential point-source disturbances

In general, a well-managed mining operation, in which mine wastes are contained or if released to the environment, rates of dilution are controlled very carefully so as not to result in ecological harm, should result in a relatively small ecological ‘footprint’. Impact assessment in such cases is focused on a point-source and in a multi-scalar context can generally be regarded as a ‘site-specific’ study, applications, attributes and examples for which are summarised in Table 1. For such site-specific assessments, stronger inference and greater sensitivity to disturbance become more important requirements, compared to broad-scale assessments. Nevertheless, and increasingly, broad-scale, landscape-level approaches are being sought and applied at mining operations. This is especially true for new mining operations being proposed in areas of high conservation value in Australia, where the level of environmental scrutiny is high.

Recently the Independent Science Panel (ISP) and IUCN, acting on behalf of the World Heritage Committee (WHC), reviewed all the principle risks to the natural values of the Kakadu World Heritage site arising from proposed mining at the Jabiluka uranium mine site. They concluded that impacts from the site-specific Jabiluka proposal were most likely very small or negligible (Anon 2000b). Nevertheless, the ISP recommended a more comprehensive risk assessment of both the freshwater and terrestrial ecosystem at a *landscape-catchment* scale. This was because the region (Alligator Rivers Region, ARR) is subject to major seasonal or long-term changes unrelated to those which may arise from mining impacts. Hence, they also recommended comprehensive monitoring programmes with accompanying analyses (assessments) to distinguish between impacts from these differing causes and any unforeseen problems arising from mining. The ISP recommended that the IA&M phase should run for several years before mining starts. The ISP review recommended that *eriss* and PAN undertake IA&M activities on the Park at landscape scales in order to guide ecosystem management well into the future.

The main risk identified for ecosystems surrounding mine sites in the ARR is from dispersion of mine waste waters to streams and shallow wetlands during the intense and highly seasonal wet seasons. Thus management of excess water that accumulates over this time at mine sites and, in the event of water releases, assurance that the environment has

not been harmed, assume critical importance and are the subject of much research and monitoring. A comprehensive monitoring programme, including chemical and biological monitoring, has been developed by *eriss*; these developments have been reported by Humphrey et al (1990, 1995), Humphrey and Dostine (1994) and Humphrey et al (1999). With this background, scalar aspects of wetland inventory, assessment and monitoring are discussed below in relation to uranium mining operations in the ARR.

Inventory

Site-level inventories

A requirement of the Environmental Impact Assessment process in Australia, prior to any new development being approved, is a need to document relevant physical, chemical and biological characteristics of the environment. Recently, legislation in Australia has been strengthened through the Commonwealth Environment Protection and Biodiversity Conservation (EPBC) Act (1999) to require an assessment of the risks potentially posed to any threatened or endangered species. Relevant baseline data in the ARR are extensive, dating back to the early 1970s. The focus of this work was mainly aquatic and semi-aquatic systems and organisms, as aquatic ecosystems had been identified as those most at risk from mining operations in the ARR. The baseline data were gathered as part of fact-finding studies, government consultancies including taxonomic studies, and environmental impact statements. A summary of the baseline information gathered for the ARR on algae, vascular plants, microinvertebrates, macroinvertebrates, fish, amphibians, reptiles, birds, mammals and alien species is provided in Humphrey and Dostine (1994), Gardner et al (2002) and Johnston and Milnes (2002).

If there is a criticism of this ARR inventory, it is that the information, being confined to the Region, lacks in many cases a context upon which to properly assess the conservation status of the constituent flora and fauna. (This feature, however, is a common problem with inventory studies. Further discussion on this matter is provided below.) It could also be argued that much of the information was not gathered efficiently and nor does it provide a proper basis upon which to assess the cultural and conservation significance of, and potential threats to, important ecosystems, wetland complexes and wetland habitats. In the following section we describe how the hierarchical scalar approach to inventory (Finlayson et al 2002a,b) potentially provides an improved basis to assess changes to higher-order landforms and to plan site-level inventories – amongst other advantages.

Broad-scale inventory

In response to the recommendations of the ISP (Anon 2000b) and Kakadu Research Advisory Committee (Anon 2001b), *eriss* is producing a tiered hierarchical landscape approach to inventory, from river basins, to wetland regions, to wetland complexes, to wetland habitats using the Asian Wetland Inventory and Ramsar inventory frameworks (Finlayson et al 2002a,b). The elements of this generalised framework were discussed in the accompanying paper by Finlayson et al (2002a; figure 3); the levels sit above site-level inventories.

To date, a top-level, land systems map has been produced of the ARR. Inventory is currently underway to provide mapping of the lower tiers (wetland regions, wetland complexes, wetlands habitats). Initially at least, this mapping will be conducted in the catchments containing the Ranger and Jabiluka mine sites and will utilise existing 1:50 000 digital data, historical aerial photography and possibly multispectral airborne scanning. GIS

will be used to store and manipulate all data gathered in this study and provide common formats for mapping at a variety of spatial scales ranging from sub-catchment (1: 10 000) to whole-of-catchment (1: 100 000) scale.

The inventory data gathered under this hierarchical scheme will assist the Supervising Scientist, as well as provide important information to PAN as managers of Kakadu National Park. Foremost, the mapping will provide:

- a basis upon which to distinguish mining from non-mining-related impacts in the relevant catchments;
- direct measurement of possible adverse changes to higher-order landforms, many of which are listed under the World Heritage values of Kakadu National Park;
- improved context upon which to assess human-related disturbances in the Region – such as could lead to (re-)prioritising resources for management, including control; and
- through mapping and stratification of habitats etc, an improved basis upon which to plan and conduct site-level inventories.

Assessment

We provided a definition above for wetland assessment, i.e.:

the identification of the status of, and threats to, wetlands as a basis for the collection of more specific information through monitoring activities.

Implicit in this definition is a twofold use of assessment, (i) predictive assessment of risk, and (ii) evaluation of the current status and any observed change. Assessment builds on information obtained through the inventory procedure and links this with monitoring. For mining in the ARR, we consider the dual roles for which assessment may be employed.

Ecological risk assessment

van Dam et al (1999a) provided a framework for wetland risk assessment encompassing six basic steps – identification of the problem, identification of the effects, identification of the extent of the problem, identification of the risk, risk management and reduction, and monitoring. We will not elaborate upon these steps in detail here but highlight applications of some of the steps in assessing risks arising from mining operations.

Use of direct toxicity testing to determine a ‘safe’ dilution for mine waste water release

The use of local aquatic species for toxicological assessment of chemical contaminant impacts is an approach that has been promoted and used in increasing industrial situations in Australia (ANZECC & ARMCANZ 2000, van Dam & Chapman 2001). This approach was adopted as part of the environmental protection programme for the Ranger mine in the mid 1980s; the rationale as well as history of ecotoxicity developments at *eriss* were most recently reviewed by Johnston and Milnes (2002). Toxicity tests for at least 10 local species have been developed since this period with five local aquatic species regularly used for toxicity testing purposes.

Three local-species toxicity tests are used to directly assess the toxicity of some mildly-contaminated Ranger waste waters prior to their release into Magela Creek during the wet

season. The dilution of the whole waste required to render it harmless is used as a control parameter to regulate its discharge. A 'safe' dilution ratio for release of the water is determined by dividing the NOEC (No Observed Effect Concentration) of the most sensitive of the species by a safety factor of 10 (Johnston & Milnes 2002). Use of direct toxicity testing in this manner represents the second step in the risk assessment model, ie identification of the effects.

Risks associated with pond failure at the proposed Jabiluka mine site

A more complex risk assessment, involving effects identification, identification of the extent of the problem and identification of the risk, was required to assess risks to downstream wetlands associated with potential containment-pond failure at the proposed Jabiluka mine site. The assessment is summarised in Johnston and Prendergast (1999) and involved:

- estimation of the probabilities of overtopping of the pond (from high rainfall), static pond failure or failure due to severe earthquake;
- using results of pond volume, hazard assessment and concentration, and direct toxicity testing using water column and sediment-dwelling species, estimation of the exposure and risks to water column and sediment-dwelling organisms in the receiving waters and sediments.

As described in the Introduction above, ecological risk assessments have also been developed by *eriss* for a variety of potential problems, including invasive species and altered water allocations within a river basin.

Evaluation of the current status of wetlands, including any observed change

Assessment of the status of wetland condition by way of change detection, is intimately tied to the nature of, and information arising from, the monitoring programme, including the indicators and responses measured, and statistical decision criteria pre-set to measure these indicators and responses. These decision criteria include acceptable error rates³ and the level of acceptable change.

Indicators and responses may also be selected and measured along a gradient of responsiveness to change and for sites of high conservation value, in particular, there is now national and international precedent in recommending 'early warning' indicators so as to pre-empt or prevent important – and possibly irreversible – change from occurring. Thus, the Australian and New Zealand Water Quality Guidelines recommend use of early detection indicators (ANZECC & ARMCANZ 2000) whilst a Ramsar resolution includes the need for undertaking ecological risk assessment, incorporating early detection capability (van Dam et al 1999a, www.ramsar.org/key_guide_risk_e.htm).

Changes observed in early detection indicators may bear no consequence to the integrity or health of ecosystems and, in general, there is an inverse relationship between early detection capability and the ecological relevance of the measured response – as portrayed in Figure 2. This is why the best monitoring programmes include, ideally, indicators that provide both early warning and information about the ecological importance of any impact. The latter indicators have been termed 'biodiversity indicators' (ANZECC & ARMCANZ

³ The probability of falsely attributing an impact – Type I error, and the probability that an impact has passed undetected – Type II error

2000); they represent suitable surrogates of ‘ecosystem-level’ and ‘biodiversity’ change, where important effects might be reflected in:

- changes to species richness, community composition and/or structure;
- changes to species of high conservation value or species important to the integrity of ecosystems; and/or
- changes to ecosystem processes of a physical, chemical or biological nature (ANZECC & ARMCANZ 2000).

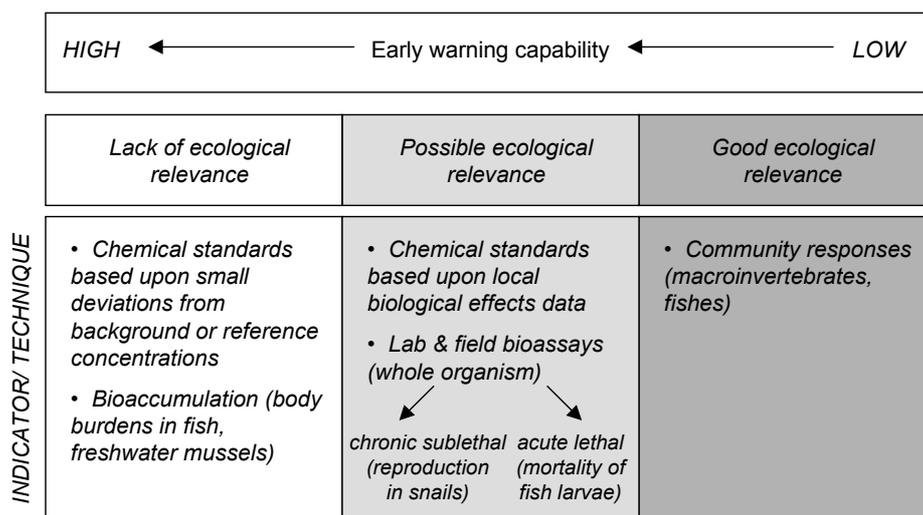


Figure 2. Monitoring techniques and responses used for assessing mining impact in the ARR in relation to ecological relevance and early warning capability. (Adapted from van Dam et al 1999a)

A commitment to employ early detection and/or biodiversity indicators in a monitoring programme would carry with it the expectation that suitable management intervention takes place when pre-determined statistical criteria, or ‘triggers’, are reached (van Dam et al 1999a).

The above description is the basis of the approach used to assess possible mining impact in the ARR (Humphrey et al 1999). A key aspect of assessment lies in the decisions made upfront about critical effect sizes. The issue of determining a level of acceptable change is one that is beyond the scope of this paper. For guidance on this topic the reader is referred to Humphrey et al (1995) and ANZECC & ARMCANZ (2000).

The relevance of broad-scale assessment to the ARR mining programmes is discussed in the ‘Monitoring’ section below.

Monitoring

Site-level monitoring

For the mine-related assessment and monitoring programmes in the ARR, indicators have been selected to serve the needs of early detection and biodiversity assessment, as described above and shown in Figure 2. For the biological indicators, macroinvertebrate and fish communities, or representative species therein, have been selected for study. These groups have been shown in biological assessment programmes conducted elsewhere to be

particularly sensitive to mine-related disturbances (Humphrey & Dostine 1994). Fish communities also have the advantage in holding a high public profile: they may be an important food resource for some communities and provide important social and cultural amenity. For early detection and biodiversity measurement, the following indicators/techniques have been selected (Humphrey et al 1999; see also Figure 2):

Early detection

(i) Prior to any release of a waste water to the environment, the setting of controls:

- conservative chemical standards; and
- a programme of pre-release laboratory toxicity testing, of any waters that are considered for discharge to streams.

(ii) During or after release, conducting an environmental monitoring programme in downstream ecosystems, using:

- creekside monitoring where the responses of organisms exposed to creek waters pumped to creekside shelters are measured during each wet season;
- concentrations of chemicals (including radionuclides) measured in the tissues of long-lived animals (bioavailability/bioaccumulation) at strategic locations downstream to detect far-field effects, including those arising from any potential deposition of mine wastes in sediments; and
- placement of sites in a potential ‘disturbance gradient’ — such as in a mixing zone, or on the mine site itself, to enhance predictive and early warning capabilities.

Biodiversity measurement

In streams adjacent to mine sites in the ARR, including control streams, monitoring of natural communities of benthic macroinvertebrates and fishes is used to provide information about changes to biological diversity and hence, the ecological importance of any impacts arising from the mine sites. The concept of employing multiple control sites in monitoring designs is relatively new (eg Underwood 1991, Humphrey et al 1995, ANZECC & ARMCANZ 2000) and, while adding to the cost of monitoring programmes, is regarded as an important requirement in the ARR monitoring programmes to increase statistical inference and to provide a necessary context upon which to assess any observed change.

Broad-scale monitoring of ecosystem health (at catchment, regional or larger scales)

We described above two roles for assessment and monitoring that may be required at broad scales:

- evaluation of larger, landscape level features or effects, and/or
- provision of assessments over catchment, regional or larger scales.

Up until recently, broad-scale assessment has not been a high-priority requirement in the ARR, where the focus for *eriss* has been towards assessment of impact at specific sites in streams downstream of mining impact. However, a level of broad-scale assessment is required to provide:

1. contextual information upon which to assess the ecological importance of impacts;

2. by way of independent spatial controls, an ability to correctly (or more confidently) infer potential mining impact; and
3. as described in the 'Inventory' section above, a 'landscape' context to assess the natural heritage values of Kakadu, in relation to possible future mining at Jabiluka, as requested by the ISP/IUCN. The broad-scale, 'landscape' approach to environmental assessment requested by the ISP/IUCN will better enable mining-related changes to be distinguished from other changes occurring in the Region (ie rationale of 2 above) but also enable the natural heritage values themselves to be monitored, as required under World Heritage listing. A monitoring programme for this landscape programme will be developed from the inventory phase described above.

It is worth noting, finally, that in the macroinvertebrate and fish community studies conducted in the ARR for assessing mining impact, over half of the resources for macroinvertebrate study is spent on sampling of control sites in other independent catchments, while an equal share of the resources for fish study is spent on sampling in independent catchments. For fish study in particular, migrations within or between water bodies imply that populations may be affected by factors operating at catchment or regional scales (such as flood flows etc), making the use of control sites with appropriate spacings and sizes mandatory (ANZECC & ARMCANZ 2000). Thus, there is a considerable investment to gathering data from across a broad geographical range.

Case Study 2. Landscape level impacts on migratory waterbirds

We need to understand the structure and dynamics of ecological systems in order to manage them. However, our understanding depends critically on whether or not the system is studied at an appropriate scale (eg waterbird-wetland systems). Although the appropriate scale depends on the problem at hand, May (1994) argues that there is an urgent need for applied ecologists in general, and conservation biologist in particular, to work at larger spatial scales than most of us do already, or are comfortable with.

Adaptive "experimental" management has been touted as a the new paradigm shift in how we manage populations and/or landscapes; management learning by trial and error is replaced with a structured process of "learning by doing", one that involves much more than simply better ecological monitoring and response to unexpected management impacts. However, with the exception of a few successes at the population level, "adaptive management" planning, especially for riparian and coastal wetland systems, has unfortunately failed in producing useful policy advice to resolve key uncertainties (Walters 1997). One of the main reasons cited is the lack of development of predictive holistic models, an essential tool in any decision support system; efforts at modelling complex wetland systems have been plagued by cross-scalar effects, from rapid hydrologic change to long-term ecological response.

Other major reasons why experimental management policies have failed are: lack of data on key processes that are difficult to study; the difficulty of "validating" historical data trends with contemporary experimental data because factor effects may be confounded; experimental policies are seen as too costly or risky (particularly in relation to monitoring costs); and research and management stakeholders have shown too much self-interest. Clearly best practice management and policy development for complex landscape-scale ecosystems will still depend heavily on the use of an effective inventory, assessment and

monitoring system (IAMS). We argue here and in an accompanying paper (Finlayson et al 2002a) that such a system will be multi-scalar and, in the face of uncertainty, will use risk management and the precautionary principle as guiding tenets.

1. Inventory, assessment and monitoring (IAM) at the broad-scale: global

Much of the recent progress in conservation planning in Australia is a result of Commonwealth and State acceptance of the strategy to establish a comprehensive reserve system (Woinarski et al. 1999). However, with migratory species, reserve planning is more difficult and involves cooperative and coordinated management initiatives, as well as agreements at regional, national and international scales. Nevertheless, if movement patterns are simple and consistent, as with migratory waterbirds (including wildfowl, waterfowl, shorebirds/waders), then protection of breeding grounds, non-breeding feeding grounds and waypoints along the flyway may assure conservation of these species. Such a strategy is being adopted for many shorebird species through a proposed reserve network along the East Asian-Australasian Flyway (Watkins 1996), which in itself is a subset of the global Asia-Pacific Migratory Waterbird Conservation Strategy⁴ (see also Anon 2001a). Both strategies are initiatives of Wetlands International (WI)⁵, who have the necessary world-wide infrastructure to undertake waterbird conservation and management programmes from local sites up to global or broad-scales (Figure 1). Specific inventory, assessment and monitoring programmes for waterbirds include (Anon 2000a): (1) development of a Global Programme for the International Waterbird Census (IWC) combining ongoing surveys into a global strategy; (2) publication of the African Waterbird Census results, an overview of 10 years of waterbird surveys in South America; (3) discussions with BirdLife International to more closely link IWC sites to their global programme on Identifying Important Bird Areas; and (4) continued work on the World Waterbird Population Estimates 3 Programme.

Much of this world-wide scale waterbird work relies heavily on qualitative assessments of abundance by volunteers in all countries involved and, hence, the census methodology may be inadequate to quantitatively assess site-specific impacts due to point (eg mining) or landscape level changes (eg resulting from weed & feral animal invasions, fire, pollution & sea level rises due to climate change). Nevertheless, these high profile, globally-coordinated programmes have immeasurable value in raising public awareness on waterbird conservation issues with respect to site-specific problems (eg drainage, pollution) and global threats to wetland habitats (eg climate change – see van Dam et al 1999b, 2001-draft). Additionally, they may be used to monitor gross changes in waterbird abundance, their presence or absence within an area at different times of the year and, importantly, immediate impacts on habitat extent and quality.

2. IAM at the broad-scale: national & between regions

Australia is a signatory to JAMBA (Japan-Australia Migratory Birds Agreement) and CAMBA (China-Australia Migratory Birds Agreement) and, hence, has an international obligation to protect migratory waterbird species listed under the agreements within its own jurisdiction. Whilst censuses are regularly undertaken by volunteers at specific “hot spots” and provide valuable qualitative information for managers, especially with respect to

⁴ URL reference: <http://www.ea.gov.au/water/wetlands/mwp/infosrn1.html>

⁵ URL reference: <http://www.wetlands.org>

identifying important sites along the flyways, Australia has no standardised and coordinated national waterbird monitoring programme. This is despite the urgent and now timely imperative to do so; most coastal waterbird habitats in southeast Australia have been lost to development, and the so called “intact” and “pristine” wetlands of northern and inland Australia are currently under threat from a variety of pressures such as water extraction, invasive species and climate change (Finlayson & Lukacs 2001, Roshier et al 2001a,b, in press). In contrast, quantitative waterbird monitoring techniques via broad-scale aerial surveys have already been developed and used over large parts of remote and regional Australia. These methods vary from the highly statistical surveys designed to detect significant changes in abundance (Bayliss 1990, Bayliss & Yeomans 1990, Whitehead et al 1987, Kingsford et al 1999), to the more general where waterbird “hot spots” have been identified opportunistically in remote areas difficult to access (Chatto 2000). Both types of survey designs are relevant depending on the management question and spatial scale adopted.

One of the most important considerations when designing animal surveys over multiple scales is the inverse relationship between scale and precision (standard error), or repeatability, of the sample estimate of numbers. Statistical surveys of small areas (eg Kakadu National Park) require much higher sampling intensity (ie area surveyed, flying effort and hence costs) to achieve the same level of precision obtained from large areas (eg the Northern Territory tropics). This is an important cost consideration when designing surveys to detect *a priori* levels of change in the population of interest (eg say a 50% decrease in Jabiru stork numbers will trigger management action). With respect to statistical sample surveys of population abundance there has been much debate about whether or not to use a random or systematic survey design. For inventory baseline mapping purposes, however, the systematic sample design is by and large far more powerful because it provides high resolution spatial information used to map patterns of distribution and abundance. Nevertheless, the trade-off is a slightly biased overall estimate of numbers. Regardless, spatial information on abundance is often far more important for management purposes than an estimate of absolute numbers, a meaningless value in itself (ie without context). More closely spaced transects are flown if a higher level of map resolution is required and/or a more precise estimate of abundance.

However, not all waterbird species can be censused from low flying aircraft (helicopter or fixed-wing), only those that are large and conspicuous, but these may suffice as “key indicator species” of habitat condition (but see Mills et al 1993 for a critique). Hence, ground surveys are often required to census those species impossible or difficult to detect from the air, and also to validate or “ground truth” aerial census results. Nevertheless, in a review of survey methods and monitoring of wildlife populations, Bayliss (1987) found that aerial survey was often the most cost-effective method of mapping and monitoring the distribution and abundance of many keystone wildlife species in wetland habitats, especially over extensive, inaccessible and remote areas. A good example is the inventory and monitoring programme established for wildlife over the vast Pantanal wetlands of Brazil, South America (Mourão et al. 1994). And, just as important, information is obtained rapidly and so is more likely to be useful to managers that need to adapt to constantly changing circumstances, such as new and emerging threats (this is a key criterion for inventory defined in our accompanying paper by Finlayson et al 2002a). Examples of such broad-scale monitoring surveys for key iconic wildlife species in the Northern Territory are: crocodiles (Bayliss 1987); dugongs, dolphins and sea turtles (Bayliss 1986, Freeland & Bayliss 1986); and feral livestock (Bayliss & Yeomans 1989b).

A standardised monitoring technique for waterbirds has other advantages in that broad habitat characteristics and condition can be documented simultaneously over extensive areas (Bayliss & Yeomans 1990). This could range from quantifying wetland vegetation types to the inventory, assessment and monitoring of major sources of environmental impacts such as weeds (eg *Mimosa pigra*, see Smith 1999), feral animals (eg water buffalo and wild pigs, see Bayliss Yeomans 1989a,b) and dry season fires on floodplains (J Russell-Smith pers com). Additionally, with the latest advances in GIS, remote sensing and computing power, multi-species patterns of distribution and abundance can now be associated with a multitude of landscape and habitat attributes at any level (scale) of resolution. This is particularly powerful for analysing large, complex matrices of information associations when attempting to tease out possible effects of environmental impacts from natural features and processes at multiple-scales. Even two decades ago this type and level of sophistication in information processing and analysis, at varying temporal and spatial scales, was unheard of.

3. IAM at the small-scale: within-region and site specific

The issues and methodologies associated with small-scale waterbird IAMS are, in principle, similar to those discussed for the broader scales above; they are simply applied to smaller, specific sites. The management problem is often site-specific (eg the impact of wild pigs on magpie geese habitat at Boggy Plain, Kakadu National Park). However, the conservation and management of waterbirds and their wetland habitats also have a national and international context (eg the Bonn Convention, Ramsar, JAMBA & CAMBA, the Convention on Biological Diversity) which drives the global agenda. Hence, there are inseparable links between the site *per se* and the larger agendas. These complex links and interactions between the ecology and values of wetlands from sites to global scales, between knowledge acquisition and application, and between management actions and outcomes, are all expressed explicitly and succinctly in the WIAMS framework presented in the accompanying paper by Finlayson et al (2002a). As stated, although Australia does not have a national WIAMS framework, it is available through the Asian Wetland Inventory (AWI) and Ramsar inventory framework, and can be adopted in the interim.

Biodiversity monitoring in Kakadu National Park

The Australian Government is required to submit to the World Heritage Bureau (WHB) an assessment of state of World Heritage values of Kakadu National Park in 2003 (Anon 2001b), which has led to recent initiatives by PAN staff to develop and implement a "Biodiversity Monitoring Programme" on the Park. Such a monitoring programme is, in effect, an IAMS which will: recognise the current condition of a value; assess current knowledge and information; identify threats and target conditions; identify the actions (including resources) required to undertake appropriate management; and guide research priorities (Anon 2001b).

A necessary prerequisite to the development of a natural heritage monitoring and associated performance assessment framework is a clearly defined set of "values" that require protection. A set of draft natural heritage "values" has been established (R Kennett pers com) and were distilled from a variety of sources, in particular the World Heritage Nomination, Ramsar, JAMBA and CAMBA, and the Kakadu Plan of Management. To assist with the development of a monitoring framework, the landscape of KNP is being divided into units which are relevant to both Aboriginal and non-Aboriginal concepts of

“country”. These units are: Coastal (beaches/intertidal, mangroves, samphire flats); Freshwater Floodplain; Southern Hills and Basins; and Plateau/Escarpment. The draft values, landscape units and associated management objectives combine to produce a large array of possible monitoring and research activities, which because of budgetary constraints, clearly enforces the need to prioritise and select specific projects, a process which is underway.

A major natural heritage value for Freshwater Floodplain landscapes is the “high diversity and abundance of waterbirds, especially migratory species”. This value was one of the main reasons for KNP being listed as a World Heritage and Ramsar site, and much effort has been devoted to waterbird monitoring in the Alligator Rivers Region (eg Morton et al 1990a,b, 1991, 1993a,b, Bayliss & Yeomans 1990) and the surrounding “Top End” in general (Bayliss & Yeomans 1990). The earlier surveys were in effect basic inventory-type surveys and established reasonably comprehensive baseline data sets. However, the aim of an IAMS for waterbirds on KNP in today’s context would be to assess the effectiveness of management practices in protecting one of the original natural heritage values – “diverse and abundant waterbird populations” – and to assess principle contemporary threats. The main threats identified are: loss of extent and diversity of habitat due to weeds (eg *Mimosa pigra* (Giant sensitive plant), introduced grasses *Hymenachne amplexicanlis* (Olive Hymenachne) and *Brachiaria (Urochloa) mutica* (Para grass)); damage to micro and macro-scale habitats caused by feral animals (eg pigs, now classified as a “Threatening Process” under the Commonwealth EPBC Act; and buffalo); the many potential impacts of cane toads (see van Dam et al 2002; but in particular the potential impact on Jabiru stork populations due to poisoning); loss of freshwater habitat due to rising sea levels from climate change and consequent saltwater intrusion; and unknown effects of burning on the floodplains in the dry season.

To cap off this multi-scalar tour of IAMS for waterbirds in the Alligator Rivers Region, Magpie geese (a tropical waterfowl species also found in Papua New Guinea) are here used as an example of how site-specific management on KNP has critical implications for their conservation and management over larger scales. Magpie geese are now generally confined to northern Australia, with the Northern Territory containing most of the population. Most geese and all major breeding colonies occur on the extensive coastal floodplains west of Arnhem Land, a region of high rainfall. Although Magpie geese disperse to all major “Top End” river floodplains in the wet season to breed, in the dry season most (>75%) were concentrated on Boggy Plain, a large (60 km²) freshwater swamp on the South Alligator River floodplains of KNP. Boggy Plain generally holds water throughout the dry season and is only 10 km from the most extensive stand of *Eleocharis* spp. (*E. dulcis* & others) in the NT, found in a swamp draining off Nourlangie Creek. This swamp is the most important dry season feeding ground in the NT and, taken together, both swamps form the major dry season refuge for Magpie geese as a species. Magpie geese feed extensively on the bulbs of *Eleocharis* and have special feeding adaptations on the bill to dig them out. Geese that predominantly feed on *Eleocharis* bulbs deposit huge fat reserves needed to survive dry season food shortages and to develop and lay clutches in the following wet season. Any impact on the extent of this major feeding ground would have serious ramifications for the survival of this species as a whole. Hence, site-specific management outcomes will have an international and national context (justification), and not just related to World Heritage values on KNP, although these are obviously important in themselves.

There are three major threats to the Boggy Plain dry season refuge which demand an immediate IAMS to be activated. These are: (1) imminent saltwater intrusion due to sea level rises; (2) rooting damage and bulb offtake (consumption) by wild feral pigs; and (3) shifts in plant composition of wetland habitats such that dominant sedge *Eleocharis* is replaced in the feeding area by some other species with little or no nutritional value to geese (eg the native grass, *Hymenachne acutigluma*), including weeds (eg introduced grasses, *H. amplexicanlis* and *B. mutica*). Obviously all major threatening processes will interact to varying degrees and, in combination, could have far more destructive effects. There are currently collaborative research projects underway to fill some gaps in knowledge on threatening processes needed for effective long-term-management, and will hopefully occur at all scales (local sites, regional populations, sub-regional in the Asia-Pacific).

It is interesting to note that most IAMS methodologies have already been developed and tested in previous studies (including monitoring & survey methods for cane toads, Lampo & Bayliss 1996) and, hence, can be applied to any scale problem; they simply need to be resurrected and supported by the latest remote sensing and mapping (GIS) techniques, given the imperative, priority and funding.

Consultation and communication

Mining activities in the ARR

Stakeholders for mining activities in the ARR include the Aboriginal Traditional Owners of the area, other resident Aboriginal people, Commonwealth and Northern Territory governments, the mining company (ERA) and the general public. Protocols for consultation, communication and reporting on mining issues are well established and the Supervising Scientist reports on environmental matters through groups such as the Alligator Rivers Region Advisory Committee (ARRAC), Alligator Rivers Region Technical Committee (ARRTC) and Minesite Technical Committees.

It has become increasingly important that information is disseminated in a timely manner to local Aboriginal people whose country may be potentially affected by mining activities. A key commitment *eriss* has made to its monitoring programmes is the involvement and employment of local Aboriginal people in the work programmes themselves. Apart from much needed assistance, cultural insights to the monitoring programmes and the building of trust, such employment opportunities also provide excellent mechanisms to communicate monitoring results to the broader Aboriginal community of the ARR.

General consultation and communication in wetlands of northern Australia

Whilst developing wetland assessment and monitoring programmes in northern Australia a number of processes have been adopted and lessons learnt. The processes have revolved considerably around making full use of existing information and resources and engaging in constructive dialogue. These were initially discussed in a programme that was funded to specifically establish a strategic approach for coastal monitoring (Eliot et al 1999). This focused on formal consultation involving interested and relevant community groups and governmental agencies within the region of concern and from adjacent jurisdictions. On the basis of this experience, Finlayson and Eliot (1999) recommend that where possible the following steps should be included in an assessment and monitoring paradigm:

- Establishment and empowerment of an expert assessment and monitoring centre – based on discussion with key stakeholders and recognition of technical competencies of all participating groups.
- Consultation with and empowerment of key stakeholders, including the local community – identification of key stakeholders and their individual roles at the start of the process and supported by formal and informal meeting processes to both develop awareness and seek advice and assistance where practicable.
- Identification of major processes and causes of ecological change – primarily a technical exercise but honed through discussion with and input from local residents etc.
- Collation and coordination of available data and information – involving rigid data management protocols to enhance access and store/file information.
- Identification of potential collaborators and partners – an ongoing and iterative process involving technical and lobby groups.
- Design and implementation of technical assessment and monitoring projects – a technical task based on the best available knowledge and advice from as many sources as feasibly possible.
- Audit and, if necessary, termination of assessment and monitoring projects – a review process that involves outside advice and participation.
- Implementation of management prescriptions based on results of the assessment monitoring projects – dependent on the establishment and maintenance of links with management agencies and officials.
- Provision of feedback to stakeholders, partners and community groups – an ongoing and iterative process whereby awareness and trust are established and maintained.
- Audit of management outcomes and readjustment of the monitoring programme in the context of impacts arising from the management strategies adopted – a process to ensure that the best available information was being used for management purposes in an adaptive manner.

The relative merit of each of the above steps is dependent on local circumstances, such as the interest of the local community groups and their interaction with governmental officials. It is expected that the outcomes could be varied and not necessarily result in support of highly technical monitoring of biophysical processes. However, it needs to be recognised that the paradigm is not static, it is an ongoing process and involves an investment in dialogue over an undetermined period of time.

Conclusion: issues arising from wetland inventory, assessment and monitoring in the ARR

We conclude this paper by considering some key issues associated with wetland inventory, assessment and monitoring in the wet-dry tropics of Australia and which may assist in the development of a formal, hierarchical WIAMS framework applied to other issues and sites.

Why the need for a hierarchical wetland inventory, assessment and monitoring scheme?

Generalised advantages of the hierarchical WIAMS

In an accompanying paper, Finlayson et al (2002a) outlined the advantages in developing a hierarchical approach to wetland inventory, assessment and monitoring (WIA&M).

A major point highlighted by Finlayson et al (2002a) was that it is not essential to work through all levels of detail when applying a hierarchical WIA&M framework. While the approach has been developed in response to needs to acquire information at different levels and detail, and also to demonstrate the clear linkages between scales, data at any level within the hierarchy may be obtained whether or not other levels have been or will be addressed. However, when data from only a particular level has been gathered, it is most useful to adopt compatible data fields and data management procedures to maximise use, or future use, of the data. A number of factors have expedited recent moves by management agencies to develop standardised, hierarchical WIAMS. Other than the international imperatives listed in Finlayson et al (2002a), we also note the novel technologies and management philosophies that are rapidly emerging. Included here are: recent development of advanced and cost-effective remote sensing techniques; emerging best-practice experimental designs for monitoring that place emphasis on increasing the scale of study, in particular, the reference condition (see below); the notion of “ecological footprint” within a landscape context (Anon 2000b, Wackernagel & Rees 1996); and increasingly, because of the large scale of many human disturbances, a management focus at the landscape level and concomitant development of broad-scale monitoring and assessment techniques (including rapid assessment) for detecting, assessing and reporting on change.

A hierarchical approach to WIA&M in the ARR

The generalised advantages listed above for a hierarchical WIAMS are applicable and relevant to the ARR. Such an approach improves focus and, even if all levels are not required for WIA&M, we argue that the framework should be worked through to verify and determine the appropriate scales of study. For example, while a particular scalar level of study might appear obvious, it is important to determine whether or not management conclusions are likely to be confounded because information at another level was not collected or was not used. We identify some key issues arising from ARR studies that are pertinent to hierarchical WIA&M. Even for site-specific studies, landscape issues are becoming increasingly important. Note for example the following points to consider when assessing possible conservation impacts of mining:

- inventory requires a broad landscape base upon which to assess the biodiversity and conservation status, distribution and abundance of constituent flora and fauna. Surveys conducted in the receiving waters downstream of mine sites, alone, are generally inadequate for such assessments;
- through higher-order inventory including the mapping and stratification of habitats etc, there is an improved basis upon which to plan and conduct site-level inventories, including conservation assessments;
- even small-scale developments such as mining, could generate a larger ecological footprint than might first appear, including ‘hidden’ landscape disturbances, such as fragmentation of the landscape associated with roads, inevitable weed invasion, fire management, infrastructure etc.
- a landscape approach to WIA&M will provide greater confidence in attributing cause to any observed changes (ie distinguishing mining from non-mining related change); and
- another aspect of inference is the requirement in experimental designs to incorporate sufficient spatial controls. Even for point source disturbances, best-practice designs now

assume a landscape scale in order to increase statistical inference and to provide a necessary context upon which to assess any observed change.

At a broader scale, when considering migratory or mobile species or pressures that operate on a wide front across the broader landscape, other WIA&M issues become evident. For example, some points to consider are:

- some advantages to landscape inventory are listed above, but where habitat and higher-order landforms themselves are the subject of management protection or conservation issue (eg extent of wetlands, World Heritage values) direct IA&M of these features through remote sensing and other techniques is necessary;
- our waterbird case study demonstrates the multiple scales over which WIA&M may be required for migratory or mobile species. Whilst broad-scale WIAMS are often necessary to provide context at smaller scales, survey and monitoring costs may constrain use of an appropriate design. Hence, obviously there needs to be pragmatic trade-offs between multiple-scale objectives and costs of obtaining relevant information at ecological levels.

Geo-political and socio-economic constraints upon development of WIAMS

Humphrey et al (1999) were critical of the planning, assessment and approval processes for developments in Australia which rarely provided sufficient attention (and resourcing) for the gathering of relevant inventory or baseline data. They attributed these deficiencies in part to lack of foresight, political expediency and a flawed Environmental Impact Assessment process, or other aspects of a socio-economic nature. We have emphasised in the above sections how assessments at all scales are dependant upon contextual information, including inventory. Johnston (1993) also drew attention to the lack of government involvement in baseline data collection in new areas prospective for minerals in northern Australia, and suggested government could play an active role in funding the gathering of both generic information (eg taxonomic base, inventories) required to underpin the usual baseline data, as well as actual baseline data from selected streams representative of the different bioregions that were known to be particularly prospective for minerals.

For monitoring and assessment of water quality and river health in Australia at least, government has played a more active role, particularly in broad-scale assessments where national guidelines (including generic monitoring protocols) (ANZECC & ARMCANZ 2000) and rapid assessment methods for stream health (eg 'AUSRIVAS' macroinvertebrate sampling programme; Schofield & Davies 1996) have been formulated. Hopefully, these developments will lead to a greater role for biological assessments in discharge licensing and impact assessment generally in Australia.

The emerging focus on broadening the context for WIA&M brings with it an increasing cost burden to acquire necessary contextual data. This will require 'smarter' and innovative approaches to WIA&M, including streamlining of monitoring programmes and incorporating cost-sharing arrangements amongst users of monitoring data for the gathering of control or reference data (ANZECC & ARMCANZ 2000). Industry also needs to be reminded of the advantages in gathering additional control data which enhance inferences and reduce the rates of error associated with falsely attributing impact when none was present.

The ARR as a test-bed for developing a template for a wetland inventory, assessment and monitoring scheme

The inventory, assessment and monitoring programmes developed in the ARR have been reasonably well resourced and, as a consequence, new developments in wetland IA&M have often been tested in the Region. For example, *eriss* played a role in drafting of the new *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZECC & ARMCANZ 2000). Through the revision of the Guidelines, key principles and elements of the *eriss* environmental monitoring and assessment programmes for the ARR — water physico-chemistry monitoring, toxicity testing and biological monitoring — were also adopted for similar areas of high conservation value in Australia. The *eriss* biological assessment programmes were also used to develop conceptual frameworks for wetland risk assessment (van Dam et al 1999a) and monitoring (Finlayson 1996) for the Ramsar Wetland Convention and have influenced approaches being tested by *eriss* for vulnerability assessment of wetlands due to climate change and sea level rise (Bayliss et al 1997). The approaches for WIAM developed and implemented in the ARR have provided, and continue to provide, information which can be shared with those who cannot afford such programmes.

References

- Anon. 1999. *Kakadu Plan of Management: 1999 – 2003*. Parks Australia North, Environment Australia.
- Anon 2000a. Wetlands International. Global Annual Review 2000. Global Programmes, 16 pp.
- Anon 2000b. Independent Science Panel (ISP) of International Council of Science Union (ICSU) Report No 3.
- Anon 2001a. *Asia-Pacific Migratory Waterbird Conservation Strategy: 2001 – 2005*. Environment Australia, Wetlands International & Japanese Ministry of the Environment.
- Anon 2001b. *Monitoring natural heritage values – Kakadu National Park*. Unpublished report of the Kakadu Research Advisory Committee Workshop, KNP November 6 & 7, 2001.
- ANZECC & ARMCANZ 2000. *Australian and New Zealand guidelines for fresh and marine water quality*. National Water Quality Management Strategy Paper No 4, Australian and New Zealand Environment and Conservation Council & Agriculture and Resource Management Council of Australia and New Zealand, Canberra.
- Bayliss B, Brennan K, Eliot I, Finlayson CM, Hall R, House T, Pidgeon R, Walden D & Waterman P 1997. *Vulnerability assessment of predicted climate change and sea level rise in the Alligator Rivers Region, Northern Territory Australia*. Supervising Scientist Report 123, Supervising Scientist, Canberra.
- Bayliss P 1986. *Factors affecting surveys of marine fauna, and their relationship to a census of dugongs in the coastal waters of the Northern Territory*. Australian Wildlife Research 13, 27-37.
- Bayliss P 1987. *Survey methods and monitoring in relation to population management*. In *Wildlife Management. Crocodiles and Alligators*. 157-175, eds G Webb, C Manolis & P Whitehead. Surrey Beatty & Sons P/L.

Bayliss P 1990. *The correction of aerial survey estimates of Magpie geese and Whistle duck density to absolute estimates using low-level aerial photography*. Australian Wildlife Research 17, 1-10.

Bayliss P & Yeomans KM 1989a. *Correcting bias in aerial survey population estimates of feral livestock in northern Australia using the double count technique*. Journal of Applied Ecology 26, 925-933.

Bayliss P & Yeomans KM 1989b. *The distribution and abundance of feral livestock in the Top End of the Northern Territory, and relation to cost of control*. Australian Wildlife Research 16, 651-76.

Bayliss P & Yeomans KM 1990. *The seasonal distribution and abundance of Magpie geese in the Northern Territory, and its relation to habitat*. Australia Wildlife Research 17, 15-38.

Begg GW, van Dam RA, Lowry JB, Finlayson CM & Walden DJ 2001. *Inventory and risk assessment of water dependent ecosystems in the Daly basin, Northern Territory, Australia*. Supervising Scientist Report 162, Supervising Scientist, Darwin NT.

Bunn SE, Boon PI, Brock MA & Schofield NJ 1997. *National Wetlands R&D Programme: Scoping Review*. Occasional Paper 01/97, Land and Water Resources Research and Development Corporation, Canberra, ACT.

Chatto R 2000. *Waterbird breeding colonies in the Top End of the Northern Territory*. Parks & Wildlife Commission of the NT. Technical Report 69. 156 pp.

DEST (Department of Environment, Sport and Territories) State of the Environment Advisory Council 1996. *Australia, State of the Environment: An independent report*. CSIRO Publishing, Collingwood.

Eliot I, Finlayson CM & Waterman P 1999. *Predicted climate change, sea level rise and wetland management in the Australian wet-dry tropics*. Wetlands Ecology and Management 7, 63–81.

Environment Australia 2001. *A directory of important wetlands in Australia*. 3rd edn, Environment Australia, Canberra.

Finlayson CM 1995. *Wetland research in the Wet-Dry tropics*. **In** Wetland research in the Wet-Dry tropics, ed. C.M. Finlayson, Supervising Scientist Report 101, Supervising Scientist, Canberra, pp. 3–11.

Finlayson CM 1996. *The Montreux Record: a mechanism for supporting the wise use of wetlands*, **In** Proceedings of the 6th Meeting of the Conference of the Contracting Parties of the Convention on Wetlands (Ramsar Convention Bureau, Gland, Switzerland). Technical Sessions: Reports and presentations, Brisbane, Australia, Vol. 10/12 B, 32–37.

Finlayson CM 1999a. *Wetland types and their distribution in northern Australia*. **In** CM Finlayson & AG Spiers (eds), A compendium of information for managing and monitoring wetlands in tropical Australia. Supervising Scientist Report 148, Supervising Scientist Group, Canberra. 21-39.

Finlayson CM 1999b. *Protocols for an Australian national wetland inventory*. **In** CM Finlayson & AG Spiers (eds), Techniques for Enhanced Wetland Inventory, Assessment and Monitoring. Supervising Scientist Report 147, Supervising Scientist Group, Canberra. 119-145

Finlayson CM & Rea N 1999. *Reasons for the loss and degradation of Australian wetlands*. Wetland Ecology and Management 7, 1-11.

Finlayson CM & Eliot I 2001. *Ecological assessment and monitoring of coastal wetlands in Australia's wet-dry tropics: a paradigm for elsewhere?* Coastal Management 29, 105-115.

Finlayson CM & Lukacs GP 2001. *Status of wetlands in northern Australia*. Unpublished report from 'Sustaining our aquatic environments - implementing solutions', 2nd National Conference on Aquatic Environments. 20-23 November 2001, Townsville QLD.

Finlayson CM, Hall R & Bayliss B 1998. *Regional review of wetland management issues: Wet-Dry tropics of northern Australia*. LWRRDC National Wetlands R&D Programme, LWRRDC Occasional Paper 03/97, Canberra.

Finlayson CM, Davidson NC & Stevenson NJ 2001a. *Wetland inventory, assessment and monitoring – Practical techniques and identification of major issues: Summary*. In CM Finlayson, NC Davidson & NJ Stevenson (eds) 2001a. Wetland inventory, assessment and monitoring: Practical techniques and identification of major issues. Proceedings of Workshop 4, 2nd International Conference on Wetlands and Development, Dakar, Senegal, 8–14 November 1998, Supervising Scientist Report 161, Supervising Scientist, Darwin.

Finlayson M, van Dam R, Walden D & Storrs M 2001b. Risk assessment for managing the tropical weed *Mimosa pigra*. In: Assessment and Management of Alien Species that Threaten Ecosystems, Habitats and Species. Abstracts of keynote addresses and posters presented at the sixth meeting of the Subsidiary Body on Scientific, Technical and Technological Advice, Montreal, Canada, 12-16 March 2001. CBD Technical Series No. 1. Secretariat of the Convention on Biological Diversity, Montreal, Canada. pp. 17-19.

Finlayson CM, Begg G, Humphrey CL & Bayliss P 2002a. *Developments in wetland inventory, assessment and monitoring*. Proceedings of workshop on developing a framework for a wetland assessment system in Malaysia, Kuala Lumpur, Malaysia, 18-19 April, 2002. Organised by Wetlands International – Malaysia Programme (in press)

Finlayson CM, Howes J, Begg G & Tagi K 2002b. *A strategic approach for characterising wetlands – the Asian wetland inventory*. Proceedings of Asian Wetland Symposium, Penang, Malaysia, 27-30 August, 2001. (in press)

Freeland WJ & Bayliss P 1989. *The Irrawaddy river dolphin (Orcaella brevirostris) in coastal waters of the Northern Territory: Distribution, abundance & seasonal changes*. Mammalia 53, 49-57.

Gardner S, Finlayson CM & Pidgeon RWJ (eds) 2002. *Description and literature review of the flora and vertebrate fauna of Magela Creek, Alligator Rivers Region, northern Australia: A literature resource for landscape-scale environmental assessment of the wetland habitats within the catchment, with particular reference to Swift Creek (Ngarradj)*. Supervising Scientist Report, Supervising Scientist, Canberra. (in press)

Government of Western Australia 1997. *WA Wetlands Conservation Policy*. Government of Western Australia, Perth.

Humphrey CL & Dostine P 1994. *Development of biological monitoring programmes to detect mining waste impacts upon aquatic ecosystems of the Alligator Rivers Region, Northern Territory, Australia*. Mitteilungen Internationalis Vereinigung Limnologie 24, 293–314.

Humphrey CL, Bishop KA & Brown VM 1990. *Use of biological monitoring in the assessment of effects of mining wastes on aquatic ecosystems of the Alligator Rivers Region, tropical northern Australia*. Environmental Monitoring and Assessment 14, 139–181.

Humphrey CL, Faith DP & Dostine PL 1995. *Baseline requirements for assessment of mining impact using biological monitoring*. In *The use of biota to assess water quality*, Australian Journal of Ecology 20, 150–166.

Humphrey CL, Thurtell L, Pidgeon RWJ, van Dam RA & Finlayson CM 1999. *A model for assessing the health of Kakadu's streams*. Australian Biologist 12, 33–42.

Johnston A 1993. *Future directions in research on the environmental impact of mining*. Internal report 112, Supervising Scientist, Canberra, Unpublished paper.

Johnston A & Prendergast B 1999. *Assessment of the Jabiluka Project: Report of the Supervising Scientist to the World Heritage Committee*. Supervising Scientist Report 138, Supervising Scientist, Canberra.

Johnston A & Milnes AR 2002. *Review of mine-related research in the Alligator Rivers Region 1978–2002*. Report to the Alligator Rivers Region Technical Committee Meeting 25–27 February 2002. In draft.

Kingsford RT, Wong PS, Braithwaite LW & Maher MT 1999. *Waterbird abundance in eastern Australia, 1983-92*. Wildlife Research 26, 351-366.

Lampo M & Bayliss P 1996. *Density estimates of cane toads from native populations based on mark-recapture data*. Wildlife Research 23, 305-15.

May RM 1994. *The effects of spatial scale on ecological questions and answers*. In *Large scale ecology and conservation biology*, Oxford, Blackwell Scientific, 1-17.

Mills LS, Soulé ME & Doak DF 1993. *The keystone-species concept in ecology and conservation*. BioScience 43, 219-224.

Morton SR, Brennan KG, Armstrong MD 1990a. *Distribution and abundance of Magpie Geese, Anseranas semipalmata, in the Alligator rivers Region, Northern Territory*. Australian Journal of Ecology 15, 307-320

Morton SR, Brennan KG, Armstrong MD 1990b. *Distribution and abundance of ducks in the Alligator Rivers Region, Northern Territory*. Australian Wildlife Research 17, 573-590.

Morton SR, Brennan KG, Armstrong MD 1991. *Distribution and abundance of waterbirds in the Alligator Rivers Region, Northern Territory*. Open file record 86, Supervising Scientist for the Alligator Rivers Region, Jabiru, 1-460.

Morton SR, Brennan KG, Armstrong MD 1993a. *Distribution and abundance of herons, egrets, ibises and spoonbills in the Alligator Rivers Region, Northern Territory*. Australian Wildlife Research 20, 23-43.

Morton SR, Brennan KG, Armstrong MD 1993b. *Distribution and abundance of grebes, pelicans, darters, cormorants, rails and terns in the Alligator Rivers Region, Northern Territory*. Australian Wildlife Research 20, 203-217.

Mourão G, Bayliss P, Coutinho M & Abercrombie C 1994. *An aerial survey of caiman and other wildlife on the vast Pantanal floodplains, Brazil*. Wildlife Society Bulletin 22, 50-56.

Pajmans K, Galloway RW, Faith DP, Fleming PM, Haanjens HA, Heyligers PC, Kalma JD & Loffler E 1985. *Aspects of Australian wetlands*. CSIRO Australia, Division of Water and Land Resources Technical Paper No. 44, Canberra.

Parks and Wildlife Commission of the Northern Territory 2000. *A Strategy for the Conservation of the Biological Diversity of Wetlands in the Northern Territory of Australia*. Northern Territory Government, Darwin.

Phillips B 1996. Introduction. **In** A directory of important wetlands in Australia, 2nd edn, Australian Nature Conservation Agency, Canberra, 1–6.

Press T, Lea D, Webb & Graham A (eds) 1995. *Kakadu Natural and Cultural Heritage and Management*. Australian Nature Conservation Agency and North Australia Research Unit, The Australian National University, Darwin.

Queensland Department of Environment 1996. *Proposed Strategy for the Conservation and Management of Queensland's Wetlands*. Discussion paper. Department of Environment, Brisbane.

Roshier DA, Robertson AI, Kingsford RT & Green DG 2001a. *Continental-scale interactions with temporary resources may explain the paradox of large populations of desert waterbirds in Australia*. *Landscape Ecology* 16, 547–556.

Roshier DA, Whetton PH, Allan RJ & Robertson AI 2001b. *Distribution and persistence of temporary wetland habitats in arid Australia in relation to climate*. *Austral Ecology* 26, 371–384.

Roshier DA, Robertson AI & Kingsford RT in press. *Responses of waterbirds to flooding in an arid region of Australia and implications for conservation*. *Biological Conservation*.

Schofield NSJ & Davies PE 1996. *Measuring the health of our rivers*. *Water* 23, 39–43.

Semeniuk V & Semeniuk CA 1998. *A geomorphic approach to global classification for natural wetlands and rationalization of the system used by the Ramsar Convention – a discussion*. *Wetlands Ecology and Management* 5, 145–158.

Smith N 1999. *Unwanted plants on Northern Land Council land, Northern Territory, Australia: an overview of naturalised exotic plants and potential weed species on Aboriginal land*. Report funded by Tropical Savannas CRC, 216 pp.

Spiers AG & Finlayson CM 1999. *An assessment of the extent of wetland inventory data held in Australia*. **In** CM Finlayson & AG Spiers (eds), *Techniques for Enhanced Wetland Inventory, Assessment and Monitoring*. Supervising Scientist Report 147, Supervising Scientist Group, Canberra. pp. 1–43.

Storrs MJ & Finlayson CM 1998. *Overview of the conservation status of wetlands of the Northern Territory*. Supervising Scientist Report 116, Supervising Scientist, Canberra.

Underwood AJ 1991. *Beyond BACI: experimental designs for detecting human environmental impacts on temporal variations in natural populations*. *Australian Journal of Marine and Freshwater Research* 42, 569–587.

van Dam RA & Chapman JC 2001. *Direct toxicity assessment (DTA) for water quality guidelines in Australia and New Zealand*. *Australasian Journal of Ecotoxicology* 7, in press.

van Dam RA, Finlayson CM & Humphrey CL 1999a. *Wetland risk assessment: A framework and methods for predicting and assessing change in ecological character*. **In** *Techniques for enhanced wetland inventory, assessment and monitoring*, eds CM Finlayson & AG Spiers, Supervising Scientist Report 147, Supervising Scientist Group, Environment Australia, pp. 83–118.

van Dam R, Finlayson CM & Watkins D 1999b. *Vulnerability of two major wetlands in the Asia-Pacific region to climate change and sea level rise*. Supervising Scientist Report 149, Supervising Scientist, Darwin.

van Dam R, Gitay H & Finlayson M 2001. *Climate change and wetlands: Impacts, adaptation and mitigation*. Ramsar STRP10 Working paper 2. Draft Only. 65 pp.

van Dam RA, Walden DJ & Begg GW 2002. *A preliminary risk assessment of cane toads in Kakadu National Park*. Supervising Scientist Report 164, Supervising Scientist, Darwin NT.

Wackernagel M & Rees W 1996. *Our ecological footprint: reducing human impact on the earth*. New Society Publishers, Gabriola Island, GA.

Walters C 1997. *Challenges in adaptive management of riparian and coastal ecosystems*. Conservation Ecology [online] 1, 1-23.

Watkins D 1996. *An international network of reserves for shorebirds*. Wingspan 9, 9.

Watkins D 1999. *Review of wetland inventory information in Oceania*. In Global review of wetland resources and priorities for inventory. (Eds CM Finlayson and AG Spiers.) Supervising Scientist Report No. 144, 493-526. (Canberra)

Whitehead P, Bayliss P & Yeomans K 1987. *Aerial survey of Magpie geese populations and nesting in the Top End of the Northern Territory. Wet Season 1987*. Conservation Commission of the Northern Territory Technical Report No. 35.

Williams WD 1983. *Life in inland waters*. Blackwell Scientific Publications, Melbourne.

Woinarski JCZ, Franklin D & Connors G 1999. *Landscape mapping of nectar resources as a base for conservation management*. Australian Biologist 12, 97-105.

Invited Paper No. 3

THE ASIAN WATERBIRD CENSUS

– A TOOL FOR WATERBIRD AND WETLAND MONITORING

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1.0 BACKGROUND AND INTRODUCTION

Waterbirds are ecologically dependent on wetlands. Due to its natural beauty, the waterbirds attract people's interest into the wetlands. The Ramsar Convention (in full Convention on Wetlands of International Importance especially as Waterfowl Habitat), was first established primarily for the conservation of waterbird habitats. Over the years the Convention has evolved, however protecting the important waterbird habitat is still one of the main priority areas of the Convention. The criterion for waterbirds is still being used as an important criterion for identifying wetlands of international importance.

The Asian Waterbird Census (AWC), which was started in 1987, is an integral part of the Global International Waterbird Census (IWC), coordinated by Wetlands International. The AWC was first introduced in the Indian subcontinent and then gradually to the rest of Asia. In the census conducted in 1992, a total of 1,860 wetland sites in 30 countries were covered. Since 1994, the Census in Middle East and Central Asia (from Afghanistan westwards) were covered by Wetlands International office in Netherlands). In general, the AWC mainly covers the region of South Asia, East Asia, South East Asia, Australasia and Far East Russia.

The major objectives of the Asian Waterbird Census are:

- to obtain information on an annual basis of waterbird populations at wetlands in the region during the non-breeding period of most species (January), as a basis for evaluation of sites and monitoring of populations;
- to monitor on an annual basis the status and conditions of wetlands; and
- to encourage a greater popular interest in waterbirds and wetlands, and thereby promote their conservation.

The AWC is conducted during the 2nd or 3rd week of January across the region and undertaken by volunteer participants. Where the number of participants is limited and/or where coverage is poor, counts from December and February are included.

The results of the census and associated information are widely used to promote regional and national waterbird and wetland conservation initiatives. These include the identification of internationally important wetlands under the Ramsar Convention and as support for the development of a draft agreement on the conservation of migratory waterbirds. The AWC is also contributing to the Convention on the Conservation of Migratory Species of Wild Animals (CMS), in the conservation of migratory waterbird species. The information has also assisted in the development of *the "Asia-Pacific*

Migratory Waterbird Conservation Strategy: 2001-2005”, its action plans and related initiatives.

2.0 IMPLEMENTATION OF THE AWC

Geographic coverage

The AWC currently being implemented in the three main regions: South Asia (Bangladesh, India, Nepal, Pakistan and Sri Lanka), Southeast Asia (Brunei Darussalam, Indonesia, Lao P.D.R., Malaysia, Myanmar, Papua New Guinea, Philippines, Singapore, Thailand and Vietnam) and East Asia (Mainland China, Taiwan, Hong Kong, Japan and Republic of Korea). Other than these three main regions, the census covers Australasia and Far East Russia.

Site and Species Coverage

The AWC sites covers all types of wetlands, include rivers, lakes, reservoirs, tanks, swamps, coastal sites, mangroves and mudflats, reefs, sandy beaches, etc.

All waterbird species encountered in the region are covered by the census (grebes, cormorants, pelicans, herons, egrets, storks, ibises, spoonbills, flamingoes, ducks, geese, swans, cranes, rails, jacanas, shorebirds, gulls, terns). In addition to waterbird species as recognised by the Ramsar Convention, counts of species of birds of prey (raptors) that are regularly encountered at wetlands have been included, as several of these species are largely dependent on the food resources of these habitats.

Participants and coordinators

At a national level, the census is coordinated by one or more coordinators. The coordinators organise a network of volunteer participants from all walks of life with varying levels of skills in identification and counting of birds. In countries where the coverage is poor and there is no coordinator, information is sent directly to Wetlands International by the field counters.

Coordination of the census is undertaken largely on a voluntary basis, however frequent changes of the coordinator in some countries has affected the implementation of the census.

Data collection and handling

The annual waterbird count data and site information are recorded on standardized census forms by a network of participants. Single counts are made at each site. The information is sent to the coordinators and, after checking, collation and preparation of an annual country report, is forwarded to Wetlands International. This information is entered into standard databases using customized Microsoft Access 97 programmes at the Wetlands International office in Malaysia..

Data checking and quality of information

The census depends on accurate reporting of species and numbers by the participants. As the information is being collected by a variety of volunteers with different levels of skills in

identifying species and making counts, it is likely that there are some errors in the data supplied. As the coordinators are aware of local conditions, they need to check and to request additional verification where counts of birds appear unusually large, threatened species are reported in greater numbers than published information indicates are likely, or species are reported outside their normal range.

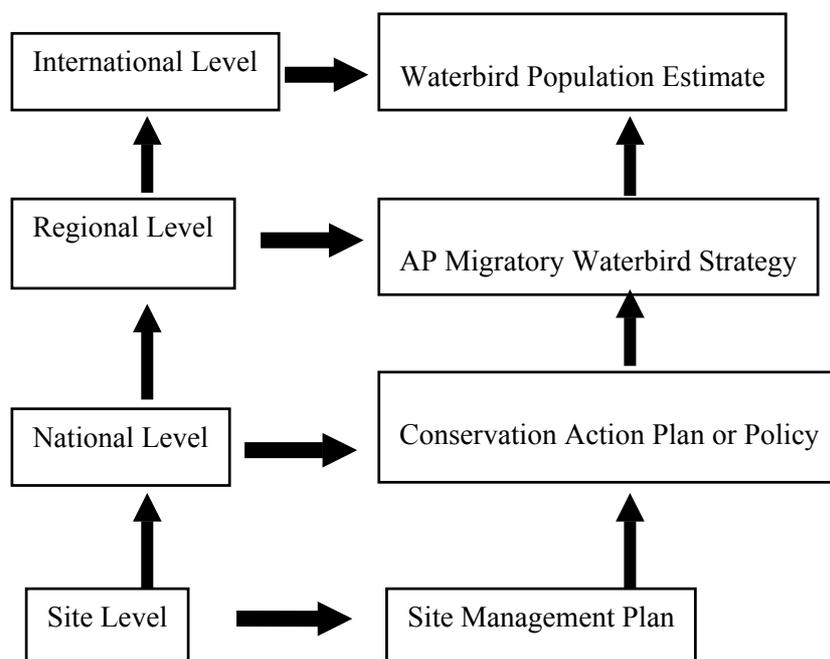
Wetlands International makes all attempt to verify the data received from coordinators and participants in case of any ambiguous information. In some cases, where unusual records have been received (threatened species, vagrants or large numbers) and where no supporting information was forthcoming from coordinators or participants, Wetlands International will make a judgement on whether the record could be attributed to be a transcribing error on the form or other reasons and these records are either included in the unidentified waterbird category or deleted.

Data Maintenance

All information received from national coordinators and participants is computerised and stored in a central database that runs on a Microsoft Access system. Wetlands International is responsible for the management and maintenance of this database.

3.0 AWC CYCLES

AWC contribute to the conservation work at different levels.



4.0 AWC DATA UTILIZATION

Reporting

Information collected by the census from 1987 through to 1993 has been published in a series of annual reports (van der Van 1987, 1988; Scott and Rose 1989; Perennou *et al.* 1990; Perennou and Mundkur 1991, 1992; Mundkur and Taylor 1993). The data of the 1994-1996 census are compiled in a three year report by Lopez & Mundkur 1997. Wetlands International is currently working on the AWC 1997-2001 report.

In addition to these annual reports, results from the years 1987 to 1991 have been analysed to identify species distribution and identify important wetlands in a comprehensive report by Perennou *et al.* (1994).

Mapping of the location of sites and species

Site and species maps are generated by using mapping software. Information on the precise location of sites is taken from the site forms submitted by participants. With this information, the census area and important sites and species distribution map can be drawn.

Identification of Important sites

Using the Ramsar Criteria on waterbirds, the internationally important wetlands can be easily identified by the AWC data. For example, during the 1994-1996 count, 75 sites were reported to have at least supported 20,000 waterbirds.

Monitoring status of the Threatened species

The AWC provides important information on the threatened species. During the 1994-1996 census, 31 species of the categorized as globally threatened were encountered.

Monitoring wetlands status

AWC also collect information on site utilization and threats as well as monitoring the status of the sites. Sites information form is required for each count. This provides a tool for wetlands monitoring not only for waterbird species and population, but also for other ecological character of the wetlands, as well as wetlands utilization status and threats/problems.

5.0 CHALLENGES FACED IN IMPLEMENTATION OF THE AWC

Site coverage decreasing

The sites covered by the AWC have gradually decreased since 1993. Therefore, attempts are being made to increase the site coverage of the AWC, particularly for those of international and national importance.

Lack of Communication

Effective communication and follow up is the key in maintaining a volunteer based network to implement the AWC. Funding constraints has resulted in the lapse of coordination and communication and eventually leading to a decrease in the number of volunteers for the AWC. The success of AWC is dependent on people's interest in contributing to this initiative.

Lack of expertise

In some countries, although there are a number of people who are keen to contribute to the AWC, the lack of skills (e.g. bird identification and counting), results in inaccurate count results.

Lack of financial support particularly among developing countries

Local bird groups often do not have funds to cover their travel costs, purchase/rental of equipment (binoculars and telescopes) and guide books, etc. for this voluntary activity. This has greatly affected the development of the AWC. Due to lack of funds, Wetlands International has not published an AWC report in the last five years. In return, this has contributed to a loss of interest among the participants. In addition, it has also resulted in the drop of information being submitted.

6.0 RECOMMENDATIONS FOR DEVELOPMENT OF THE AWC

6.1 Fund raising is the first priority to ensure the development and strengthening of the AWC. Wetlands International will need to work together with the national coordinators to raise funds for the activities at the regional/national/local level to promote the AWC. If possible, small grant funds, survey equipment and waterbird guides need to be provided to AWC participants to support their fieldwork and to improve their skills.

6.2 Development and strengthening of AWC volunteer networks in all the countries covered by AWC. The AWC website needs to be regularly updated and biannual newsletters need to be produced and widely disseminated. AWC coordinator's workshops need to be organised regularly to promote the understanding of the AWC and strengthen the future coordination of the AWC.

6.3 Training programmes need to be conducted to improve skills and knowledge to coordinate and undertake the census among the AWC volunteer network.

6.4 Awareness programmes need to be conducted to improve knowledge about the value of the census and the importance of conservation of wetlands and their biodiversity amongst the public.

7.0 REFERENCES

- Asia-Pacific Migratory Waterbird Conservation Committee. 2001 *Asia-Pacific Migratory Waterbird Conservation Strategy: 2001-2005*. Wetlands International - Asia Pacific, Kuala Lumpur Malaysia.
- Lopez, A and Mundkur, T. (eds) 1997. *The Asian Waterfowl Census 1994-1996. Results of the Coordinated Waterbird Census and an Overview of the Status of Wetlands in Asia*. Wetlands International, Kuala Lumpur.
- Mundkur, T. & Taylor, V. 1993. *Asian Waterfowl Census 1993*. AWB, Kuala Lumpur and IWRB, Slimbridge.
- Perennou, C., Rose, P. & Poole, C. 1990. *Asian Waterfowl Census 1990*. IWRB, Slimbridge.
- Perennou, C. & Mundkur, T. 1991. *Asian Waterfowl Census 1991*. IWRB, Slimbridge.
- Perennou, C. & Mundkur, T. 1992. *Asian Waterfowl Census 1992*. IWRB, Slimbridge.
- Perennou, C., Mundkur, T., Scott, D. A., Follestad, A. & Kvenild, L. 1994. *The Asian Waterfowl Census 1987-91: Distribution and Status of Asian Waterfowl*. AWB Publication No. 86. AWB, Kuala Lumpur.
- Scott, D.A. and Rose, P. 1989. *Asian Waterfowl Census 1989*. IWRB, Slimbridge.
- van der Van, J. 1987. *Asian Waterfowl 1987. Midwinter bird observations in some Asian countries*. IWRB, Slimbridge.
- van der Van, J. 1988. *Asian Waterfowl 1988. Midwinter bird observations in most Asian countries*. IWRB, Slimbridge.

Invited Paper No. 4

THE EFFECTIVENESS OF THE ASIAN WATERBIRD CENSUS AND OTHER RELATED PROGRAMMES AS A TOOL FOR WATERBIRD AND WETLAND MONITORING IN MALAYSIA

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Malaysian Nature Society

1.0 INTRODUCTION

Wetlands are an integral part of Malaysia's landscape and biological diversity. According to Ramsar (1971), wetlands are defined as "areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres." Wetlands "may incorporate riparian and coastal zones adjacent to the wetlands, and islands or bodies of marine water deeper than six metres at low tide lying within the wetlands."

The total area of natural wetlands in Malaysia is estimated at 3.5 – 4.0 million hectares or 10% of the total land area (Burhanuddin Mohd Nor 1994). In Peninsular Malaysia, the largest proportions are found in Pahang (2.5% of the peninsula). The States of Selangor, Johor, Perak and Terengganu also have a relatively large proportions of the total wetlands in the peninsula (1.1%, 1.1%, 1.0% and 0.8% respectively). However, from 1974-1990 (16 years), total decline in major wetlands during that period corresponds to 17,000 hectares in the peninsula. To this figure would have to be added the numerous smaller wetland sites which nevertheless undoubtedly have also been drained and converted to other uses (DWNP-DANCED 1996). In Sabah and Sarawak, mangroves and peat and freshwater swamps amount to 5,104 and 13,180km² respectively (Smythies 1999).

Wetlands play an important in environmental services. They act as natural sponges, absorbing extra water during times of heavy rain, thus avoiding damage caused by inundation. They recharge and purify aquifers and rivers, enhancing the supply of clean water. Their aesthetic and productive characteristics provide recreational and educational opportunities unmatched by other habitats.

Both natural and artificial wetlands are also important habitats for waterbirds. Waterbirds are broadly defined as "birds ecologically dependent on wetlands." It includes traditionally recognised groups popularly known as wildfowl, waterfowl and shorebirds/waders. Apart from these, kingfishers, birds of prey and passerines also depend on wetlands to a certain extent. Besides birds, these areas have been documented to harbour endemic wetland-dependent mammals, plants and other taxa. The *Malaysian Wetland Directory* listed 105 sites as significant areas for wetland conservation (DWNP 1987).

In the fast pace of development, wetlands are often sacrificed eventhough studies have shown that it is more economical to conserve rather than convert them to other forms of land use. The conversion of wetlands and other indirect threats such as pesticides, hunting,

loss of secure roost sites and pollution takes its toll on its wildlife particularly waterbirds thus eroding our level of biological diversity (Mundkur et al 1996). According to BirdLife International (2000), of the 146 (12% of all) threatened birds that occur in wetland habitats, 57% inhabit lakes and pools, 36% rivers and streams, 30% bogs, marshes and swamps, 22% coastal lagoons, 11% estuaries and 5% salt and brackish marshes. In Malaysia, threatened species such as Storm's Stork (*Ciconia stormi*), Spotted Greenshank (*Tringa guttifer*), Chinese Egret (*Egretta eulophotes*), Milky Stork (*Mycteria cinerea*), Lesser Adjutant (*Leptoptilos javanicus*), Spoon-billed Sandpiper (*Eurynorhynchus pygmeus*) and Hook-billed Bulbul (*Setornis criniger*) depend exclusively on wetlands for their survival.

2.0 THE ASIAN WATERBIRD CENSUS (AWC) IN MALAYSIA

The Asian Waterbird Census (AWC) is a coordinated international scheme for the collection and dissemination of information on waterbirds and wetlands (Lopez & Mundkur 1997). Malaysia become involved in the scheme with the Department of Wildlife and National Parks (DWNP) Peninsular Malaysia as National Coordinator when it started in 1987 under the coordination of Wetlands International (formerly the Asian Wetland Bureau and the International Waterfowl and Wetlands Research Bureau).

The major objectives of the Asian Waterfowl Census are:

- To obtain information on an annual basis of waterbird population at wetlands in the region during the non-breeding period of most species (January), as a basis for evaluation of sites and monitoring of populations;
- To monitor on an annual basis the status and conditions of wetlands; and
- To encourage greater popular interest in waterbirds and wetlands, and thereby promote their conservation.

The Malaysian Nature Society (MNS), a non-governmental organisation, joined the programme as a joint National Coordinator with DWNP in 1999. The AWC in Malaysia is conducted during the 2nd or 3rd week of January by utilizing its base of MNS volunteers and birdwatchers. Since then, apart from natural wetlands, the survey coverage of wetlands extended to man-made wetlands such as oxidation ponds, reservoirs and former tin-mining pools.

3.0 IS MONITORING WORTH THE EFFORT?

Monitoring brings about different meaning to different people. For the purpose of this paper, monitoring means “surveillance that is carried out with specific objectives in mind, usually to detect departures from a set standard” (Bennun 2001). In order to ensure the ‘wise use’ of any wetlands, long-term monitoring in an integral part of its management. However, sustaining monitoring over a long period of time is a challenge. Funding and manpower are the hard to come by especially if it is over an indefinite period. Therefore, what we monitor is an important question that must be address in order for that process to be sustainable and effective. Furthermore, without these long-term data, we have no basis for making decisions. Nor do we have any way of assessing whether ecological changes are within natural variation, or in need further investigation and corrective action (Bennun 2001).

The design of the monitoring process should take into account the following;

1. determine the issues concerned,
2. decide what variables to measure,
3. know when our measurements indicate a problem, and
4. to be able to take action to tackle that problem (Bennun 2001).

Through this exercise, we are able to (1) detect responses to human-induced changes and natural changes, (2) evaluate the success of conservation efforts, (3) review and improve management and action plans (if any) and (4) evaluate the effectiveness of policies. In order to be effective, the monitoring process needs to be carefully designed.

As biological diversity issues becomes one of conservation's highest priorities, habitat inventories as well as effective monitoring are necessary to solve some of the issues as a national and local level. In order to do so, animal indicators need to be identified. An indicator group should cover species which are closely connected with certain types of habitats and those which are clearly linked to environmental changes (Flint 1998). Shorebirds have been known to make suitable indicators (Flint 1998; Rutschke 1987). Studies have shown that they can be indicators in different types of the tundra and forest-tundra (genera: *Pluvialis*, *Tringa*, *Phalaropus*, *Philomachus*, *Calidris*, *Gallinago*, *Limnodromus*), steppe and desert habitats (genera: *Vanellus*, *Chettusia*, *Himantopus*, *Recurvirostra*, *Limosa*, *Glareola*) and in forest zone wetlands, agricultural lands and raised bogs (genera: *Vanellus*, *Gallinago*, *Numenius*) (Flint 1998). Monitoring can also provide baseline data on bird populations and their fluctuations at key sites, and permit the identification of species or groups that are in long-term decline (Bennun & Nasirwa 2000).

The annual Asian Waterbird Census (AWC) was designed to be a monitoring tool for the conservation and management of wetlands. The programme concentrates on several areas of concern and the monitoring efforts are focused mainly on:

- Conservation (eg. threatened species, important nesting colonies or refuges)
- Ecology (eg. vegetation, keystone species, animals and plant communities)
- Potential problems and threats (eg. industrial or agricultural pollution etc.)

Although the programme has been running for about a decade in Malaysia, there is still room for improvement, growth and consolidation. This paper attempts to highlight its achievements, limitations and experiences of the Malaysian Nature Society (MNS) in conducting the census.

3.1 Growth of the Census

For the past four years, the MNS has been utilizing its volunteer base to implement the annual census. For the Society, this is an important part of its bird conservation work. Since 1999, the growth of the census has been increasing, albeit slowly (Table 1). Twenty to thirty MNS volunteers are involved in the census each year. Over at least twenty sites are surveyed each year in 7-10 States. The number of counted individual waterbirds have also been increasing steadily.

Table 1. Summary of the AWC (Malaysia) Results (1988/89-2002).

Year	No. of Individual Waterbirds	No. of Sites Counted	No. States Involved
1988/89	54,000	70	8
1990	41,659	71	8
1991	63,881	86	8
1992	67,396	76	8
1993	43,369	80	8
1994	30,767	10	4
1995	7,477	7	2
1996	4,208	11	4
1997	N/A	N/A	N/A
1998	N/A	N/A	N/A
1999	11,182	26	9
2000	15,566	20	7
2001	16,308	25	10
2002*	18,633	20	7

Sources: Siti Hawa Yatim & Ismail Hj Mamat (1994); Scott & Rose (1989); Noramly (1999, 2000); Yeap [2001, 2002 (in prep)]

3.2 Achievements, Strengths and Limitations

Listed below are some of the achievements of this undertaking since its inception in Malaysia:

- Better understanding of the distribution and abundance of migratory waterbirds in Malaysia during the migration period after the preliminary aerial and ground surveys in the 1980s (Hawkins & Howes 1986; Edwards et al 1989; Howes et al 1986; Howes & NPWO 1986; Edwards et al 1986; Parish & Wells 1984; Parish et al 1986). Through the surveys, the west coast of Peninsular Malaysia and certain wetland pockets in East Malaysia (Sarawak and Sabah) were identified as hotspots for migratory waterbirds, which the total migrating through has been estimated at about 315,000 individuals twice a year (1991). The continued monitoring work through AWC (Malaysia) provided further information on some of those sites (Mundkur et al 1992).
- Distribution of threatened waterbird species in Malaysia {Hawkins & Howes 1986; Edwards et al 1989; Howes et al 1986; Howes & NPWO 1986; Edwards et al 1986; Parish & Wells 1984; Parish et al 1986; Noramly 1999, 2000; Yeap 2001, 2002 (in prep.)}. Key roosting and nesting sites for certain threatened species such as the Lesser Adjutants and Milky Stork were discovered. Other threatened waterfowls are periodically recorded during the census throughout the years (Table 2).

Table 2. The Number and Distribution of Threatened Waterbirds Recorded in Malaysia during the AWC from 1999-2002.

Year	Species	Location	State	No. of Individual Waterbirds
1999	Lesser Adjutant	1) North-Central Selangor Coast & Matang	Selangor, Perak	27
	Chinese Egret	2) Pulau Kukup	Johor	13
2000	Lesser Adjutant	N/A	N/A	2
	Spotted Greenshank	N/A	N/A	2
2001	Spotted Greenshank	1) Penaga-Kuala Muda	Pulau Pinang	1
	Lesser Adjutant	2) Matang	Perak	3
	Storm's Stork	3) Loagan Bunut	Sarawak	2
2002	Spotted Greenshank	1) Bako-Buntal Bay	Sarawak	2
	Spoon-billed Sandpiper	2) Stesen Janaelektrik Sultan Salahuddin Abdul Aziz	Selangor	1
	Chinese Egret	3) Stesen Janaelektrik Sultan Salahuddin Abdul Aziz	Selangor	1
	Lesser Adjutant	4) Bako-Buntal Bay	Sarawak	1
		5) Parit Jawa	Johor	19
		6) Matang	Perak	26
		7) Stesen Janaelektrik Sultan Salahuddin Abdul Aziz	Selangor	1

- The identification of some important waterbird sites, which may qualify as wetlands of international importance under the criteria of the Ramsar Convention. For example Matang Forest Reserve (Perak), Pulau Bruit (Sarawak) and south-west coastal Johor. These areas frequently host a high diversity of waterbirds in terms of both number of individuals and species.
- Better understanding of the importance of man-made wetlands especially former tin-mining pools to waterbirds, both resident and migrant. The data essential and useful in lobbying for the establishment of the Kinta Nature Park in Perak (MNS 2000) recently. Apart from being suitable waterbird habitats, they also function as recreational areas and flood control.
- Assisted in the nomination of Important Bird Areas (IBA) in Malaysia particularly for wetland habitats. The project is currently under progress. The IBA programme is a collaborative project between MNS and BirdLife International, Cambridge, which aims at identifying crucial bird habitats based on predetermined selected criteria. Twenty-six wetland-related IBAs have been identified so far based on information gathered through AWC (Malaysia) and previous waterbird surveys (see Box 1).

BOX 1. Important Bird Area (Malaysia) – Bako-Buntal Bay, Sarawak

Administrative Region : Sarawak State, Kuching District

Coordinates : 1°42'N, 110°21'E

Altitude : Sea level

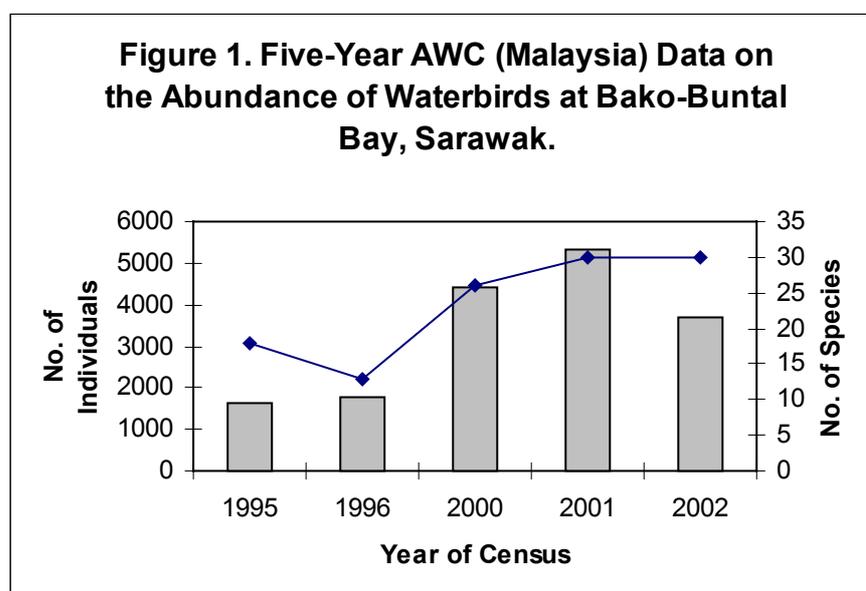
Habitat Type : Mangrove and mudflats

IBA Criteria : A1. Globally Threatened Species; A4i. Congregations

Justification

*The area was selected based on its importance to migratory waterbirds especially for shorebirds, egrets and terns. Previous AWC (Malaysia) surveys have shown that the area consistently host over 3,000 birds during the one-day census (Figure 1). Bako-Buntal Bay is nominated under the A1 and A4i Categories. This year, two Spotted Greenshank (*Tringa guttifer*), a globally threatened species, was recorded (Sebastian, pers. comm.). Chinese Egrets (*Egretta eulophotes*) have also been recorded in 1968 (Croxall 1969). The area also host 1% of the biogeographic population of the Lesser Sand-Plover (*Charadrius mongolus*). Other large congregations include Greater Sand-Plover (*C. leschenaultia*), Terek Sandpiper (*Xenus cinereus*) and Intermediate Egret (*Egretta intermedia*).*

For more information on the IBA programme, see Appendix 2.

**3.3 Strengths and Limitations of the AWC (Malaysia) Data**

The large amount of data collected can serve as the basis for decisions regarding the future of migratory waterbirds and wetland habitats conservation in the country. However, these data need to be carefully analysed. The exact type of analysis that could be used depends on the strengths and limitations of information gathered.

The strength of the AWC data lies in its:

- 1) standard data collection methods (without it, there can be no justification for comparisons); and
- 2) replicability.

The limitations include;

- 1) the number of survey sites is still generally low. Survey sites concentrate mostly on the west coast of Peninsular Malaysia, corresponding with the concentration of the majority of birdwatchers. The situation in east coast of the peninsula and East Malaysia needs to be improved,
- 2) the economic cost involved in visiting some key but remote sites, which is an important factor affecting the selection of the sites to survey by volunteers,
- 3) the availability of motivated and trained people in the country, and
- 4) the entry of data in the AWC (Malaysia) database is slower than expected.

The limitations have to a certain degree hampered the growth of the AWC (Malaysia). As a result, the information gathered is not yet sufficient for a comprehensive analysis carrying sufficient statistical weight.

4.0 APPLICATION, PROPOSED ACTIVITIES AND FUTURE PRIORITIES

The final question remains: Is the AWC (Malaysia) a useful and effective monitoring tool for waterbird and wetland conservation and management? Although the monitoring programme has its share of weaknesses and limitations, it has shown that it has the potential to grow even further. The recent nomination of more Ramsar sites in the country by the Minister of Science, Technology and Environment provide strong reasons to implement the AWC monitoring programme more extensively in this country. As the Ramsar manual justly states, “A monitoring programme should, ideally, be an integral part of a site-specific wetland management plan” (Ramsar Convention Bureau 1997).

The effects relating to application of the results or process of monitoring is tremendous which include the following:

- 1) Use in education, awareness and advocacy.
- 2) Building of capacity.
- 3) Exchange of information between organisations.
- 4) Establishment of a long term database.
- 5) Enhancement of long-term credibility with donors and policy makers.

In the short term, the following is planned for the enhancement of AWC (Malaysia):

- To stress the importance of visiting the same sites every year amongst volunteers, as the information value from a site will increase with the amount of data from it.

- To work closely with volunteers to solve problems as local level and to standardise information gathering and avoid duplicity. Closer cooperation with Wetlands International-Asia Pacific (WIAP) especially between the Regional and National Coordinator.
- To accelerate census data entry in the database.
- Priority monitoring based on two-tier system; IBA wetland sites and non-IBA wetland sites. Currently, less than 20% of the IBA sites are surveyed regularly. The AWC (Malaysia) should be utilised as a monitoring tool for the IBA sites thus providing much needed up-to-date information on the condition of the sites annually. Thus, the integration between IBA and AWC (Malaysia) is possible and will benefit both programmes (See Appendix 1).
- Better cooperation between NGO (eg. MNS, WIAP) and DWNP and other wildlife departments in the country to ensure better coverage of the census.

Continuity and success of the programme ultimately will depend on the sum of the individual efforts of the volunteers, government agencies and NGOs. Teamwork and commitment are crucial ingredients in which all monitoring work depend on. It is hoped that in Malaysia the efficacy of monitoring programmes such as AWC will reach the levels of those in Europe and some African nations in the future.

In summary, monitoring programmes should focus on likely threats, and ecological or economic concerns, should be as simple, robust and inexpensive as possible, should be sustained and consistent, and should involve local people and volunteers. If it is effective, monitoring must have a clear linkage to wetland management (Bennun 2001). The AWC (Malaysia) fits that description.

5.0 ACKNOWLEDGEMENTS

The Bird Conservation Council-Malaysian Nature Society would like to thank all the volunteers who faithfully take part in the census annually. Without their contribution, the AWC will not be possible. Special thanks also goes to Anthony Sebastian for his data on Bako-Buntal Bay waterbirds. Appreciation also goes to Wetlands International (Asia Pacific and Malaysia) for their enthusiasm, support and encouragement to the National Coordinators. The author would like to express his gratitude to Ms. Jaya Mary for her critical comments on this manuscript.

6.0 REFERENCES

- Bennun, L.A. 2001. Long-term monitoring and the conservation of tropical wetlands: high ideals and harsh realities. *Hydrobiologia* 458: 9-19.
- BirdLife International. 2000. *Threatened birds of the world*. Lynx Edicions and BirdLife International. Barcelona and Cambridge, United Kingdom.
- Blanco, D.E. & Canevari, P. 1997. The Neotropical Waterbird Census: Review and Future Priorities. In van Vessem (ed.), *J. Determining Priorities for Waterbird and Wetland Conservation*. Proceedings of Workshop 4 of the International Conference on Wetlands and Development. Kuala Lumpur, Malaysia, 9-13 October 1995. Wetlands International, Kuala Lumpur.
- Burhanuddin Mohd Nor. 1994. Malaysia Country Report. In D'Cruz, R. & O'Calaghan, B. *Priorities and Institutional Mechanisms for Wetland Protection and Wise Use in South-east Asia*.

Proceedings of the Ramsar South-east Asia Regional Workshop, Bogor, Republic of Indonesia, 29 March – 1 April 1994. Ramsar Bureau, PHPA & Asian Wetland Bureau.

Croxall, J.P. (1969). *Bird Notes from Sarawak: September-October 1968*. Sarawak Museum Journal 71: 391-394.

Davison, G.W.H. 1991. Birds. In Kiew, R (ed.). *The State of Nature Conservation in Malaysia*. Malaysian Nature Society, Kuala Lumpur.

DWNP. 1987. *Malaysian Wetland Directory*. Department of Wildlife and National Parks, Peninsular Malaysia.

DWNP-DANCED. 1996. *A Master Plan on Capacity Building & Strengthening of the Protected Areas System in Peninsular Malaysia*. Department of Wildlife and National Parks, Kuala Lumpur.

Edwards, P., Parish, D. & NPWO. 1986. *Survey of western coastline of Sarawak to evaluate the status of wetlands and to identify key sites for migratory waders – Preliminary Report No. 3*. INTERWADER, Kuala Lumpur.

Edwards, P.J., Haxby, J.B. & NPWO. 1989. *Evaluation of Sarawak Wetlands and Their Importance to Waterbirds Report No. 5: Pulau Bruit Revisited*. AWB Report No. 47. Asian Wetland Bureau, Kuala Lumpur.

Flint, V.E. 1998. Waders as indicators of biological diversity. In Hötter, H., Lebedeva, E., Tomkovich, P.S., Gromadzka, J., Davidson, N.C., Evans, J., Stroud, D.A. & West, R.B. (eds.). *Migration and international conservation of waders. Research and conservation on north Asian, African and European flyways*. International Wader Studies 10.

Hawkins, A.F.A. & Howes, J.R. 1986. *Preliminary Assessment of Coastal Wetlands and Shorebirds in South-west Peninsular Malaysia*. INTERWADER Publication No. 13, Kuala Lumpur.

Howes, J.R. & NPWO. 1986. *Evaluation of Sarawak Wetlands and their Importance to Waterbirds. Report 3: Pulau Bruit*. INTERWADER Publication No. 10, Kuala Lumpur.

Howes, J.R., Hawkins, A.F.A. & Parish, D. 1986. *Preliminary survey of wetlands and shorebirds along the east coast of Peninsular Malaysia*. INTERWADER Publication No. 14, Kuala Lumpur.

Lopez, A. & Mundkur, T. (eds.). *The Asian Waterfowl Census 1994-1996. Results of the Coordinated Waterbird Census and an Overview of the Status of Wetlands in Asia*. Wetlands International, Kuala Lumpur.

MNS. 2000. *Batu Gajah Nature and Heritage Park, Perak Darul Ridzuan*. A Concept Proposal by the Malaysian Nature Society (MNS) for the State Government of Perak, Malaysia. Malaysian Nature Society, Kuala Lumpur.

Mundkur, T., Parish, F., Wells, D. & D'Cruz, R. 1996. Status and Conservation of Shorebirds and Wetland Habitats in Malaysia. In Wells, D.R. & Mundkur, T. *Conservation of Migratory Waterbirds and their Wetland Habitats in the East Asian-Australasian Flyway*. Proceedings of an International Workshop, Kushiro, Japan. 28 November – 3 December 1994. Wetlands International-Asia Pacific, Kuala Lumpur, Publication No. 116, and International Waterfowl and Wetlands Research Bureau-Japan Committee, Tokyo.

Mundkur, T., Yus Rusila Noor, Rudyanto & Lane, B. 1992. *A Status Overview of Shorebirds in Malaysia and Indonesia. (Internal Report No. 1: AWB East Asia Flyway Coordination Project)*. Asian Wetland Bureau, Kuala Lumpur. (Unpublished)

Nasirwa, O. & Bennun, L.A. 2000. Co-ordinated waterbird counts: the Kenyan experience. *Ostrich* 71: 99-101.

Noramly, G. 1999. Waterfowl Census 1999 Local Report. *Suara Enggang* 4 (July-August): 6.

Noramly, G. 2000. Waterfowl Census 2000 Report. *Suara Enggang* 3 (May-June): 49-50.

Parish, D. & Wells, D.R. (eds.) 1984. *Interwader '83 Report*. INTERWADER Publication No. 1. INTERWADER, Kuala Lumpur.

Parish, D., Prentice, R.C. & Taylor, C.E. 1986. *INTERWADER-East Asia/Pacific Shorebird Study Programme – Annual Report 1985*. INTERWADER Publication No. 16, Kuala Lumpur.

Ramsar Convention Bureau. 1997. *The Ramsar Convention Manual: a guide to the Convention on Wetlands (Ramsar, Iran, 1971)*. (2nd Edition). Ramsar Convention Bureau, Gland, Switzerland.

Rutschke, E. 1987. Waterfowl as Bio-Indicators. In Diamond, A.W. & Fillion, F.L. (eds.). *The Value of Birds*. Proceedings of a Symposium and Workshop held at the XIX World Conference of the International Council for Bird Preservation, June 1986, Queens University, Kingston, Ontario, Canada. ICBP Technical Publication No. 6. ICBP, England.

Scott, D.A. & Rose, P.M. (comps.). 1989. *Asian Waterfowl Census 1989: Mid-Winter Waterfowl Counts in Southern and Eastern Asia*. The International Waterfowl and Wetlands Research Bureau (IWRB), Slimbridge.

Siti Hawa Yatim & Ismail Hj. Mamat. 1994. A Review of the Four Years Mid-Winter Waterfowl Census in Peninsular Malaysia 1990-1993. *Journal of Wildlife and Parks* 8: 27-39.

Smythies, B.E. 1999. *The Birds of Borneo (4th Edition)*. Revised by G.W.H. Davison. Natural History Publications (Borneo) Sdn Bhd and The Sabah Society.

Yeap, C.A. 2001. The Asian Waterfowl Census (AWC) 2001: A Malaysian Report. *Suara Enggang* 4 (July-August): 13-18.

Yeap, C.A. In prep. The Asian Waterfowl Census (AWC) 2002 Country Report.

APPENDIX 1. Important Bird Area wetland-related sites in Malaysia

SITES	HABITAT TYPE
<p>PENINSULAR MALAYSIA</p> <ol style="list-style-type: none"> 1. Timah-Tasoh 2. Penaga-Kuala Muda 3. Pondok Tanjung 4. Matang 5. Kland Islands 6. North-Central Selangor Coast 7. Stesen Janaelektrik Sultan Salahuddin Abdul Aziz 8. Benut 9. Pulau Kukup 10. Parit Jawa 11. South-east Pahang Swamp Forest 12. Pulau Layang-layang (Under Federal Government) 	<p>Reservoir / Freshwater lake Mangroves & mudflats Freshwater peatswamp forest Mangroves & mudflats Mangroves & mudflats Mangroves & mudflats Artificial ash ponds Mangroves & mudflats Mangroves & mudflats Mangroves & mudflats Freshwater peatswamp forest Reef atoll</p>
<p>SARAWAK</p> <ol style="list-style-type: none"> 13. Pulau Bruit 14. Bako-Buntal Bay 15. Limbang Estuary 16. Loagan Bunut 17. Maludam 18. Talang-Satang 19. Trusan-Sundar 	<p>Mangroves & mudflats Mangroves & mudflats Mangroves, mudflats & sandflats Peatswamp forest, freshwater lake Peatswamp forest Offshore islands & rocks Mangroves, mudflats & sandflats</p>
<p>SABAH</p> <ol style="list-style-type: none"> 20. Lower Kinabatangan 21. Klias Peninsula 22. Kulamba 23. Pulau Sipadan 24. Pulau Mantanani 25. Pulau Tiga 26. Tempasuk Plains 	<p>Riverine forest, freshwater swamp forest, peatswamp forest, open reed swamp Mangrove forest, Nipa swamp, freshwater swamp forest, peatswamp forest Mixed swamp forest Coral reef, beach vegetation Coral reef, beach vegetation Coral reef, beach vegetation Freshwater swamp forest</p>

APPENDIX 2. Important Bird Area Programme (Malaysia)

What is an IBA?

The function of the IBA programme is to identify and protect a network of sites, at a biogeographic scale, critical for the long-term viability of naturally occurring bird populations, across the range of those species for which a site-based approach is appropriate.

Important Bird Areas or IBAs;

- are places of international significance for the conservation of birds at the global, regional or sub-regional level,
- are practical tools for conservation,
- are chosen using standardised, agreed criteria applied with common sense,
- must, wherever, possible, be large enough to support self-sustaining populations of those species for which they are important,
- must be amenable to conservation and, as far as possible, be delimitable from surrounding areas,
- will, preferably include, where appropriate, existing protected areas,
- should form part of a wider, integrated approach to conservation that embraces sites, species and habitats.

Criteria for the selection of IBAs have been set in a hierarchy to identify sites of global and regional importance. At a global level, criteria embrace:

Category A1: Globally Threatened Species: sites which regularly hold significant numbers of globally threatened species, or other species of global conservation concern.

Category A2: Restricted-Range Species: sites which hold a significant component of the restricted-range species whose breeding distributions define an Endemic Bird Area (EBA) or a Secondary Area (SA). Sites also have to form one of a set selected to ensure that, as far as possible, all restricted-range species of an EBA or Secondary Area are present in significant numbers in at least one site and, preferably, more.

Category A3: Biome-Restricted Assemblages: sites which hold a significant component of the group of species whose distributions are largely or wholly confined to one biome. Sites also have to form one of a set selected to ensure that, as far as possible, all species restricted to a biome are adequately represented e.g. Indo-Malayan tropical dry zone, Sundaic lowland forest and Sundaic montane forest.

Category A4: Congregations: a site may qualify on any one of the four criteria listed below:

- i. Site known or thought to hold, on a regular basis, $\geq 1\%$ of a biogeographic population of a congregatory waterbird species;
- ii. Site known or thought to hold, on a regular basis, $\geq 1\%$ of the global population of a congregatory seabird or terrestrial species;
- iii. Site known or thought to hold, on a regular basis, $\geq 20,000$ waterbirds or $\geq 10,000$ pairs of seabirds of one or more species;
- iv. Site known or thought to exceed thresholds set for migratory species at bottleneck sites.

*For more information on the Malaysian IBAs, please contact Yeap Chin Aik at the address above.

NOTES AND BACKGROUND MATERIAL for use in Working Groups

DEVELOPING A PROPOSED FRAMEWORK FOR A WETLAND INVENTORY, ASSESSMENT AND MONITORING SYSTEM (WIAMS) IN MALAYSIA

Sundari Ramakrishna

Wetlands International-Malaysia Programme

1.0 BACKGROUND AND CONTEXT

Inventory, assessment and monitoring are vital components of effective wetland management. In synergy, these components provide the essential information that will support management decisions that impinge wetland areas. With the recognition that inventory, assessment and monitoring cannot be treated separately from effective management processes, increasing attention has been focussed on the design and implementation of an integrated wetland inventory, assessment and monitoring (WIAM) program.

The Malaysian Wetland Directory was published in 1987 and no national updates have been conducted since then. In addition, the data collected were fairly limited, with more emphasis on identifying wetlands of importance for protection purposes rather than for their importance for direct uses and for functions and services. The directory was also published as a printed document, not in an electronic format, which has made the updating process now very difficult and time consuming.

A need has been recognized for a more systematic, comprehensive approach to wetland assessment and inventory. Protocols for planning a wetland inventory have been developed and used in the past and are readily available.

2.0 DISTINCTIONS BETWEEN WETLAND INVENTORY, ASSESSMENT AND MONITORING

Wetland inventory: The collection and/or collation of core information for wetland management including the provision of an information base for specific assessment and monitoring activities.

Wetland assessment: The identification of the importance and status of wetlands and the threats operating on them as a basis for the collection of more specific information through monitoring activities.

Wetland monitoring: Regular collection of specific information on variables which may cause impacts on wetlands (such as increases in population pressure and pollutant levels) and the analysis of trends for implementing management.

3.0 A FRAMEWORK FOR DESIGNING A WIAMS

Step 1: Establish the purpose of gathering the information.

- Is it for assessing or evaluating the ecological features of the wetland?
- Is it for identification of the nature of a problem or impact or adverse change in the wetland?
- Is it for assigning values to the functions of the wetlands?
- Is it for evaluating the importance of the wetlands based on current status and threats? End result of this objective is to prioritize the list of wetlands in terms of their importance.

Step 2: Gather information

Inventorise or have a checklist of all the wetland sites both natural and man-made:

- State location, size, physical, chemical and biological features.
- State human activities, threats, protection and management status.
- State the benefits provided by the wetland.

*Notes: **Benefits (goods and services)** that wetlands provide encompasses direct uses, their functions and their attributes. **Direct uses** (also termed as goods) imply resources in wetlands that can be harvested directly for use. **Wetland functions** (also termed as services) are defined as physical, chemical or biological processes occurring within a wetland system such as those related to flood control, groundwater recharge etc.. **Wetland attributes** are values of wetland which are perceived as valuable to society such as cultural and religious values and biodiversity.*

Step 3: Uses of the assessment

- The evaluation of wetlands proposed for development
- Evaluation of impact for planning purposes.
- Evaluation of wetland restoration potential for conservation purposes.
- Determining wildlife habitat potential
- Evaluation of impacts to wetlands from development.
- Determine the value of wetlands where changes in land management are proposed to occur.

Step 4: Choose an appropriate method

Choose a method that is appropriate for a specific assessment need.
There are 4 general types of approaches:

I. Desk study assessment

These are techniques which describe the aerial extent and/or types of wetlands. This includes aerial photographs, topographical maps, watershed based GIS data, remote sensing data, wetland classification based on soil or substrate type or vegetation community.

II. Rapid assessment protocols

These are mostly low-cost techniques in which the data necessary to perform the assessment may be gathered in a short period of time. The results are likely to involve a large extent of subjective judgement. (e.g. Wetland Evaluation Technique 2.0, Habitat Evaluation Procedure –Thiesing, 2001).

III. Data-driven assessment methods

These are data based analytical (quantitative) methods which are usually expensive to develop and time consuming and often model-based, but provide a high degree of reproducibility. The results often have predictive value. (E.g. hydrologic engineering models, hydrogeomorphic classification method)

IV. Bio-indicators / Indices of Biotic Integrity

Single criterion evaluation - e.g. bird species richness may be used or multi-criteria evaluation techniques have been used to assess the ecological importance of sites. These may include biological criteria such as species richness, species diversity, habitat diversity, presence of rare, endangered and endemic species.

Step 5: Analysis of the Results

Evaluation Phase

Benefits that wetland provide

I. Direct uses (also called goods)

- Fisheries
- Agriculture
- Energy (water, peat, timber)

II. Functions (also called services)

- Flood control
- Shoreline stabilization
- Prevention of saltwater intrusion
- Water transport
- Sediment/nutrient retention
- Toxicant removal
- Microclimate stabilization
- Education
- Research
- Tourism
- Recreation.

III. Attributes

- Biological diversity; gene bank
- Unique cultural/heritage
- Life cycle – migration routes, nursery grounds.
- Global carbon sink
- Prevention of development of acid sulphate soils.

These criteria are ranked in relation to each other (direct uses, functions and attributes)

Degree of threat is also ranked according to the type and degree of threat operating on them.

The output is a listing of wetland sites prioritized for their importance.

Step 6: Report the results/information

Report the results and application

- For decision making
- For management purposes
- State whether or not objective has been achieved
- State contain recommendations for management action
- State whether further information is required.
- Evaluation of methods used.

Step 7: SOUND management of wetlands

- What type of management required for a particular wetland.
- What resources to safeguard.
- What monitoring protocols to adopt and use.
- Feedback to management plan.
- Management actions taken to minimize negative impacts identified through monitoring.

4.0 DISCUSSION

The above notes and background material detailed above will be useful to anyone who wishes to carry out a wetland inventory, assessment and monitoring system (WIAMS) for a particular wetland type or at the basin level. Wetland areas in many countries are under increasing pressure from development and urbanization within watersheds. Wetland resource managers, planners and decision-makers have differing priorities for the uses of wetlands. This often leads to conflicting management objectives. The need to make decisions about wetlands has thus created a need for information on the value, both from an ecological and social point of view of the wetland resources. In short there is a clear need for a standardized wetland inventory, assessment and monitoring system. This will enable resource managers, planners and decision-makers to make well-informed decisions.

However there is no one method or “magic bullet” when it comes to assessment of wetlands. The choice of methods is often dictated strictly by the available resources. A WIAM is best done as a collaborative effort so that recommendations arising are widely accepted and supported. The WIAM team should be multidisciplinary and include local communities and /or local NGOs who can aid in field activities.

More importantly, information collected on wetlands has not been widely disseminated to key players. This will make a WIAMS less effective. Information dissemination to all relevant stakeholders is vital component of a WIAM. When information gathered is shared among all relevant stakeholders, gaps can be identified as well as inadequacies of the procedure or methodologies can be highlighted and addressed. Another important feature of a useful WIAM is whether data/ information can be easily updated on a regular basis.

5.0 CONCLUSION

The protocol laid out here and elaborated in greater detail in Table 1 (see Conclusion) for a WIAMS is presented as a guide for planning an inventory, monitoring and assessment of wetlands. The protocol outlines a number of steps that can be followed to ensure that the best decisions are made in relation to the objectives and available resources.

6.0 REFERENCES

Ramsar Bureau 1999. Wetland Risk Assessment Framework. Website www.ramsar.org

Thiesing MA 2001. An evaluation of wetland assessment techniques and their application to decision making. In CM Finlayson, NC Davidson and NJ Stevenson (eds) 2001a. Wetland inventory, assessment and monitoring: *Practical techniques and identification of major issues*. Proceedings of Workshop 4, 2nd International Conference on Wetlands and Development, Dakar, Senegal, 8-14 November 1998, Supervising Scientist Report 161, Supervising Scientist, Darwin. pp 87-96.

Finlayson CM, Howes J, Begg GW, Tagi K and Lowry J 2002. A manual for an inventory of Asian wetlands. Asian Wetland Inventory regional workshop, Phnom Penh, Cambodia, 8-9 April 2002. In draft.

Finlayson CM and Davidson NC 2001. Wetland inventory, assessment and monitoring. Practical techniques and identification of major issues: Introduction and review of past recommendations. In CM Finlayson, NC Davidson and NJ Stevenson (eds) 2001a. *Wetland inventory, assessment and monitoring: Practical techniques and identification of major issues*. Proceedings of Workshop 4, 2nd International Conference on Wetlands and Development, Dakar, Senegal, 8-14 November 1998, Supervising Scientist Report 161, Supervising Scientist, Darwin. pp 1-10.

Finlayson, CM, Davidson NC and Stevenson NJ (eds) 2001. *Wetland inventory, assessment and monitoring: Practical techniques and identification of major issues*. Proceedings of Workshop 4, 2nd International Conference on Wetlands and Development, Dakar, Senegal, 8-14 November 1998, Supervising Scientist Report 161, Supervising Scientist, Darwin.

Spiers, AG 2001. Wetland Inventory : Overview at a global scale. In CM Finlayson, NC Davidson and NJ Stevenson (eds) 2001a. *Wetland inventory, assessment and monitoring: Practical techniques and identification of major issues*. Proceedings of Workshop 4, 2nd International Conference on Wetlands and Development, Dakar, Senegal, 8-14 November 1998, Supervising Scientist Report 161, Supervising Scientist, Darwin. pp 23-29.

Finlayson, CM 2001. Considerations for undertaking a wetland inventory. In CM Finlayson, NC Davidson and NJ Stevenson (eds) 2001a. *Wetland inventory, assessment and monitoring: Practical techniques and identification of major issues*. Proceedings of Workshop 4, 2nd International Conference on Wetlands and Development, Dakar, Senegal, 8-14 November 1998, Supervising Scientist Report 161, Supervising Scientist, Darwin. pp 11-21.

TECHNICAL WORKING GROUPS SESSIONS

Workshop participants were randomly divided up into four groups (see Appendix IV). Each group was assigned a different case scenario, each involving the *application of a multi-scalar wetland inventory, assessment and monitoring approach*. The case scenarios were as follows:

1. New agricultural development proposed in a relatively undisturbed catchment containing a Ramsar wetland downstream of the development.
2. Evaluate/assess and report on the ecological character of wetlands in Malaysia. From the assessment show how catchment-level activities that are likely to result in ecological degradation can be identified, prioritised and risks managed.
3. Remediation of wetlands adjacent to urban (including domestic and industrial) and agricultural developments that are subjected to more stringent waste-water discharge regulations and enforcement.
4. Assessment of water bird conservation status in Malaysia.

After deliberations and discussions, the four groups presented their outcomes. These are summarised in the following section.

BREAK OUT GROUP REPORTS

1. New Agricultural development proposed in a relatively undisturbed catchment containing a RAMSAR wetland downstream of the development

STEP 1- Objective

Main Objective: To assess the potential impact(s) of the proposed agricultural development to the RAMSAR site downstream (e.g. Tasik Bera Ramsar Site)

Sub-Objectives:

1. to identify potential direct and indirect impacts
2. to review biophysical/chemical parameters
3. to identify issues relating to physical environments, socio-economics and biodiversity
4. to identify mitigating and monitoring measures

STEP 2-Information Gathering

1. review a comparable situation at another site
2. review the current inventories of the site
3. study the proposed project's activities (using Environmental Impact Assessment, project proposal)
 - a. land clearing practices – extent of clearing, open burning and associated impacts including siltation and changes to water quality,
 - b. type of crops - rubber, oil palm
 - c. use of chemicals - pesticides, herbicides, fertilizers
 - d. settlement
 - e. hydrology - surface water, groundwater
 - f. waste management
 - g. pollution control
4. fieldwork/survey – data collection
 - focus on whole-of-catchment
 - RAMSAR site – use existing inventories
 - site of the proposed development
5. identify any monitoring systems:
 - yes – utilise
 - no – propose and establish

STEP 3 – Assessment Of The Impacts

Method: Assessment of Project Impacts

Assessment of project impacts can be carried out using EIA Matrices or by considering the overall nature of the project as below.

A. EIA Matrix

Activities	Parameters				
	Water Quality	Noise	Facilities		
Land Clearance					

B. Overall Project Impacts

No	DIRECT IMPACTS
1	Water quality
2	Soil erosion and siltation
3	Soil pollution
4	Changes in hydrological regimes-lower flow, high flow, groundwater and flooding
5	Loss of wildlife habitats
6	Microclimate changes
	INDIRECT IMPACTS
7	Changes in biodiversity
8	Changes to socio-economics - tourism, recreation, fisheries, hunting areas
9	International obligations threatened
10	Fragmentation of wildlife habitats
11	Economic opportunities - employment
12	Infrastructure development – leads to encroachment, more development

STEP 4, 5 and 6 - Method, Result, Analysis, Recommendation & Reporting**Method****Assessment of Wetland Function Impairment**

The analysis of the relative severity of wetland function impairment is based on the changes in the parameters identified in the project impact assessment (Step 3). Analysis is carried out by scoring the impact of the parameter change to specific wetland functions. The scoring system is given below:

Wetland Function Impairment Scoring System	
Type of Impact	Score Value
No impact	0
Indirect impact	1
Direct impact	2

Analysis

Three types of analysis may be carried out based on the resulting score table (see page 124). These are;

1. the severity of impairment of a specific wetland function,
2. the severity of impairment to the total wetland system, and

3. the importance of a parameter change in affecting the total wetland system.

1. The severity of impairment of a specific wetland function

The severity of impairment to a specific wetland function is calculated as a ratio to the total maximum possible impairment which could occur due to all the parameter changes identified. The maximum possible impairment by any of the change parameters (from Step 3) on a wetland functions is regarded to be the result of a direct impact. The value of the maximum possible function impairment is equivalent to the direct impact score. It is calculated as below:

$$\begin{aligned} &\text{Maximum possible function impairment, MPFI,} \\ &= (\text{change parameter}) \times (\text{direct impact score}) \end{aligned}$$

The total maximum possible impairment on a wetland function is calculated from the sum of all maximum possible impairments. Therefore, if there are 3 change parameters identified, then the total maximum possible impairment is

$$\begin{aligned} &\text{Total maximum possible function impairment, TMPFI,} \\ &= (\text{change parameter}) \times (\text{direct impact score}) \\ &= 3 \times 2 \\ &= 6. \end{aligned}$$

The Wetland Function Impairment Severity is then calculated as the total score for a function divided by the TMPFI. The maximum severity will result in a value of 1 while the minimum severity will result in a value of 0.

2. The severity of impairment of the total wetland system

The total impairment of a wetland ecosystem is calculated similarly based on the number of functions which the system performs. Thus if there are 3 change parameter identified and 5 wetland functions, the total maximum possible impairment on the wetland ecosystem is calculated as below:

$$\begin{aligned} &\text{Total maximum possible system impairment, TMPSI,} \\ &= (\text{wetland function}) \times (\text{change parameter}) \times (\text{direct impact score}) \\ &= 5 \times 3 \times 2 \\ &= 30 \end{aligned}$$

The Wetland System Impairment Severity is then calculated as the total score for all change parameters on all wetland functions divided by the TMPSI. The maximum severity will result in a value of 1 while the minimum severity will result in a value of 0.

3. The importance of a parameter change in affecting the total wetland system

The importance of a parameter in affecting all wetland functions may also be assessed based on the total impact of a particular change parameter on all wetland functions.

Again the total maximum impact of a change parameter on the wetland system is given by

$$\begin{aligned} &\text{Total maximum impact of a change parameter, TMICP} \\ &= (\text{wetland function}) \times (\text{direct impact score}) \end{aligned}$$

Then Parameter Change Importance can be calculated as the total score for all wetland functions divided by the TMICP. The maximum severity will result in a value of 1 while the minimum severity will result in a value of 0.

The use of these three indices allow for a semi-quantitative method for:

1. an overall assessment of wetland sustme impacts that may occur,
2. a ranking of functions that would be most affected, amd
3. indicate parameter changes that need to be mitigated and monitored closely.

Qualifications to the Method of Analysis

There are some qualifications which need to be made to the method of analysis described above. The first, of course is the implication that the effect of indirect impacts as less than that of direct impacts, and that direct are twice as importance as indirect impacts. This is due to the scoring system where indirect impacts are given a score of 1 whereas direct impacts are given a score of 2. In addition there may be some query as to the distinction between what might be considered a direct impact and what might be an indirect impact. An important consideration is whether different individuals give different scores.

The only defense is that the method represents a quick method of assessment which circumvents the problem of having to wait for all information to be available before management measures can be considered, The subsequent proposed monitoring and mitigation measures itself will be sufficient control to ensure gathering of data and information for evaluation of the preliminary assessment.

As for the distinction between direct and indirect impacts, some guidance may need to be given to the assessor as to the distinction between the two categories. In essence an ecosystem specialist may argue that all impacts can be considered direct due to the ecological web linkages. A good prescription is to consider whether the impact suspected will be of an immediate nature, and thus a direct impact, or whether the effects would only be felt over a longer period of time, and considered as an indirect impact. The use of ecosystem function charts or models, with the relevant environmental linkages, will also be one method to refine direct and indirect impacts to the function.

Another consideration which is often considered in EIA matrices is the duration of impact. This method ignores the issue of time. The analysis becomes more complex and it is arguable if the analysis would be much improved if the time factor is included. Probably not, is the answer, Although a particular event may be short-term, often its results are long term. For example, land clearing often is short-duration but it results in long-term landuse change or hydrological regime change. In this case the overall assessment method in Step 3 appears to be the more appropriate direction to take rather than the use of conventional EIA matrices.

Project Impact Score Table

		Change No. (Step 3)	1	2	3	4	5	Total Score	Wetland Function Impairment Severity
		Change Parameter	Water Quality	Soil erosion, siltation	Soil pollution	Hydrological regime	Habitat & biodiversity		TMPFI = 5 x 2 = 10
Method	No	Wetland Functions							
	1	Flood Control	0	2	1	2	0	5	0.5
	2	Water Purification	2	2	1	2	0	7	0.7
	3	Biodiversity	2	2	2	1	2	9	0.9
	4	Socio-economics	1	2	1	1	1	6	0.6
	9	Etc							
Results & Analysis		Total score TMICP = 9 x 2 = 18	5	10	6	16	8	45	TMPSI = 9 x TMPI = 90
		Change Parameter Importance	5/18 = 0.28	10/18 = 0.56	6/18 = 0.33	16/18 = 0.89	8/16 = 0.5		Wetland System Impairment Severity = 0.5
		Wetland Function							
Description of Impacts	1	Flood Control				Water level changes affect organism habitat			
	2	Water Purification							
Recommendations		Mitigation Measures & Control							
	1	Existing				None			
		Additional				Ensure minimum flow			
		Cost							
	2								
Recommendations		Monitoring							
	1	Parameter				Water level			
		Criteria & Critical Levels				Warning system when below critical level Action: Notify relevant parties			

2. Evaluate/assess and report on the ecological character of wetlands in Malaysia. From the assessment show how catchment-level activities that are likely to result in ecological degradation can be identified, prioritised and risks managed.

To best illustrate the case scenario objective, it was decided to narrow the focus of the investigation to mangroves of Malaysia.

STEP 1 - Objectives

- To map and assess the distribution of mangroves
- To assess the extent of mangrove loss
- To assess the diversity / quality of mangroves
- To assess the dominant role that mangroves play in the ecosystem (values/functions)
- To establish a baseline

STEP 2 – Need / Fulfilling The Objectives

1. Literature review
 - Remote sensing / GIS
 - Developmental Plan
 - Inventory
 - Wetland complex (name, location, climate, ecology, population, land and water use, jurisdiction, management issues, data sheet etc.)
2. Determine the level of degradation.

STEP 3 – What are the Uses of the Assessment?

- Basic for policy-setting
- Current status (this can be modified into step 1)
- Park resources for managers
- Prioritize management measures
- Adopt proper mitigation / restoration measures
- Determine level of involvement of local population /community

STEP 4 – Choose an Appropriate Method of Gathering Information

1. Use existing information
2. Remote sensing and aerial photos
 - extent of loss, distribution, establishment of baseline and identification of threats.
3. Ground survey
 - topographic maps, land use maps.
4. Common standardized database (GIS)

STEP 5 – Assessment

1. Ranking of mangroves according to their importance (direct uses, functions, attributes)
2. Current status
3. Current and potential threats
4. Extent of degradations
5. Public awareness
6. National / regional / international commitments
7. Determine where restoration programmes are required
8. Perception of different stakeholders

STEP 6 – Report

- Recommendation/ suggestions
- Action plans
- Research
- Funding

STEP 7 – Monitoring

- Changes in the areal extent of mangroves
- Mitigation efforts
- Existing threats
- Mechanism – remote sensing , ground survey
- Implementation of the action plan by the management authorities.

CONCLUSION

- Objectives driven
- Stakeholders needs
- Emphasize on inventory stage
- Adaptation of the WIAM to local scenarios

3. Remediation of wetlands adjacent to urban (including domestic and industrial) and agricultural developments that are subjected to more stringent waste-water discharge regulations and enforcement

FRAMEWORK FOR WETLAND REMEDIATION

- 1) Describe the present characteristics of the wetlands
- 2) Make a comparative assessment of unaffected wetlands
 - original conditions
 - target conditions
- 3) List all factors affecting wetlands
 - prioritise
- 4) List remedial actions
- 5) Describe target conditions
 - stepped targets
- 6) Measuring success in reaching targets
 - monitoring
 - selection and use of indicators
- 7) Public awareness and consultation at all steps

1) DESCRIBE THE PRESENT CHARACTERISTICS OF THE WETLANDS

Degraded wetland including having 'Class V' water quality standard (refer Appendix I)

- Water brown in colour
- River flows is sluggish
- Not suitable for drinking
- Excessive blue green algae and eutrophication
- Birds populations reduced to 10%
- No aquatic plants
- High sedimentation
- High suspended solids
- Degraded catchment
- Fish resources reduced to cater only for subsistence fishing
- Fish fauna dominated by *Tilapia*

2) COMPARATIVE ASSESSMENT OF UNAFFECTED WETLANDS

Original conditions

- 50 square kilometers in area
- The wetland comprised a river flowing into a lake
- Water quality 'Class I' (refer Appendix I)

- Provided habitat for wildlife
- Freshwater fish resources were abundant

- Wildlife was abundant
- The wetland was used as a stopover by migratory bird
- The wetland supported a high bird population
- Local communities depended heavily on the wetland, e.g. it supported 400 fishermen with income of RM100,000 annually
- By way of a water channel, water from the wetland was diverted and used for adjacent agricultural activities.

Target conditions and indicators

- Water quality 'Class II' (refer Appendix I)
- Indicators: fish, shrimps, mussels, migratory birds and bird population, flora

3) LIST ALL FACTORS AFFECTING THE WETLANDS

Prioritise:

- i) Palm oil industries- effluents/ suspended solids affecting BOD
- ii) Light industry (textile, rubber gloves) with chemical effluents
- iii) Land clearing and agriculture with dispersion of sediment, pesticides, fertilisers
- iv) Urbanisation
 - domestic waste
 - stormwater run off

4) REMEDIAL ACTIONS

Controls:

- 1) Implement efficient treatment plants in all industries
- 2) Build strategic retention ponds to mitigate adverse effects of storm water run off

Specific remedial actions:

- 3) Rehabilitation and revegetation of wetland/stream banks
- 4) Introduction of aquatic plants
- 5) Landscaping

5) TARGET CONDITIONS

- 1) Water quality index improves from Class V to Class II
- 2) Restore habitat including aquatic and riparian vegetation and fish stocks

6) MEASURING SUCCESS IN REACHING TARGETS

Indicators for monitoring

- *Biological*

1. Plants - aquatic and riparian
2. Fish stocks
3. Phytoplankton communities
4. Birds
5. Mammals
6. Amphibians and reptiles

- *Chemical and Department of Environment effluents standards for sewage discharge into rivers (refer Appendix I)*

1. Dissolved oxygen
2. Suspended solids
3. BOD (Biological Oxygen Demand)
4. COD (Chemical Oxygen Demand)
5. pH
6. Ammoniacal nitrogen, phosphate

- *Aesthetic*

1. Odour
2. Scenic/landscape
3. Clear water/transparency

7) PUBLIC AWARENESS AND CONSULTATION

- have consultations and discussions with local communities on fish resources, water quality etc..
- get feedback from locals to validate actual data collected on the field.
- consult local community when conducting remedial action.
- disseminate information to local community and groups.

Appendix I

Water Quality Index System for Rivers in Malaysia based on standards established, administered and enforced by the Department of Environment (DOE) Malaysia

A Water Quality Index, in common with many other indices systems, relates a group of water quality parameters to a common scale and combines them into a single number in accordance with a chosen method or model of computation. The main objective of the WQI system is to use it as a preliminary means of assessment of a water body for compliance with the standards adopted for five designated classes of beneficial uses. The desired use of WQI to an assessment of water quality trends for management purposes even though it is not meant specially as an absolute measure of the degree of pollution or the actual water quality.

WQI Based on DOE Formula

The parameters chosen for the WQI based on the DOE's formula are DO, BOD, COD, SS, AN and pH. The formula used in the calculation of the DOE's WQI is:

$$WQI = 0.22 * SIDO + 0.19 * SIBOD + 0.16 * SICOD + 0.15 * SIAN + 0.16 * SISS + 0.12 * SIpH$$

where

- SI is the subindex of each parameter.
- DO - Dissolve Oxygen
- BOD - Biological Oxygen Demand
- COD - Chemical Oxygen Demand
- AN - Ammoniacal Nitrogen
- SS - Suspended Solid
- pH - Acidity/Alkalinity

General Rating Scale for the Water Quality Index (WQI)

Usage	10	20	30	40	50	60	70	80	90	100	WQI
General	Very Polluted						Slightly Polluted		Clean		
Water Class	V			IV		III			II	I	
Public Water Supply	Not Acceptable			Doubtful		Necessary Treatment Becoming more Expensive			Minor Purific Required	Purification not Necessary	
Recreation	Not Acceptable		Obvious Pollution Appearing	Only for Boating	Doubtful for Water Contact	Becoming Polluted Still Acceptable Need Bacteria Count		Acceptable for all Sports			
Fish, Shellfish and Wildlife	Not Acceptable			Coarse Fish Only	Handy Fish Only	Doubtful for Sensitive Fish	Marginal for Trout	Acceptable for all Fish			
Navigation	Not Acceptable			Obvious Pollution Appearing	Acceptable						
Treated water Transportation	Not Acceptable	Acceptable									
	10	20	30	40	50	60	70	80	90	100	WQI

Interim National River Water Quality Standards for Malaysia

Parameters (units)	Classes					
	I	IIA	IIB	III	IV	V
Ammoniacal Nitrogen (mg/l)	0.1	0.3	0.3	0.9	2.7	>2.7
BOD ₅ (mg/l)	1	3	3	6	12	>12
COD (mg/l)	10	25	25	50	100	>100
DO (mg/l)	7	5-7	5-7	3-5	<3	<1
pH	6.5-8.5	6-9	6-9	5-9	5-9	-
Colour (TCU)	15	150	150	-	-	-
Elect. Cond. [#] (mmhos/cm)	1,000	1,000	-	-	6,000	-
Floatables	N	N	N	-	-	-
Odour	N	N	N	-	-	-
Salinity [#] (‰)	0.5	1	-	-	2	
Taste	N	N	N	-	-	
Total Diss. Solid [#] (mg/l)	500	1,000	-	-	4,000	
Total SS (mg/l)	25	50	50	150	300	>300
Temperature (°C)	-	Normal±□	-	Normal±□	-	-
Turbidity (NTU)	5	50	50	-	-	-
F. Colif ⁺ (counts/100ml)	10	100	400	5,000	5,000	-
Tot. Colif. (counts/100ml)	100	5,000	5,000	(20,000)* 50,000	(20,000)* 50,000	>50,000

N - No visible floatable materials/debris, or no objectionable odour, or no objectional taste

- Related parameters, only one recommended for use

+ - Geometric mean

* - Maximum not to be exceeded

Effluent Discharge Standards to Malaysian Inland Waters

Parameter (mg/l unless otherwise stated)	Maximum Permitted Value	
	Standard A	Standard B
Temperature (°C)	40	40
pH (units)	6.0-9.0	5.5-9.0
BOD ₅ at 20°C	20	50
COD	50	100
Suspended Solids	50	100
Mercury	0.005	0.05
Cadmium	0.01	0.02
Chromium, hexavalent	0.05	0.05
Arsenic	0.05	0.10
Cyanide	0.05	0.10
Lead	0.10	0.5
Chromium, trivalent	0.20 [#]	1.0 ⁺
Copper	0.20 [#]	1.0 ⁺
Manganese	0.20 [#] 0.20 ⁺	1.0 ⁺
Nickel	0.20 [#] 0.20 ⁺	1.0 ⁺
Tin	0.20 [#]	1.0 ⁺
Zinc	1.0	1.0
Boron	1.0	4.0
Iron	1.0	5.0
Phenol	0.001	1.0 [⊕]
Free Chlorine	1.0	2.0 [⊕]
Sulphide	0.5	0.5
Oil and Grease	Not detectable	10.0

Source: Environmental Quality (Sewage and Industrial Effluents) Regulations 1979

Notes:

* The legislation does not specify any tolerance percentiles for the maximum permitted values and as such they are absolute values.

Where two or more of these metals are present in the effluent, the concentration of these metals shall not be greater than 0.50 mg/l in total.

+ Where two or more of these metals are present in the effluent, the concentration of these metals shall not be greater than 3.0 mg/l in total or 1.0mg/l in total for solution forms.

⊕ When both phenol and free chlorine are present, the concentration of phenol shall not be greater than 0.2 mg/l nor the concentration of free chlorine greater than 1.0 mg/l.

4. Assessment of water bird conservation status in Malaysia

STEP 1: State the purpose and objective of gathering the information

Purpose: To assess impacts of mudflat ecosystem services on waterbirds

- Waterbirds and mangroves/mudflats are intricately linked to each other. The habitat bears much importance to resident and migratory waterbirds, which may number a few thousands in an area particularly during the migratory months. Mudflats are either used as staging or wintering sites by migrant waterbirds. Globally, each mudflat sites within a flyway is *akin* a bead in a chain of necklace.

Objectives:

1. Assess populations of waterbirds
 - Waterbird populations that utilises the mudflats need to be assessed in terms of their abundance and species composition.
2. Identify conservation needs
 - Conservation needs of the waterbirds must be determined by identifying its ecological needs and the current and potential threats that they may face.
3. Determine the effects of changes in mudflat ecosystems on waterbirds
 - Natural abiotic factors and threats will have profound effects on the mudflats which in turn will determine the survival of the waterbirds and the degree of habitat utilisation by waterbirds on the area.

STEP 2: Information gathering

- Desk study - Check out published materials (reports/books/papers)
 - Published and unpublished materials can be gathered from libraries of local universities, non-governmental organisations (eg. Malaysian Nature Society, Wetlands International Offices, WWF Malaysia etc.), from government agencies (Wildlife departments, Forestry departments etc.), waterbird and wetland researchers (foreign and local) and from wetland site managers.
 - These materials will give an overview of the waterbird conservation and historical information of the selected survey sites (associated biodiversity and abiotic factors).
- Remote sensing information
 - GIS maps can provide information of spatial and temporal changes to the waterbird sites (if available).
- Field surveys
 - Could be done after completing the desk study and in wanting to fill the information gaps identified while conducting the desk study e.g. to ascertain the current extent of the waterbird sites.

STEP 3: Uses of the assessment

- Knowledge of populations and diversity of waterbirds
 - Literature search will provide information on previous waterbird population and diversity of the surveyed site(s). The current survey will yield new information on the matter. A comparison of both sets of data will give wetland or resource managers/conservationist/researchers an understanding of the current situation e.g. whether there is an increase or decline of the waterbird population, whether any species require special conservation attention, etc. Ecological changes in wetlands are intricately linked to the rise and fall of the waterbird population.
- Identify conservation needs
 - Changes between both data sets will allow the identification of the degree of conservation needs of the particular population or species.
- Understand current changes in mudflat ecosystems and effects on waterbirds
 - Long term data will be needed to assess the health of the mudflats. Various waterbirds depend on the fertility of the mudflats for survival e.g. the abundance of molluscs and annelids in the mudflats which are the source of food for these birds. As mudflats are a dynamic habitat, changes to its relative position within a mangrove ecosystem may need to be given due attention.

STEP 4: Choose appropriate methods and criteria

Certain criteria can be selected and used, according to suitability, to rank the conservation importance of the particular waterbird site. Priority action can then be drafted according to that ranking order.

- Species richness and abundance (use Ramsar and IUCN criteria)
- Changes in water quality (abiotic factors) (water quality classifications)
- Threats to waterbirds and other species (high – low)
- Management and conservation status (good – bad)
- Public awareness (high – low)
- Socioeconomic status (high income – low income)
- Habitat change (undisturbed – degraded)

STEP 5: Analysis of results

- Based on criteria established in step 4, and having done inventory, assess the present situation/status.
 - e.g. use Ramsar criterion on waterbirds to identify wetlands of international importance.
- Attention should then be focused on endangered waterbird habitats and threatened birds used as flagship species to promote the conservation of waterbird sites, in this context, the surveyed mudflats. For example, the usage of the Black-faced Spoonbills and Spoon-billed Sandpipers in East Asia as conservation ambassadors has increased protection for their mudflat habitats. Indirectly, other threatened flora and fauna in the particular habitat will also benefit from the protection efforts.

STEP 6: Report and document results

- Include development of waterbird monitoring programme according to system of Asian waterbird census, with increased frequency (more than once a year).

- Preparation of report and dissemination of findings to relevant parties is needed to alert them about the changes taking place. Action plans (habitat or species) may be drawn up based on the survey findings and agreed upon by all stakeholders of that particular site. One of the important components within that action plan is the need for regular monitoring in order to build up a database on the site and its waterbirds. The future of the site may be determined by the information gathered. Among the problems the site managers have been facing for many years, is the lack of manpower to carry out monitoring exercises. A solution to this problem would be in establishing some sort of cooperation and collaborative efforts between the site management and NGOs (e.g. MNS, WI). Utilising the Asian Waterfowl Census programme as a monitoring tool may be applied. Similar experiences using such tool have proved to be cost effective (to a certain degree) in South America and Africa. The information obtained from these exercises will drive future conservation efforts in many wetland areas throughout the world.

STEP 7: Implementation of monitoring programme

4.0 CONCLUSION

Based on all the papers presented at the workshop, the deliberations and feedback obtained from the workshop participants via Questions & Answers (see Appendix V) and the results from the group break-out sessions, a proposed framework for a Wetland Inventory, Assessment and Monitoring System (WIAMS) in Malaysia has been developed. Many participants felt that the idea of an interlinked and multi-scaled wetland inventory, assessment and monitoring approach has great appeal, with application well beyond that of wetland ecosystems. The developed proposed framework has combined a number of key elements but formerly disparate ideas on these subjects. See Table 1 for further details on the proposed framework for WIAMS. The proposed WIAMS framework seen overleaf is a guide to wetland practitioners what logical steps to follow in order to conduct an inventory of wetlands and its assessment as well. It explains the rationale behind each step taken in the process and what specific outputs can be obtained from each step of the process. The most essential feature of the framework is that it can be used at any level: river basin (catchment), wetland complex or at wetland habitat level.

The objectives of the workshop were met to some extent but to assess whether each participant has fully understood the WIAMS processes would be hard to quantify since it was beyond the scope of the workshop to determine it. It was clear that the majority participants understood the difference between inventory, assessment and monitoring. The Asian Wetland Inventory which incorporates a multi-scalar approach to inventory could be used as the basis for conducting a national wetland inventory for Malaysia.

Some Malaysian participants at the workshop demonstrated considerable expertise in assessment methodologies and this highlighted further the need to coordinate and develop national frameworks for WIAMS through effective networks and partnerships. A review of gaps and coordination of data collection on wetland inventory is imminent, therefore developing and making greater use of communication networks as well as the need for coordination of all relevant agencies in Malaysia, including those holding existing data and those that could contribute further to data collection for an inventory.

Participants agreed in principle that the draft framework can be used but required some fine tuning when it comes to the steps included in the process of WIAM. The case studies of WIAM from India and Australia helped many participants to understand the importance of WIAMS in the management and wise use of wetlands. Much awareness was enhanced on the ongoing programmes e.g. Wetland Monitoring Programme in Putrajaya, and the Asian Waterbird Census Programme.

The Workshop discussions and presentations had reached out to important key government agencies who play a pivotal role in wetland management and conservation in Malaysia.

TABLE 1: A PROPOSED FRAMEWORK FOR A WETLAND INVENTORY, ASSESSMENT AND MONITORING SYSTEM (WIAMS) IN MALAYSIA

STEP NO	TASK	DESCRIPTION	RATIONALE	OUTPUT
Initiate the wetland inventory, assessment and monitoring system				
1	SET OBJECTIVES	1. State purpose & objective 2. Decide at which spatial scales wetland inventory, assessment and monitoring (WIAM) need to be carried out.	It is important to state why WIAM are needed. The coverage and level of detail required need to be decided upon. See the AWI and WIAM papers for more information. However, it should be remembered that, for any level of detail, information on the catchment areas and ecological health of the wetland should be gathered in addition to information on the wetlands themselves.	Clear statement of purpose & objectives in undertaking WIAM.
2	IDENTIFY PARTNERS	Identify individuals/organizations with which to collaborate in undertaking WIAM.	WIAM are best done as a collaborative effort so that recommendations arising are widely accepted and supported. The team should be multi-disciplinary, and include at least an ecologist, a hydrologist and a socio-economist. Government agencies involved with natural resource management in wetland areas should be involved. The team should also include representatives of the local community and local NGOs who can aid in the field activities.	Multidisciplinary team to undertake WIAM.
3	TIME & TIMING	Establish how much time is needed to carry out WIAM.		Schedule of activities and itinerary, date by

		Establish season to carry out field activities	Normally, the season during which access to the wetland is easiest should be chosen. However, there may be important periods when wetlands are most vulnerable to threats (eg pollutants entering wetlands during wet season storm events) or when migratory species are present at the wetland; thus surveys should be timed to coincide with these periods.	date
4	COSTING	Develop budget for the range of activities needed for the WIAM.		Proposal with budget submitted to funding agency.
5	ENSURE BUDGET IS IN PLACE	Ensure budget is sufficient to cover activities needed to achieve objectives.		Sufficient funds to undertake all activities
6	DEVELOP STANDARDISED METHODOLOGIES	<p>Adopt/modify a wetland classification system</p> <p>Develop inventory methodologies (PRA, RWA techniques etc.)</p> <p>Establish minimum (core) data which needs to be collected to achieve objectives.</p> <p>Develop data collection sheets.</p>		<p>1.Wetland classification system to suit local needs.</p> <p>2.Standardised inventory methodology.</p> <p>3.Checklist of minimum data needed.</p> <p>4.Data collection sheets.</p> <p>5.Standardised assessment and monitoring</p>

		Develop assessment and monitoring methodologies appropriate to problem and spatial scale of the study.		methodology. (could be integrated into an “inception” report)
Conduct the inventory				
7	CARRY OUT DESK STUDY / LITERATURE REVIEW	Review of existing information; published and unpublished documents, maps, aerial and ground photos, satellite images, expert opinion/resource persons. Establish resource centre.	This step is not often carried out comprehensively. It is very important to review all existing information so that gaps in relevant data and data which need to be updated can be identified. This is essential in providing guidance as to what information has to be gathered during the field survey phase.	1. Report, a review of existing information, gaps in data and outdated information. 2. Statement of what data need to be collected in the field inventory. 3. Resource centre to hold all information gathered on wetlands.
8	SET UP DATA MANAGEMENT SYSTEM	Develop database and input information gathered from desk study		Database in operation with data gathered from desk study.
9	FINALISE LOGISTICAL ARRANGEMENTS	Ensure transport, accommodation and local assistance are available		1. Boats, vehicles available for field activities. 2. Local partners at each site to participate in activities.
10	UNDERTAKE PILOT STUDY	Carry out inventory on a pilot site, testing data collection and assessment methods		Report detailing performance of methodologies and

				recommendations for changes.
11	FINE TUNE METHODOLOGIES	From results of pilot study, adapt methodologies		Fine-tuned methodologies.
12	COLLECT FIELD DATA	Carry out field surveys to fill gaps in core data set and to update information		Completed field data collection sheets.
13	PRESENT DATA	1. Data should be inputted to the database. 2. Information should be reported in a document and circulated for comments.		1. Database in operation with completed core data fields from desk and field studies. 2. Report containing data gathered (as individual sheets for each catchment, wetland etc.)
Assess the inventory information				
14	ASSESS INFORMATION GATHERED	Use of assessment methodologies to assess the importance of the wetlands inventoried.	Wetland are normally assessed in terms of their “importance”; i.e. the benefits they provide, the degree of disturbance and in terms of the threats can be operating on them. (It is important to remember that these threats can be operating within the wetland itself, or operating in the catchment of the wetland.)	Report detailing the relative importance of the areas surveyed and the degree of threat together with draft recommendations for action. Could be presented as a draft action plan.
15	PRESENT & DISCUSS RESULTS	1. Circulate report (draft action plan?) 2. Request comments.	It is very important that the results of the inventory and further actions proposed are endorsed by as many stakeholders as possible.	Finalised and widely supported action plan for conservation and management of

		3. Hold workshop with all stakeholders to finalise action plan.		wetlands surveyed.
16	IF NECESSARY, GATHER ADDITIONAL INVENTORY DATA AND ASSESS THE NEW INFORMATION	Relevant steps from above.	Relevant steps from above.	Relevant steps from above.
Monitor				
17	MONITORING	<p>1. Identify variables which affect the individual wetlands and which are causing or may cause negative impacts.</p> <p>2. Determine the scale at which the assessment is required.</p> <p>3. Develop a programme to monitor the effects of these variables on the wetlands. This includes:</p> <ul style="list-style-type: none"> • selection of appropriate indicators and protocols, • selection of appropriate experimental design to apply to the indicator(s), and • determining acceptable 	Assess whether information gathered during the inventory phase is suitable as a baseline from which to measure any changes in the character of individual wetlands.	Tailor-made monitoring programme for broad-scale wetland assessment (eg rapid assessment) or for individual wetland sites (and their catchments).

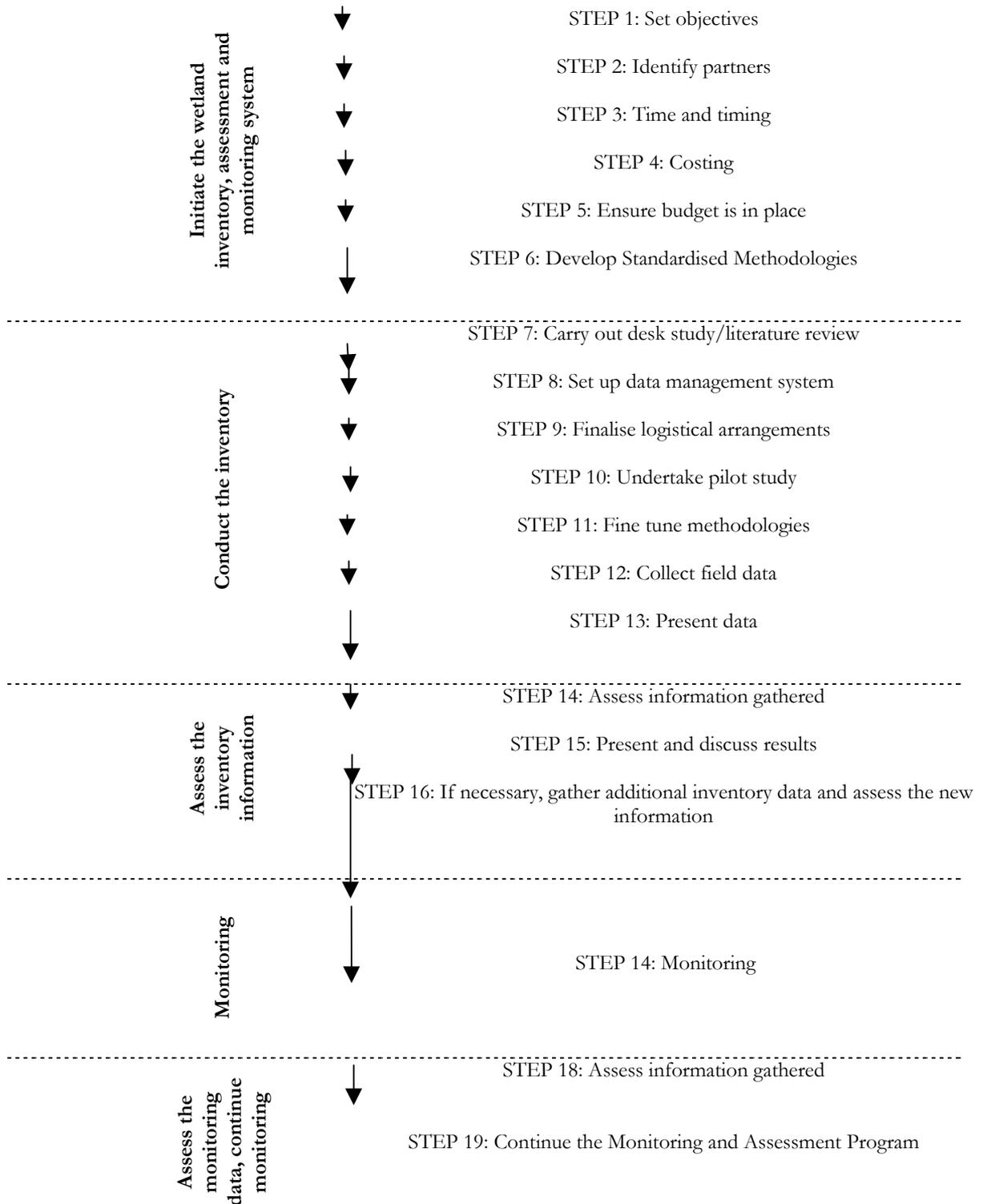
		level of change and statistical sensitivity with which to detect such change		
Assess the monitoring data, continue monitoring				
18	ASSESS INFORMATION GATHERED	Relevant steps from above.	Relevant steps from above.	Relevant steps from above.
19	CONTINUE THE MONITORING AND ASSESSMENT PROGRAM	Relevant steps from above.	Relevant steps from above.	Relevant steps from above.

NOTES:

This WIAMS framework has been developed with the aim of collecting information on a number of wetlands. It could be an inventory, assessment and monitoring investigation of the wetlands in a whole country, the wetlands of a single river basin, individual wetlands, or it could be for a distinct type of wetland; e.g. mangrove ecosystems in a country.

It is based on the Draft Resolution of the Ramsar Framework for Wetland Inventory (see Appendix VI) and also on the protocol for data collection of the Asian Wetland Inventory (AWI) project (refer paper by Alvin Lopez and <http://www.wetlands.org/inventory&/awi/default.htm>). These documents should be consulted for more details.

A FLOW CHART OF THE PROPOSED FRAMEWORK FOR A WETLAND INVENTORY, ASSESSMENT AND MONITORING SYSTEM (WIAMS) IN MALAYSIA



5.0 APPENDICES

APPENDIX I

WORKSHOP PROGRAMME

18 April 2002		
8.30 a.m.	Registration of participants	
8.45 a.m.	Arrival of Guest of Honour and other guests	
9.00 a.m.	Welcome speech by the Director, Wetlands International-Malaysia Programme	Dr. Sundari Ramakrishna
9.10 a.m.	<p>Official opening and key note speech by Guest of Honour.</p> <p>Presentation of Memento to Guest of Honour by Mr. Peter Noordermeer, Deputy Head of Mission & Councillor. Royal Netherlands Embassy</p> <p>Presentation of Memento to Mr. Peter Noordermeer by Dr. Sundari Ramakrishna</p> <p>Photography session</p>	Dr. Zulkifli Idris, Director, Conservation and Environmental Division, Ministry of Science, Technology and the Environment Malaysia (MoSTE)
9.20 a.m.	Coffee Break	
Technical Session I		
	Introduction to Wetland Inventory, Assessment and Monitoring Processes	
Chairperson:	Prof. Datin Dr. Maryati bt. Mohamed, Universiti Malaysia Sabah	
9.45 a.m.	Wetland Inventory, Assessment and Monitoring: An Introduction	Dr. Sundari Ramakrishna, Wetlands International-Malaysia Programme on behalf of Dr. Jonathan Davies
10.15 a.m. – 10.25 a.m.	Q & A	
10.25 a.m.	Developments In Wetland Inventory, Assessment And Monitoring	Dr. Chris Humphrey, Environmental Research Institute of Supervising Scientist (eriss), Australia
10.55 a.m. – 11.05 a.m.	Q & A	
11.05 a.m.	The Millennium Ecosystem Assessment: An Overview	Mr. Marcus J Lee, Millennium Ecosystem Assessment, ICLARM Office, Penang
11.35 a.m. – 11.45 a.m.	Q & A	
11.45 a.m. – 12.15 p.m.		Mr. Alvin Lopez, Wetlands International, Petaling Jaya
12.15 a.m. – 12.25 p.m.	Q & A	
12.25 p.m. – 12.45 p.m.	Summary and discussion	
12.45 p.m. – 2.00 p.m.	Lunch break	
Technical Session II		
	Wetland Inventory, Assessment And Monitoring – Possible Approaches And Tools	

Chairperson:	Assoc. Prof. Dr. Chan Ngai Weng, Universiti Sains Malaysia	
2.00 p.m.	Wetland Assessment System In Chilika Lagoon, India – A Case Study	Mr. Ajit K. Pattnaik, Chilika Development Authority, India
2.25 p.m. – 2.30 p.m.	Q & A	
2.30 p.m.	Possible Approach Towards Developing A Wetland Assessment, Inventory And Monitoring System In Australia: A Case Study From The Wet-Dry Tropics.	Dr. Chris Humphrey, eriss
2.55 p.m. – 3.00 p.m.	Q & A	
3.00 p.m.	Monitoring Programme For Putrajaya Lake And Wetland	Puan Zaharah Salamat, Perbadanan Putrajaya, Putrajaya
3.15 p.m. – 3.20 p.m.	Q & A	
3.20 p.m.	Remote Sensing And GIS For Wetlands Assessment In Malaysia	En. Jimat Bolhassan, Malaysian Centre for Remote Sensing (MACRES)
3.35 p.m. – 3.40 p.m.	Q & A	
3.40 p.m.	The Asian Water Bird Census: A Tool For Water Bird And Wetland Monitoring In Asia	Mr. David Li, Wetlands International, Petaling Jaya
3.55 p.m. – 4.00 p.m.	Q & A	
4.00 p.m.	The Effectiveness Of The Asian Water Bird Census Programme And Other Related Programmes As A Tool For Water Bird And Wetland Monitoring In Malaysia	Mr. Yeap Chin Aik, Malaysian Nature Society, Kuala Lumpur
4.15 p.m. – 4.20 p.m.	Q & A	
4.20 p.m. – 4.35 p.m.	Tea-break	
4.35 p.m.	Developing a Proposed Framework for a WIAMS in Malaysia	Dr. Sundari R., Wetlands International-Malaysia Programme
4.50 p.m. – 5.00 p.m.	Summary and discussion	
5.00 p.m. – 5.10 p.m.	Delegation of working groups	
5.10 p.m.	Close	
19 April 2002		
8.30 a.m.	Technical Working groups sessions	
10.00 a.m.	Coffee break	
10.15 a.m.	Continuation of working group sessions	
11.15 a.m.	Presentations by working groups	
12.15 p.m.	Panel discussion and conclusions	
1.00 p.m.	Workshop ends with lunch	

APPENDIX II

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APPENDIX III

STATUS OF WETLAND AREAS IN MALAYSIA

NATURAL WETLANDS	
<u>Mangroves</u>	
<p>Mangroves are well developed in sheltered estuaries where waters are brackish and waves and tidal conditions are conducive for mud accumulation. Mangroves cover about 3% (641,891 ha) of the total land area in Malaysia with about 57% in Sabah, 26% in Sarawak and the remaining 17% in Peninsular Malaysia (Chan <i>et al.</i>, 1996; WI-AP 1996; MPMJ 1999). About 70% of the total mangrove area has been gazetted as Forest Reserves with the remainder being State Land. The term “mangroves” is a collective name for a group of plants with more than 50 species identified which fall into four main genera: <i>Avicennia</i>, <i>Rhizophora</i>, <i>Bruguiera</i> and <i>Sonneratia</i>. The mangrove vegetation in Malaysia is believed to have reached its optimal development.</p>	
State	Total Area (ha)
Perlis	100
Kedah	7,949
Penang	451
Perak	43,502
Selangor	23,882
Negeri Sembilan	1,061
Melaka	305
Johor	27,733
Terengganu	954
Pahang	2,482
Kelantan	20
Sabah	365,460
Sarawak	167,992
<u>Peat Swamp</u>	
<p>The tropical climate and high annual rainfall in Malaysia have resulted in the formation of peat swamp forests. Where permanent water logging and anaerobic conditions prevail, partial inhibition of decay of vegetation has given rise to peat formation. The peat releases tannin and organic acids into the water. This accounts for the water acidity, with a pH value of between 3 and 4, and the coloration of water, which is almost black in appearance, but is clear when held up against the light. Today, about 2 million ha (Chew YF, 1997, Latiff A, 1997, Mahadon M, 1997, Mohd Radhi CA, 1997, Jalil MS, 1997 and Moktar MI, 1997) remain in Malaysia which accounts for about 7.2% of the total land area of Malaysia. Less than 25% of this wetland type is found in the Peninsula with another 75% in Sarawak, while the rest is in Sabah.</p>	

State	Total Area (ha)
Perlis	No significant Peat Swamp Forest
Kedah	No significant Peat Swamp Forest
Penang	No significant Peat Swamp Forest
Perak	96,000
Selangor	76,134
Negeri Sembilan	No significant Peat Swamp Forest
Melaka	No significant Peat Swamp Forest
Johor	13,346
Terengganu	13,819
Pahang	198,866
Sabah	166,698
Sarawak	1,500,000

Freshwater Swamp Forest

Freshwater swamps occur in areas permanently or seasonally flooded where the soils contain more than 35% mineral content, normally found along upper reaches of certain rivers. Examples include the freshwater swamp forests in Sg. Sedili in Johor, Tasek Chini and Tasek Bera in Pahang, along Sabah's east coast and along lower reaches of certain rivers in Sarawak (Chew YF, 1997; Malaysian Wetland Working Group, 1987). This type of forest is quite species-rich with a high diversity of understorey species including rattan and palm species. The swamp forest vegetation of Tasek Chini is dominated by *Eugenia* species (Wetlands International – Malaysia Programme, 1998).

State	Total Area (ha)
Perlis	No significant Freshwater Swamp Forest
Kedah	No significant Freshwater Swamp Forest
Penang	No significant Freshwater Swamp Forest
Perak	1,967
Selangor	Data Not Available
Negeri Sembilan	No significant Freshwater Swamp Forest
Melaka	No significant Freshwater Swamp Forest
Johor	11,900
Terengganu	10,433
Pahang	330,890
Kelantan	No significant Freshwater Swamp Forest
Sabah	152,702
Sarawak	28,907

Nipa Swamp

Nipa swamps occur in association with mangroves and extend further into brackish water. They are normally found surviving in the borderline of brackish and freshwater areas of tidal influence. Comprising mono-specific stands of the palm *Nypa fruticans*, they form huge swamps in tidal reaches of rivers as in the Sarawak Mangrove Reserve (Chew YF, 1997, Malaysian Wetland Working Group, 1987).

State	Total Area (ha)
Perlis	Data Not Available
Kedah	Data Not Available
Penang	Data Not Available
Perak	Data Not Available
Selangor	Data Not Available
Negeri Sembilan	Data Not Available
Melaka	Data Not Available
Johor	Data Not Available
Terengganu	24,100
Pahang	Data Not Available
Kelantan	1,020
Sabah	758,770
Sarawak	869,700

Melaleuca Swamp Forest

Melaleuca swamp forests, or locally as “gelam” forests, are actually freshwater swamp forests, only that the vegetation comprises almost exclusively of *Melaleuca cejeputi*. The forests replace the original freshwater swamp forest after it has been burnt as *Melaleuca* are resistant to fire. These forests occupy extensive areas of alluvial flats along the East Coast of Peninsular Malaysia, mainly in Kelantan and Terengganu (Chew YF, 1997, Malaysian Wetland Working Group, 1987).

State	Total Area (ha)
Perlis	No significant <i>Melaleuca</i> Swamp Forest
Kedah	No significant <i>Melaleuca</i> Swamp Forest
Penang	No significant <i>Melaleuca</i> Swamp Forest
Perak	No significant <i>Melaleuca</i> Swamp Forest
Selangor	No significant <i>Melaleuca</i> Swamp Forest
Negeri Sembilan	No significant <i>Melaleuca</i> Swamp Forest
Melaka	1,400
Johor	No significant <i>Melaleuca</i> Swamp Forest
Terengganu	29,100

Pahang	No significant <i>Melaleuca</i> Swamp Forest
Kelantan	11,020
Sabah	No significant <i>Melaleuca</i> Swamp Forest
Sarawak	No significant <i>Melaleuca</i> Swamp Forest
<u>Marshes</u>	
<p>Marshes have a number of specific characteristics. They are usually dominated by reeds, rushes, grasses and sedges that are commonly referred to as emergents since they grow with their stems partly in and partly out of the water. Marshes rely on water sources and include some of the most productive ecosystems in the world. In Malaysia, marshes are normally found in areas where the original freshwater swamp forest has been cleared or burnt. They are a stage of ecological succession, and not normally a permanent vegetation type. Dominant plants include species of reeds, reedmace, club rush, sedges and spike rushes. There are relatively few open marsh areas in Malaysia (Malaysian Wetland Working Group, 1987) with the exception of Kota Belud Bird Sanctuary on the Tempasuk Plain in north-western Sabah.</p>	
State	Total Area (ha)
Perlis	No significant marsh areas
Kedah	No significant marsh area
Penang	No significant marsh areas
Perak	1,967
Selangor	No significant marsh areas
Negeri Sembilan	No significant marsh areas
Melaka	600
Johor	No significant marsh areas
Terengganu	No significant marsh areas
Pahang	20,350
Kelantan	No significant marsh areas
Sabah	721,216
Sarawak	Data Not Available
<u>Mudflats</u>	
<p>Intertidal mud and sand flats are extremely important wetland habitats in Malaysia. They fringe the majority of Malaysia's coastlines and may in certain places be several kilometers in width at low tide. Mudflats that are associated with major mangrove forests support a very rich benthic (organisms that are either attached or living within the bottom sediments). These areas represent the richest feeding grounds for migratory shorebirds and resident water birds such as herons, egrets and storks. In Malaysia, there are approximately 400,000 ha (MoSTE, 1997; Sasekumar <i>et. al.</i> 1998) of tidal mudflats. This is about 1.9% of the total land area of Malaysia. Yet they are rarely included in reserve areas and are very poorly documented.</p>	
State	Total Area (ha)
Perlis	0.22

Kedah	1,483.46
Penang	4,189.90
Perak	7,797.64
Selangor	20,806.14
Negeri Sembilan	301.62
Melaka	1,012.85
Johor	16,586.61
Terengganu	Data Not Available
Pahang	1,777.00
Kelantan	Data Not Available
Sabah	Data Not Available
Sarawak	Data Not Available

Sandy Beaches

In Malaysia, sandy beaches occur largely along the East Coast of the Peninsular Malaysia, Sabah and Sarawak (Sasekumar *et al.*, 1998). Plants in this habitat have to anchor themselves deeply in the shifting sands and find enough freshwater between the loose silica sand grains. Animals are found mostly in the tidal zones, with bivalve mollusks being the most common. Sandy beaches are also important as turtle landing and nesting sites. Largely beaches are attractive recreational areas for people, hence are capitalised for tourism.

State	Total Area (ha)
Perlis	343.00
Kedah	181.22
Penang	390.38
Perak	734.20
Selangor	4767.19
Negeri Sembilan	816.66
Melaka	381.23
Johor	285.54
Terengganu	Data Not Available
Pahang	Data Not Available
Kelantan	Data Not Available
Sabah	Data Not Available
Sarawak	Data Not Available

Rocky Shores

Rocky shores are rare habitats in Malaysia. Isolated rocky headlands and islands occur at places such as Tanjung Tuan, at the many offshore islands along the west and east coast of Peninsular Malaysia

(Sasekumar *et al.* 1998), and in Sabah and Sarawak. Rocky shore ecosystems support animals and plants found nowhere else in Malaysia. Ecological information on this unique habitat is scarce.

State	Total Area (ha)
Perlis	11.82
Kedah	195.38
Penang	158.27
Perak	86.98
Selangor	No significant Rocky Shores
Negeri Sembilan	48.25
Melaka	1.12
Johor	33.37
Terengganu	No significant Rocky Shores
Pahang	No significant Rocky Shores
Kelantan	No significant Rocky Shores
Sabah	Data Not Available
Sarawak	Data Not Available

Coral Reefs

A coral reef is an assemblage of many types of plants and animals of which corals form one of the dominant components. Reefs are essentially massive deposits of calcium carbonate that have been produced by corals with major additions from calcareous algae and other organisms that secrete calcium carbonate. Coral reefs are sensitive and easily destroyed because they need specific conditions such as water temperature above 18°C, water depth shallower than 50m, low sedimentation rates and sufficient circulation of pollution-free water to grow and survive. Coral reefs are distributed mainly around the offshore islands in three regions - East and West Coast regions in Peninsular Malaysia, Sabah and Sarawak. Largely the marine waters of the offshore islands where the corals occur are either protected as Marine Parks or are areas prohibited from fishing (MoSTE, 1997; Jabatan Perancang Bandar & Desa, 2001). Marine Parks are protected area which extends for a distance of two nautical miles seaward from the outer most points of the islands. However, the land areas of these islands are not protected as part of the marine park processes.

State	Total Marine Protected Area (ha)
Perlis	No significant coral reefs
Kedah (4 islands)	18,700
Penang	Data Not Available
Perak	Data Not Available
Selangor	No significant coral reefs
Negeri Sembilan	Data Not Available
Melaka	Data Not Available
Johor (13 islands)	68,151
Terengganu (11 islands)	53,029

Pahang (9 islands)	6,7661
Kelantan	No significant coral reefs
Sabah	20,622
Sarawak	Data Not Available
<p><u>Seagrass Beds</u></p> <p>Seagrass beds are flowering plants complete with leaves, rhizomes (an underground, usually horizontally oriented stem) and root systems. Seagrass beds are located within the shallow coastal zones, hence they are directly affected by the way we treat the land and what we put into the sea. Most seagrass species are located in soft (silty or sandy) sediments. Seagrass beds play an important role in maintaining nutrient levels in marine ecosystems, providing food for turtles and dugongs, and acting as a nursery, shelter and food source for fish and other invertebrates. In Peninsular Malaysia, seagrass beds are commonly found in Penang coast, Port Dickson, South West Johor mangroves and mudflats, East Johor Islands and Langkawi group of islands.</p>	
<p><u>River Systems</u></p> <p>As rivers meander through the low-lying basins, they form various wetland complexes. The wetlands alongside rivers are also referred to as riparian fringes or riverine habitats. There are 159 rivers in Malaysia, 88 in the Peninsula, 48 in Sarawak and the rest in Sabah. The Rajang River basin is the largest in Malaysia with a catchment area of 51,000 km². In Peninsular Malaysia, most of the rivers originate from the central mountain range. Flowing into the South China Sea, the Pahang River and its tributaries, with a catchment area of 26,800 km², form the largest river basin in the Peninsula. The state and area of the river are hard to discern in Malaysia, as different sections of a river can be under the management of different local governments as rivers are known to transcend through many administrative boundaries.</p>	
<p><u>Natural Lake Systems (including oxbow lakes)</u></p> <p>Lakes are permanent/seasonal bodies of freshwater occupying either large basins or small depressions in the landscape. There are very few natural lakes in Malaysia; good examples are Tasek Bera and Tasek Chini in Pahang and Loagan Bunut (a floodplain lake) in Sarawak. Tasek Bera is Malaysia's sole Ramsar Site (Wetlands International-Asia Pacific, 1999). The ox-bow lakes, which occur mainly in East Malaysia, are found along the meandering lower reaches of major rivers such as Baram and Liman Rivers in Sarawak and the Kinabatangan, Sugut and Segama Rivers in Sabah. Lakes are predominantly known for mitigating floods as well as have great importance for providing fish resources for local inhabitants. They are also natural breeding areas for certain fish species, namely the migrating ones from inflowing rivers. In addition, lakes have great cultural and spiritual significance to local people. Nature tourism in lake ecosystems is highly popular in Malaysia.</p>	
Records of natural lake system	Total wetland area (ha) during high water flows
Tasek Bera Ramsar Site	6,800
Tasek Chini	902
Loagan Bunut	260

CONSTRUCTED WETLANDS

Reservoirs

Dams are usually constructed in catchment areas which function in gathering, collecting, storing and transmitting the water provided by rainfall. They are constructed both for water supply (water for domestic use and irrigation) as well as for hydro-electric power generation. Reservoirs and barrages are results of these structures. There are about 54 dams in Malaysia with a total water capacity of 12 billion cubic meters per year. The integrity of a dam depends very much on the surrounding land activities in the catchments; illegal logging and indiscriminate land clearing as a result of human intervention are contributory factors which lead to siltation and decreases the life span of dams.

Rice Fields

Wet rice fields are major, man-made wetland habitats in Malaysia. Rice fields occur chiefly on level terrain in former wetlands, floodplains and swamps. Rice fields are of major importance as they are the producers of Malaysia largest staple diet. In addition, rice fields are known for their biodiversity values, namely in providing food resources for resident and migrating waterbirds and in some cases also a breeding areas for some bird species. They support large numbers of winter visitors and passage migrant birds, such as pond-herons, egrets and waders. There are over 650,000 ha of wet rice fields in Malaysia, of which 450,000 ha occur in the Peninsula, mainly in Krian-Perak, Sekinchan-Selangor, and in coastal areas of Perlis and Kedah. In Sabah, freshwater swamps have been converted to rice fields while small scale ventures exist in Sarawak (Chew YF, 1997; Malaysian Wetland Working Group, 1987).

State	Total Area (km ²)
Perlis	Data Not Available
Kedah	Data Not Available
Penang	Data Not Available
Perak	23,100
Selangor	5,000
Negeri Sembilan	Data Not Available
Melaka	Data Not Available
Johor	4,000
Terengganu	Data Not Available
Pahang	Data Not Available
Kelantan	Data Not Available
Sabah	Data Not Available
Sarawak	70,000

Created and Rehabilitated Wetlands

This category include created wetlands such as the Putrajaya Wetlands, and rehabilitation carried out in wetlands such as abandoned tin-mining pools and degraded peat swamp forest. Paya Indah Wetland Sanctuary, Kinta Nature Park, Kelana Jaya Lakes are examples of rehabilitated wetlands. Most of the wetlands in this category were developed mainly for recreational purposes, however their full range

<p>benefits surpasses beyond that of recreation i.e. these wetlands attracts and supports significant biodiversity, can serve as flood control measures etc.. Putrajaya Wetlands (consists of marsh, swamps and open water lake system) was created primarily to serve a functional purpose; natural remediation of inflowing river water and storm water. Despite efforts to rehabilitate, large abandoned tin-mining areas still occur in the states of Perak and Selangor and are generally unrecorded.</p> <p>Other man-made wetlands such as constructed lakes and ponds including aquaculture and oxidation ponds are evident in Malaysia, however, data on them are lacking in general.</p>	
Records of man-made and rehabilitated wetlands	Total Wetland Area (ha)
Paya Indah Wetland Sanctuary, Selangor	3,100
Kinta Nature Park, Perak	950
Putrajaya Wetlands, Putrajaya	650

References:

1. Chan HT, Ong JE, Gong WK & Sasekumar A. 1996. The socio-economic, ecological and environmental values of mangrove ecosystems in Malaysia and their present state of conservation. In: The economic and environmental values of mangrove forests and their present state of conservation in the South-east Asia/Pacific region, Clough BF (ed.), 1993. International Society for Mangrove Ecosystems. Mangrove Ecosystems Technical Report Vol.1.
2. Chew Yoke Fun. 1997. Wetland Resources in Malaysia. In: Proceedings of State of the Environment in Malaysia Conference, 5-9 January 1996, Consumers' Association of Penang and Sahabat Alam Malaysia, Penang.
3. Jabatan Perancangan Bandar dan Desa. 2001. Pelan Spatial Negara. Draft Technical Report (Volume V) Package F: Environment and Natural Resources, Jabatan Perancangan Bandar dan Desa, Kuala Lumpur.
4. Jalil MS. 1997. Status hutan paya gambut di Negeri Selangor. In: Proceedings of the GEF Inception Workshop on Conservation and Sustainable Use of Peat Swamp forest in Malaysia (eds. Phang TJ and Mohd. Khairul E), United Nations Development Programme (UNDP), Ministry of Science, Technology and the Environment Malaysia & Wetlands International-Asia Pacific, Kuala Lumpur.
5. Latiff A. 1997. Biodiversity, conservation and sustainable use of peat swamp forests in Malaysia. In: Proceedings of the GEF Inception Workshop on Conservation and Sustainable Use of Peat Swamp forest in Malaysia (eds. Phang TJ and Mohd. Khairul E), United Nations Development Programme (UNDP), Ministry of Science, Technology and the Environment Malaysia & Wetlands International-Asia Pacific, Kuala Lumpur.
6. Mahadon M. 1997. Status hutan paya gambut dan pelan pengurusan Negri Johor Darul Takzim. In: Proceedings of the GEF Inception Workshop on Conservation and Sustainable Use of Peat Swamp forest in Malaysia (eds. Phang TJ and Mohd. Khairul E), United Nations Development Programme (UNDP), Ministry of Science, Technology and the Environment Malaysia & Wetlands International-Asia Pacific, Kuala Lumpur.
7. Malaysian Wetland Working Group. 1987. Malaysia Wetland Directory. Department of Wildlife and National Parks, Kuala Lumpur:
8. Mohd Radhi CA. 1997. Hutan paya gambut di Negeri Pahang Darul Makmur. In: Proceedings of the GEF Inception Workshop on Conservation and Sustainable Use of Peat Swamp forest in Malaysia (eds. Phang TJ and Mohd. Khairul E), United Nations Development Programme (UNDP), Ministry of Science, Technology and the Environment Malaysia & Wetlands International-Asia Pacific, Kuala Lumpur.
9. Moktar MI. 1997. Status report on the management of swamp forests in Terengganu Darul Iman. In: Proceedings of the GEF Inception Workshop on Conservation and Sustainable Use of Peat Swamp forest in Malaysia (eds. Phang TJ and Mohd. Khairul E), United Nations Development Programme (UNDP), Ministry of Science, Technology and the Environment Malaysia & Wetlands International-Asia Pacific, Kuala Lumpur.
10. MoSTE (Ministry of Science, Technology and the Environment Malaysia). 1997. Assessment of Biological Diversity. Malaysia: Country Study on Biological Diversity, MoSTE, Kuala Lumpur.

11. MPMJ. 1999. Management Plan for the Mangroves of Johor (2000-2009). Forestry Department Peninsular Malaysia, Johor State & Danish Cooperation for Environment and Development, Johor Bahru.
12. Sasekumar A, Chong, VC and Phang SM. 1998. Malacca Straits Demonstration Project. Draft Report Project 4. Marine and Coastal Resource Valuation for the Straits of Malacca (Malaysia), University Malaya, Kuala Lumpur.
13. Wetlands International-Asia Pacific- Malaysia Programme. 1998. The Ecological Assessment of Tasek Chini, Pahang, Peninsular Malaysia: An evaluation of its conservation value and environmental improvement requirements, Wetlands International-Malaysia Programme, Kuala Lumpur.
14. Wetlands International-Asia Pacific. 1996. Guidelines for the Sustainable Utilisation and Management of Mangrove Forest in Kedah. Wetlands International-Asia Pacific, Institute of Advanced Studies, University Malaya & WWF Malaysia, Kuala Lumpur.
15. Wetlands International-Asia Pacific. 1999. Tasek Bera Ramsar Site Integrated Management Plan-Summary. Wetlands International-Asia Pacific, Kuala Lumpur.

Further Reading:

1. Forum on Sustainable Management of Ecotourism in Wetlands: The case of Lower Kinabatangan Floodplain, 31 January 2002, Institute for Development Studies (Sabah), WWF Malaysia, Sabah Wildlife Department, Kota Kinabalu.
2. Gan BK. 1995. A Working Plan for the Matang Mangrove Forest Reserve, Perak (Fourth Revision), Perak State Forestry Department, Ipoh.
3. IPT- Asian Wetland Bureau. 1994. Glimpses of Mangroves. Asian Wetland Bureau, Institute of Advanced Studies, University Malaya and Government of Canada, Kuala Lumpur.
4. Mohd. Lokman H and Sulong I. 2001. Mangroves of Terengganu. Mangrove Research Unit (KUSTEM) & Forestry Department Peninsular Malaysia, Kuala Terengganu.
5. Persatuan Pencinta Alam Malaysia. 2000. Concept Proposal for the Batu Gajah Nature and Heritage Park, Perak Darul Ridzuan, Persatuan Pencinta Alam Malaysia, Kuala Lumpur.
6. Sebastian AC, Hughes RN and Hurrell PJ. 1993. Integrating ash pond management with shorebird conservation, tourism and education at Stesen Janaletrik Sultan Salahuddin Abdul Aziz, Kapar, Selangor Darul Ehsan. Asian Wetland Bureau, Institute of Advanced Studies University of Malaya & Tenaga Nasional Berhad, Kuala Lumpur.
7. Sham Sani. 1998. The Encyclopedia of Malaysia: The Environment, Archipelago Press, Singapore.
8. Wetlands International-Malaysia Programme. 2000. Klang Islands Group: Issues and needs for conservation. A working paper submitted to the Selangor Forestry Department. Wetlands International-Malaysia Programme, Petaling Jaya.

APPENDIX IV

BREAK-OUT GROUP MEMBERS LIST

GROUP 1

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- | | |
|--|--|
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APPENDIX V

SUMMARY OF COMMENTS, QUESTION & ANSWER SESSIONS

WORKSHOP PAPER PRESENTATIONS: COMMENTS, QUESTION & ANSWER SESSIONS

THURSDAY, 18 APRIL 2002

Q: Dr. G. Balamurugan (ERE Consult Sdn Bhd) emphasised the importance of careful design for data collection in wetland inventory and asked which were the most important elements for wetland inventory in Malaysia and what type of data needed to be collected?

A: Dr Humphrey (eriss) emphasised the AWI's goal of describing the wetland resource of Asia using a core data set for which data collection sheets and computerised database for each level of the hierarchy have been developed. The data sheets indicate the core data that are considered necessary for each level of the hierarchy, and provide a standardised approach to record and present this information. The top two levels of the hierarchy are at the landscape scale and are desk-top studies that use existing information from maps or remotely sensed images to describe the landforms, water regimes, climate etc of each geographic region or to identify the wetland regions within each geographic region. The bottom two levels deal with wetland complexes and habitats and use field studies to describe complexes and habitats, their ecological characteristics and information on management.

A: Dr. Sundari R (Wetlands International-Malaysia Programme) replied that the last wetland inventory in Malaysia was published in year 1987. The data collected in the inventory were fairly limited, with an emphasis on species richness and conservation status of wetland in Malaysia but there was no information that provides feedback into a management plan so that management actions can be taken to minimise any negative impact identified. It was difficult for decision-makers to utilise the information for decision making. It is more like a directory. However, an inventory should include a set of data that at its lowest ebb can serve as a tool for wetland management. The level and type of data that should be collected for use need to be consulted first with the appropriate stakeholders.

Comment: Mr. Alvin Lopez (Wetlands International-Asia Regional Programme) reiterated Dr Chris's points, suggesting that the participants look critically at the structured framework and step-wise checklist for planning a wetland inventory, as provided in the AWI and based on the Draft Resolution on the Ramsar Framework for a Wetland Inventory. This has been provided in Dr. Humphrey's [Finlayson and co-authors] paper. Alvin L further added that the Ramsar13 steps framework for inventory can be a guide for assisting interested parties in designing an inventory that is suited to their respective needs.

Comment: Dr. Saim Suratman (Mineral and Geoscience Department) commented that before we embark on a nation wide inventory, the need for more information on wetlands is pertinent. The Ramsar definition on Wetlands isn't adequate because the definitions for wetlands are versatile and they vary between different countries. For example, Dr. Saim personally feels that constructed wetlands such as dams should not be represented under the definition of wetlands as stipulated by Ramsar.

A: Dr. Humphrey explained that the Ramsar definition is deliberately broad and all-encompassing, and includes coastal and marine wetlands, all inland waters – natural or artificial – as well as

those with only seasonal or sporadic inundation by water. The AWI similarly takes a liberal definition of the term 'wetland'. This should not present a problem. Jurisdictions can subdivide wetlands into whatever classification system they like and in many cases it is convenient – and indeed necessary – to break-down aquatic ecosystems into appropriate management systems, such as rivers and streams, shallow standing waters, coastal zone and so forth. Needless to say, national consistency in the classification system is important.

Q: To reiterate the point mentioned by Dr. Saim previously, Murugadas TL (Wetlands International-Malaysia Programme) requested Dr. Humphrey to address the workshop participants if Environment Australia has a local definition for wetlands?

A: Dr. Chris H again emphasised the point that the Australian government is comfortable with the Ramsar definition of wetlands and is a signatory to the Convention. It is important of course that the classification system used at a national level is rigorous. To this end, the classification system of Ramsar is likely to be reviewed later this year to assess whether improvements need to be made to assist users to better decide on what type of wetland they are dealing with. (The AWI has a rigorous approach to wetland classification using established criteria.) As mentioned earlier, however, the Australian Government does subdivide wetlands into convenient management systems. For example, in the new Australian and New Zealand Water Quality Guidelines, wetlands are defined as shallow bodies of standing water (permanent or temporary), thus distinguishing 'wetlands' from rivers, streams and deep lakes. Similarly, Environment Australia has separate programs on wetlands (shallow bodies of standing water), river health and marine and coastal systems. This separation simply recognises the practical realities that inventory, assessment, monitoring, management, socio/geopolitics and economics will differ for particular ecosystem types.

Q: En Jimat Bolhassan (MACRES) wanted to know how we proceed to undertake an inventory? It is appropriate to start from Level 4 (wetland habitat level) and move up the hierarchy or rather start from Level 1 (river basin level) and move down the hierarchy? He also highlighted that it is important that the tabulated inventory information be useful for policy makers and the processes involved to be less time consuming.

A: Dr. Humphrey explained that basically, it doesn't matter where one begins. However, by beginning at level 1 and working progressively through to level 4, there is value in putting into perspective the catchment related influences (externalities) to which wetlands in the region are affected.

While the hierarchical approach will provide a logical progression in scale, it is expected that delineation and mapping at the lower, habitat scale will occur at the same time as the less detailed analyses at the higher scales. This is because national agencies will want to address both specific site-based and regional management and conservation priorities at the same time. National and regional management and conservation could include, for example, analysis of water or forest resources or assessment of global change impacts. And so the hierarchical approach allows for a strategic assessment of information needs in relation to spatial scales. It also provides a framework for considering individual wetland habitats and sites within and outside of established jurisdictional boundaries.

Q: Alvin Lopez asked of how the MA is linked or tied-up with other initiatives such as the AWI or initiatives mooted by the Ramsar Convention?

A: Marcus L (MA) explained that the conceptual framework of the Millennium Ecosystem Assessment (MA) can be used to identify the primary reasons for the loss and degradation of wetlands in the region. The goods and services that are provided by wetlands in the region can also be identified by using the information developed by the Working Group of the MA as a guide.

Ramsar represents one of the key user groups of the MA among the international conventions (apart from CBD, CCD etc.). Ramsar's information needs from the MA have been discussed with the STRP (in June 2001). These include specific areas such as:

- Global wetland area coverage and trends
- Wetland functions in ecosystems, particularly those functions with socio-economic relevance e.g. water supply, and the economic valuation of such functions
- Ecosystem response scenarios to major wetland restoration projects

To meet these needs, a synthesis report focusing on the specific issues that Ramsar identified, and other issues particularly relevant to wetlands, will be one of the MA products.

Ramsar Secretary-General Mr. Delmar Blasco represents Ramsar on the MA Executive Committee, and he and Dr. Jorge Jimenez (current STRP chair) are members of the MA Board.

The STRP has also designated 2 STRP focal points, Dr. Max Finlayson (STRP Oceania member) and Dr. Douglas Taylor (Wetlands International), for channeling technical inputs for the MA design and for the review of MA products.

Comment: Dr. Humphrey supported Alvin Lopez' concerns and made the point that it is essential that the MA is integrated with current national and international programmes and utilises existing methodologies for WIAM, as were being developed by Ramsar and the AWI.

Q: Prof. Chan Ngai Weng (USM) - How are we going to make sure that policy makers use the end results of the MA as there is no obligation for any particular government to do so unlike the global treaties such as the Ramsar Convention or CBD?

A: Yes, the design of the MA process emphasizes engagement with users from the beginning stages of planning the assessment. As such, meeting the needs of decision-makers is built into the process, although of course there is no obligation from the policy-making side with respect to particular findings from the MA. One example at the global level is the Montreal protocol which got rid of CFCs – it worked, but it has also been pointed out that such examples are few and far between.

Marcus L also mentioned that the MA offer seed funding for sub-global assessments wishing to join the MA process. More information etc. can be solicited from <http://www.millenniumassessment.org>

Q: Prof. Datin Maryati Mohamed (UMS) - Is the Ministry of Science, Technology and the Environment Malaysia (MoSTE) planning on producing an inventory on wetlands in Malaysia?

A: Dr. Zulkifli Idris (MoSTE) responded by stating that under the 8th Malaysia Plan (2001-2005) funds have been allocated to produce an inventory of all natural resources in Malaysia. We may embark on producing a national inventory on wetlands as part of the larger inventory first but discussions on this are still on the preliminary stage. He further reiterated that the previous national wetland inventory was published in 1987, and most of the information in that inventory has changed since then, therefore it is necessary to update the information mainly for decision making processes. MoSTE will plan adequately for this current initiative for an inventory and is hoping to secure the best available methodology for it.

GROUP PRESENTATIONS: COMMENTS, QUESTION & ANSWER SESSIONS FRIDAY, 19 APRIL 2002

Group 1: New agricultural development proposed in a relatively undisturbed catchment containing a Ramsar wetland downstream of the development

Group Chair: Mr Augustine Tuuga (Sabah Wildlife Department) and assisted by Dr Zelina Zaiton Ibrahim (UPM)

Comment and Q: Dr Sundari praised the draft assessment/monitoring system presented by this group and asked if the group used the draft framework?

A: Mr. Augustine replied that they did not follow the framework in entirety but agreed with the components of the framework.

Comment: Mr Ajit added that the stakeholder consideration should have been included in the process.

A: To which Dr Zelina responded that the stakeholder issues would have been identified in the socio-economic section of their draft although it did not specify the method of data collecting.

Comment: Dr. Chris Humphrey (eriss) added that the risk assessment section would have collected a lot of input from the people/stakeholders and thus more parameters and quantification would have been incorporated.

Group 2: Evaluate/assess and report on the ecological character of wetlands in Malaysia. From the assessment show how catchment-level activities that are likely to result in ecological degradation can be identified, prioritised and risks managed

Group Chair: Dr Mohd Lokman Husain (KUSTEM)

Comment: En Mohamed Basir (Johor State Park Corporation) suggested that the WIAMS approach is good but needs to be adapted to the local context. [Eds: the workshop case studies were designed to explore the issue of adaptation of WIAMS to local management problems.]

Group 3: Remediation of wetlands adjacent to urban (including domestic and industrial) and agricultural developments that are subjected to more stringent waste-water discharge regulations and enforcement

Group Chair: Puan Daria Mathew (WWFM)

The group commented frankly that they did not follow the framework provided. However, results of the presentation clearly demonstrated elements of the WIAMS processes.

Comment: Prof Datin Dr Maryati Mohamed (UMS) commented that biological indicators have broad applicability, irrespective of species used.

Group 4: Assessment of water bird conservation status in Malaysia

Group Chair: Mr Yeap Chin Aik (MNS)

Q: Dr Chan Ngai Weng (USM) asked on how will remote sensing (RS) be used to conduct water bird census?

A: En Jimat Bolhassan (MACRES) replied that RS can be used rather to gather information on the bird habitats, for example in checking out the extent of mangroves and its condition.

Q: Dr Sundari Ramakrishna (Wetlands International-Malaysia Programme) posed a question to En Jimat if remote sensing can point out much about the mudflats?

A: En Jimat responded that the route of migratory birds is related to land cover, and here, remote sensing can play a role. Together with data collected from ground surveys, one can use the GIS system to show the flight corridor and use the information gathered as supplementary information.

A: Dr Ajit Pattnaik (Chilika Development Authority) also responded that GIS is used with limited application in Chilika. It can be used to survey area changes in relation to low tide and high tide exposures. In addition, RS has also been utilised to observe exposed areas of wetlands in relation to vegetation cover.

APPENDIX VI

**"Wetlands: water, life, and culture"
8th Meeting of the Conference of the Contracting
Parties
to the Convention on Wetlands (Ramsar, Iran, 1971)
Valencia, Spain, 18-26 November 2002**

Ramsar COP8 – DRAFT 6

Submitted by the Standing Committee

DRAFT RESOLUTION: A RAMSAR FRAMEWORK FOR WETLAND INVENTORY

1. RECALLING Recommendation 1.5, in which the Contracting Parties stated the need to prepare inventories of their wetlands “as an aid to the formulation and implementation of national wetland policies”, and Resolution VII.16, in which the Parties adopted guidelines on these matters;
2. RECALLING ALSO Recommendation 4.6, Resolutions 5.3 and VI.12, and Action 6.1.2 of the Strategic Plan 1997-2002, in all of which the Parties recognized the value of national inventories for identifying sites suitable for inclusion in the List of Wetlands of International Importance (the Ramsar List) under the Convention;
3. AWARE that in Action 6.1.3 of the Strategic Plan 1997-2002 and Resolution VII.20 the Parties also recognized the importance of baseline wetland inventory for quantifying the global wetland resource as the basis for assessment of its status and trends, for identifying wetlands suitable for restoration, and for risk and vulnerability assessments;
4. [NOTING that this meeting has adopted *Principles and guidelines for wetland restoration* (Resolution VIII.xx), *Guidelines for integrating wetland into Integrated Coastal Zone Management* (Resolution VIII.xx); additional guidelines for the identification and designation of Wetlands of International Importance (Resolution VIII.xx); *New Guidelines for management planning for Ramsar sites and other wetlands* (Resolution VIII.xx); and *Guidelines for Global Action on Peatlands* (Resolution VIII.xx), the implementation of all of which will be substantially assisted by the availability of wetland inventory at national and other scales];
5. RECALLING the findings of the *Global Review of Wetland Resources and Priorities for Wetland Inventory* (GRoWI) report of Wetlands International, from which it was indicated to COP7 that few countries, if any, had comprehensive national inventories of their wetland resources, and that it was not possible to provide a clear baseline estimate of the world’s wetland resources with any confidence;
6. NOTING that a joint project between Wetlands International and the Institute for Inland Water Management and Waste Water Treatment (RIZA) in the Netherlands has expanded and updated the GRoWI analyses for all European countries;
7. AWARE that the Millennium Ecosystem Assessment (MA) is evaluating the condition, status and trends in global ecosystems including inland wetlands, subterranean (karst), and coastal and marine systems, and that this will include new applications of remote sensing which may enhance information on the global distribution of wetlands and their status;
8. ALSO AWARE of the European Space Agency’s project Treaty Enforcement Services using Earth Observation (TESEO) is evaluating the use of remote sensing for wetland inventory, assessment, monitoring and site management, as well as for dryland ecosystems;

9. RECALLING that in Resolution VII.20 the Conference of the Parties urged “all Contracting Parties yet to complete comprehensive national inventories of their wetland resources, including where possible wetland losses and wetlands with potential for restoration, to give highest priority in the next triennium to the compilation of comprehensive national inventories”, but NOTING with concern that in their National Reports to this meeting only [xx] Contracting Parties have reported the initiation of national wetland inventory, and only [yy] the completion of such comprehensive inventories since COP7;
10. ALSO RECALLING that in Resolution VII.20 the Contracting Parties requested the Scientific and Technical Review Panel, in collaboration with Wetlands International, the Ramsar Bureau, and other interested organizations, to review and further develop existing models for wetland inventory and data management, including the use of remote sensing and low-cost and user-friendly geographic information systems, and to report their findings to the 8th Meeting of the Conference of the Contracting Parties with a view to promoting international common standards;
11. FURTHER RECALLING that in Resolution VII.20 the Contracting Parties resolved that their inventory data, where it exists, should be housed and maintained in such a way that the information resource should be available to all decision-makers, stakeholders, and other interested parties;
12. APPRECIATIVE of the financial support of the governments of the United Kingdom and the United States of America for the preparation by the STRP of further guidance on wetland inventory; and
13. RECOGNIZING that various methodologies for national inventory can in general be applied also to local, sub-national (e.g. provincial), and transboundary international scales;

THE CONFERENCE OF THE CONTRACTING PARTIES

14. ADOPTS the *Framework for Wetland Inventory* as annexed to this Resolution;
15. RECOGNIZES that it is appropriate to apply different wetland inventory approaches, methods and wetland classifications for different purposes and objectives, but that common standards can be achieved by ensuring consistency in the collection of a core (minimum) dataset, as provided in the Framework;
16. URGES all Contracting Parties that have yet to complete comprehensive national wetland inventories to continue to give a high priority in the next triennium to the compilation of such inventories, utilizing the *Framework for Wetland Inventory* to ensure that their inventory design appropriately addresses their purpose and objectives, in order that their activities that require the sound basis of wetland inventory, such as policy development and Ramsar site designations, can be carried out on the basis of the best possible information;
17. ENCOURAGES Contracting Parties initiating development of a national wetland inventory to consider the application or adaptation of an existing inventory methodology and data management system, including the updated inventory methodology developed by the Mediterranean Wetlands Initiative (MedWet), so as to ensure consistency in inventory data and information collected;
18. CALLS UPON Contracting Parties that have undertaken wetland inventories to ensure that they have appropriate arrangements in place for housing and maintaining their wetland inventory data, both in printed and electronic formats, and to make this data and information available, including where possible through the World Wide Web and CD-ROM formats, to all decision-makers, stakeholders, and other interested parties;
19. ALSO CALLS UPON all Contracting Parties and others who have undertaken, or are undertaking, wetland inventory to document information about the inventory, its data holdings, management and availability using the standard metadata record provided in the *Framework for Wetland Inventory* and the COP8 information paper providing further guidance on the metadata methodology, so as to make this information available as widely as possible;

20. REQUESTS the Bureau and Wetlands International, working with its Wetland Inventory and Monitoring Specialist Group, to make available the standard metadata record for wetland inventory on the World Wide Web so that Contracting Parties and others can report and make fully available the information about their wetland inventories, and so as to assist in the updating by Wetlands International of global information about the status of wetland inventory;
21. ENCOURAGES Contracting Parties and other interested organizations and funding bodies to provide resources to Wetlands International, working with other relevant organizations, to review and update the *Global Review of Wetland Resources and Priorities for Wetland Inventory* (GRoWI) report made available to COP7, and to report on its findings to the 9th Meeting of the Conference of the Contracting Parties, including progress in the implementation of Resolution VII.20;
22. REQUESTS the Scientific and Technical Review Panel, working with Wetlands International, the Ramsar Bureau, remote sensing agencies, and other interested organizations to review further the application of remote sensing data, low-cost geographical information systems, and classification systems in wetland inventory, and to report on its findings to the 9th Meeting of the Conference of the Contracting Parties;
23. CALLS UPON Contracting Parties and other organizations with experience in training and capacity building in wetland inventory, including in the use of remote sensing and geographical information systems, to work with Wetlands International in order to make available this expertise through the Ramsar Training Framework;
24. FURTHER CALLS UPON bilateral and multilateral donors to assign priority to supporting wetland inventory projects in developing countries and countries with economies in transition, noting the importance of such projects in forming the basis for developing and implementing the sustainable use of wetlands; and
25. DIRECTS that priority be given to appropriate wetland inventory projects in the consideration of projects submitted to the Ramsar Small Grants Fund.

A Framework for Wetland Inventory

Background and context

1. *In Resolution VII.20 (1999) the Contracting Parties recognised the importance of comprehensive national inventory as the vital basis for many activities necessary for achieving the wise use of wetlands, including policy development, identification and designation of Ramsar sites, documentation of wetland losses, and identification of wetlands with potential for restoration (see also Resolution VII.17 [and Resolution VIII.xx]). It also encouraged the collection of information for the management of shared wetlands, including those within river basins and/or coastal zones (see also Resolution VII.18 [and Resolution VIII.xx]) as appropriate. [Furthermore, Theme 1 of the Convention's Strategic Plan is devoted to wetland inventory and assessment, with a series of concrete actions to achieve its Operational Objective.]*
2. *The Global Review of Wetland Resources and Priorities for Wetland Inventory (GRoWI), prepared in 1999 for the Ramsar Convention by Wetlands International and the Environmental Research Institute of the Supervising Scientist, Australia, indicated that few countries have comprehensive national inventories of their wetland resources, and lack this essential baseline information on their wetlands. [In addition, the National Reports submitted to Ramsar COP8 indicated that insufficient progress has been made in wetland inventory.]*
3. *The GRoWI review concluded that a clear identification and statement of purpose and objectives is fundamental to the design and implementation of effective and cost-efficient inventory, but found that the purpose and objectives for many existing inventories were poorly, if at all, stated.*
4. *In Resolution VII.20 the COP urged Contracting Parties which had yet to complete national inventories of their wetland resources to give the highest priority to the compilation of comprehensive wetland inventories, and requested the Convention's Scientific and Technical Review Panel (STRP) to review and further develop existing models for wetland inventory and data management, including the use of remote sensing and low-cost and user-friendly geographic information systems.*
5. *This Framework for Wetland Inventory has been developed by the STRP, working with the Ramsar Bureau, Wetlands International, the Environmental Research Institute of the Supervising Scientist (Australia) and others, in response to Resolution VII.20. The Framework provides guidance on a standard approach to designing a wetland inventory program. It includes information on determining appropriate remote sensing techniques to apply, wetland classifications and existing standardised inventory methods, and recommends standards for core data fields and data and metadata recording.*
6. *The Framework provides guidance for designing wetland inventory at multiple scales from site-based to provincial, national and regional. The extent of detail that can be compiled in the inventory will generally decrease as the geographical area of coverage increases, unless large resources can be allocated for the program.*
7. *The data fields included in any particular inventory will be based on the specific purpose and scale of the inventory. A core data set is recommended as a minimum, but with the option of adding further data fields as required.*
8. *The Framework uses the definition of "inventory" agreed in Workshop 4 on Wetland Inventory, Assessment and Monitoring – Practical Techniques and Identification of Major Issues held during the 2nd International Conference on Wetlands and Development, Dakar, Senegal, 8-14 November 1998 (Finlayson et al. 2001). The definition is provided below along with those for the inter-connected concepts of assessment and monitoring:*

Wetland inventory: The collection and/or collation of core information for wetland management, including the provision of an information base for specific assessment and monitoring activities.

Wetland assessment: The identification of the status of, and threats to, wetlands as a basis for the collection of more specific information through monitoring activities.

Wetland monitoring: Collection of specific information for management purposes in response to hypotheses derived from assessment activities, and the use of these monitoring results for implementing management. (Note that the collection of time-series information that is not hypothesis-driven from wetland assessment should be termed *surveillance* rather than monitoring, as outlined in Resolution VI.1.)

9. It is important to distinguish between inventory, assessment and monitoring when designing data gathering exercises, as they require different categories of information. Wetland inventory provides the basis for guiding the development of appropriate assessment and monitoring, but wetland inventories repeated at given time intervals do not constitute ‘monitoring’.

A framework for wetland inventory

10. A structured framework for planning and designing a wetland inventory is summarized in Table 1. The framework comprises 13 steps that provide the basis for making decisions in relation to the purpose (and objectives), and the available resources, for an inventory.
11. All steps in the Framework are applicable to the planning and implementation of any wetland inventory, and all steps should therefore be followed during the design and planning process. The framework does not provide prescriptive guidance on particular inventory methods; rather it provides guidance to the Contracting Parties and others who are planning to undertake wetland inventory by drawing attention to different methods and wetland classifications already in use and of proven utility under different circumstances.
12. The framework should be used as a basis for making decisions for undertaking a wetland inventory under the circumstances particular to each inventory program. Guidance on the application of each step is provided.

Table 1. A structured framework for planning a wetland inventory

Step	Guidance
1. State the purpose and objective	State the reason(s) for undertaking the inventory and why the information is required, as the basis for choosing a spatial scale and minimum data set.
2. Review existing knowledge and information	Review the published and unpublished literature and determine the extent of knowledge and information available for wetlands in the region being considered.
3. Review existing inventory methods	Review available methods and seek expert technical advice to: a) choose the methods that can supply the required information; and b) ensure that suitable data management processes are established.
4. Determine the scale and resolution	Determine the scale and resolution required to achieve the purpose and objective defined in Step 1.
5. Establish a core or minimum data set	Identify the core, or minimum, data set sufficient to describe the location and size of the wetland(s) and any special features. This can be complemented by additional information on factors affecting the ecological character of the wetland(s) and other management issues, if required.
6. Establish a habitat classification	Choose a habitat classification that suits the purpose of the inventory, since there is no single classification that has been globally accepted.
7. Choose an appropriate method	Choose a method that is appropriate for a specific inventory based on an assessment of the advantages and disadvantages, and costs and benefits, of the alternatives.

8. Establish a data management system	Establish clear protocols for collecting, recording and storing data, including archiving in electronic or hardcopy formats. This should enable future users to determine the source of the data, and its accuracy and reliability. At this stage it is also necessary to identify suitable data analysis methods. All data analysis should be done by rigorous and tested methods and all information documented. The data management system should support, rather than constrain, the data analysis. A meta-database should be used to: a) record information about the inventory datasets; and b) outline details of data custodianship and access by other users.
9. Establish a time schedule and the level of resources that are required	Establish a time schedule for: a) planning the inventory; b) collecting, processing and interpreting the data collected; c) reporting the results; and d) regular review of the program. Establish the extent and reliability of the resources available for the inventory. If necessary make contingency plans to ensure that data is not lost due to insufficiency of resources.
10. Assess the feasibility & cost effectiveness	Assess whether or not the program, including reporting of the results, can be undertaken within under the current institutional, financial and staff situation. Determine if the costs of data acquisition and analysis are within budget and that a budget is available for the program to be completed.
11. Establish a reporting procedure	Establish a procedure for interpreting and reporting all results in a timely and cost effective manner. The report should be succinct and concise, indicate whether or not the objective has been achieved, and contain recommendations for management action, including whether further data or information is required.
12. Establish a review and evaluation process	Establish a formal and open review process to ensure the effectiveness of all procedures, including reporting and, when required, supply information to adjust or even terminate the program.
13. Plan a pilot study	Test and adjust the method and specialist equipment being used, assess the training needs for staff involved, and confirm the means of collating, collecting, entering, analysing and interpreting the data. In particular, ensure that any remote sensing can be supported by appropriate “ground-truth” survey.

Step 1 State the purpose and objective

13. *Wetland inventory has multiple purposes. These include:*
- a) *listing particular types, or even all, wetlands in an area;*
 - b) *listing wetlands of local, national and/or international importance;*
 - c) *describing the occurrence and distribution of wetland taxa;*
 - d) *describing the occurrence of natural resources such as peat, fish or water;*
 - e) *establishing a baselines for measuring change in the ecological character of wetlands;*
 - f) *assessing the extent and rate of wetland loss or degradation;*
 - g) *promoting awareness of the value of wetlands;*
 - h) *providing a tool for conservation planning and management; and*
 - i) *developing networks of experts and cooperation for wetland conservation and management.*
14. *An inventory should contain a clear statement of its purpose and objective. This should identify the habitats that will be considered, the range of information that is required, the time schedule, and who will make use of the information.*
15. *A clear statement of the purpose(s) will assist in making decisions about the methods and resources needed to undertake the inventory.*

Step 2 Review existing knowledge and information

16. *Past investigations have resulted in the provision of broad-scale wetland inventory information for many parts of the world. Other, more detailed, but localized inventory may have been undertaken,*

restricted either geographically or to particular wetland habitats or ecosystems in the region under consideration.

17. *Valuable information may be held in many different formats and/or by many different organizations (e.g., waterbird, fisheries, water quality and agricultural information bases, and local peoples' information and knowledge).*
18. *A comprehensive review of existing data sources may be necessary and its relevance to the proposed inventory work ascertained.*

Step 3 Review existing inventory methods

19. A number of established methods for wetland inventory exist. The characteristics of five examples in current use are summarized in Appendix I. Further sources of information are listed in Appendix VI. The techniques and habitat classifications used in these methods have been successfully adapted for use in a number of locations.
20. The review should determine whether or not existing established inventory methods are suitable for the specific purpose and objectives of the inventory being planned.
21. Some inventory methods use a linked hierarchical approach, in which inventory may be designed at different spatial scales for different purposes.
22. Many inventories have been based on ground-survey, often with the support of aerial photography and topographical maps and, more recently, satellite imagery. The development of Geographic Information Systems (GIS) and the enhanced resolution of satellite imagery have resulted in greater use of spatial data.
23. A procedure for determining which remotely sensed datasets are the most appropriate for particular purposes, including their use in GIS, is given in Appendix II. A summary of currently available remote sensing data sets that can be applicable to wetland inventory is provided in Appendix III.

Step 4 Determine the scale and resolution

24. The spatial scale used for wetland inventory is inseparable from its objective and greatly influences the selection of the method to be used.
25. Wetland inventory has been carried out at a number of spatial scales, with specific objectives at each scale. When choosing the scale it is necessary first to determine the objective and then assess how this can be achieved through a chosen scale.
26. Suitable scales for wetland inventory within a hierarchical approach are:
 - a) wetland regions within a continent, with maps at a scale of 1:1,000,000 – 250,000
 - b) wetland aggregations within each region, with maps at a scale of 1:250,000 – 50,000
 - c) wetland sites within each aggregation, with maps at a scale of 1:50,000 – 25,000.
27. The choice of scale is also related to the size of the geographic area involved and to the accuracy required and achievable with available resources.
28. Each of the scales needs a minimum mapping unit that reflects the minimum acceptable accuracy for that scale. This is done by first determining what is the minimum size of feature that can be clearly delineated at that scale, to acceptable standards, and by then determining what measures are required to describe the accuracy/confidence of defining the unit. For example, a land systems map compiled to a scale of 1:250,000 typically involves taking one on-the-ground site observation for every 600 ha surveyed.

Step 5 Establish a core or minimum data set

29. A core or minimum data set sufficient to describe the wetland(s) should be determined. The specific details of this data set are inseparable from the level of complexity and the spatial scale of the inventory.
30. It is recommended that sufficient information (the core, or minimum, data set) should be collected so as to enable the major wetland habitats to be delineated and characterized for at least one point in time.
31. The core data can be divided into two components:
 - a) that describing the biophysical features of the wetland; and
 - b) that describing the major management features of the wetland.
32. The decision whether to undertake an inventory based only upon core biophysical data or also to include data on management features will be based on individual priorities, needs, and resources. The second component is likely to provide information that can immediately be used for assessment purposes, but it may require more extensive data collection and analyses. Care should be exercised to ensure that the inclusion of this information does not detract from the primary purpose of obtaining sufficient information to enable the delineation and characterization of the wetland(s).
33. Recommended core data fields for the collection of biophysical and management features of wetlands are listed in Table 2.

Table 2. Core (minimum) data fields for biophysical and management features of wetlands

Biophysical features

- Site name (official name of site and catchment)
- Area and boundary (size and variation, range and average values) *
- Location (projection system, map coordinates, map centroid, elevation) *
- Geomorphic setting (where it occurs within the landscape, linkage with other aquatic habitat, biogeographical region) *
- General description (shape, cross-section and plan view)
- Climate – zone and major features
- Soil (structure and colour)
- Water regime (periodicity, extent of flooding and depth, source of surface water and links with groundwater)
- Water chemistry (salinity, pH, colour, transparency, nutrients)
- Biota (vegetation zones and structure, animal populations and distribution, special features including rare/endangered species)

Management features

- Land use – local, and in the river basin and/or coastal zone
- Pressures on the wetland – within the wetland and in the river basin and/or coastal zone
- Land tenure and administrative authority – for the wetland, and for critical parts of the river basin and/or coastal zone
- Conservation and management status of the wetland – including legal instruments and social or cultural traditions that influence the management of the wetland
- Ecosystem values and benefits (goods and services) derived from the wetland – including products, functions and attributes (see Resolution VI.1) and, where possible, their services to human well-being (see Resolution VI.23 and VII.8)
- Management plans and monitoring programs – in place and planned within the wetland and in the river basin and/or coastal zone (see Resolutions 5.7, VI.1, VII.17, [and VIII.xx])

* These features can usually be derived from topographical maps or remotely sensed images, especially aerial photographs.

Step 6 Establish a habitat classification

34. Many national wetland definitions and classifications are in use (Appendix IV). These have been developed in response to different national needs and take into account the main biophysical features (generally vegetation, landform and water regime, sometimes also water chemistry such as salinity) and the variety and size of wetlands in the locality or region being considered.
35. The Ramsar Classification System for Wetland Type (Resolution VI.5) is increasingly being used as a classification basis for national wetland inventories. However, when it was first developed it was not anticipated that the Ramsar classification would be used for this inventory purpose, so its usefulness as a habitat classification for any specific wetland inventory should be carefully assessed. Whilst the Ramsar Classification System has value as a basic habitat description for sites designated for the Ramsar List of Wetlands of International Importance, it does not readily accommodate description of all wetland habitats in the form and level of description that are now commonly included in many wetland inventories.
36. A classification based upon the fundamental features that define a wetland – the landform and water regime – is considered to be superior to those based on other features (Resolution VII.20). The basic landform and water regime categories within such a classification can be complemented with modifiers that describe other features of the wetland, for example, for vegetation, soils, water quality, and size.
37. As it is unlikely that a single classification can be globally acceptable, not least because different classification systems are required by some national legislations, a classification should be chosen that suits the purpose of the inventory. The core biophysical data recommended to be collected in an inventory (Table 2) may be used to derive a classification that suits individual needs.

Step 7 Choose an appropriate method

38. Many inventory methods are available (see Appendices I and IV for examples). When assessing which method (or methods) is appropriate for an inventory, it is necessary to be aware of the advantages and disadvantages of the alternatives in relation to the purpose and objective of the proposed inventory work. This applies particularly to the use of remotely sensed data (as listed in Appendix III).
39. To assist in determining which remote sensing data is most useful for a particular inventory, a simple decision-tree is provided in Appendix II. The decision-tree is also presented pictorially and contains six steps to assist in determining which data are most suitable. Importantly, the extent of “ground-truth” survey required to validate the remote sense data should be assessed when considering such techniques.
40. Physico-chemical and biological sampling should be undertaken whenever possible by standard laboratory and field methods that are well documented and readily available in published formats. There is a variety of acceptable methods in use. The bibliographical details of those used should be recorded and any departures from standard procedures clearly justified and documented.
41. As a general rule, the inventory method chosen should be sufficiently robust to ensure that the required data can be obtained within the constraints imposed by the terrain, resources, and time period available. Where adequate methods do not exist, well-directed research is needed to develop or identify specific techniques.
42. The use of Geographic Information Systems (GIS) for managing spatial data, in particular, is encouraged, noting that low-cost GIS platforms are increasingly available and widely-used.

Step 8 Establish a data management system

43. Increasing use of databases and Geographic Information Systems ensure that a large amount of data can be stored and displayed, but these capabilities will be undermined if the data are not well managed and stored in formats that are readily accessible.

44. Potential data management problems can be overcome by establishing clear protocols for collecting, recording and storing data, including archiving data in electronic and/or hardcopy formats. The protocols should enable future users to determine the source of the data, as well as its accuracy and reliability. The protocols should also ensure effective recording and reporting of data and information.
45. The data management system should support analysis of the data. Details of all analytical methods should be recorded along with the data and made available to all users. This includes details of statistical techniques and any assumptions about the data.
46. In addition, a meta-database should be used to record basic information about individual inventory data sets. These meta-data records should include a description of the type of data and details of custodianship and access. A standard metadata format has been developed specifically for recording wetland inventory (Appendix V)[, and further guidance on the use of this inventory metadata standard is available in Ramsar COP8 – DOC. XX].
47. General good practice guidance on meta-data and data custodianship, ownership and access is available in a handbook produced for the Biodiversity Conservation Information System (BCIS) (Biodiversity Conservation Information System 2000).
48. The meta-data records should be an integral part of the data management system and not treated as a separate entity from the data files, even if these have been archived.

Step 9 Establish a time schedule and the level of resources that are required

49. It is necessary to determine the time schedule for planning the inventory, as well as for collecting, processing and interpreting the data collected during an inventory. This is particularly important if field sampling is required, in which case a sampling schedule that takes into account any special features of the terrain and sampling techniques will be necessary.
50. The schedule should be realistic and based on firm decisions about funding and resources. This will determine the extent and duration of the inventory. The schedule should also include time to prepare for the inventory, especially if a team of experts needs to be gathered, and extensive background investigation and review has to be undertaken.
51. The extent and reliability of the resources available for the inventory will eventually determine the nature and duration of the inventory. The funding to secure and train suitable personnel and obtain appropriate technical resources, such as field equipment and remote sensing data, should be confirmed and steps taken to ensure that these are available when required.

Step 10 Assess the feasibility and cost effectiveness of the project

52. Once a method has been chosen and a time schedule determined, it is necessary to assess whether or not it is feasible and cost effective to undertake the project. This assessment is essentially a review of the entire inventory method, including the time schedule and costs.
53. Factors that influence the feasibility and cost effectiveness of the project include:
 - availability of trained personnel;
 - access to sampling sites;
 - availability and reliability of specialized equipment for sample collection or analysis of samples;
 - means of analyzing and interpreting the data;
 - usefulness of the data and information derived from it;
 - means of reporting in a timely manner; and
 - financial and material support for any continuation of the project.

Step 11 Establish a reporting procedure

54. The results obtained in the inventory should be recorded and reported in a timely and cost effective manner. The records should be concise and readily understood by others involved in the program or similar investigations. Where necessary the records should be cross-referenced to other documentation from the inventory.
55. It is important to keep in mind that the data may be useful for further analyses in the future – the analysts involved should be able to readily access and interpret the data records and be aware of any constraints on their usefulness for such purposes. In this respect the reporting procedure should incorporate reference to the meta-database and archived data.
56. A report on the inventory should be prepared at pre-determined intervals. It should be succinct and concise and indicate whether or not the purpose and objective of the inventory is being achieved, and whether there are any constraints on using the data (e.g. changes to the sampling regime such as lack of replication or concerns about its accuracy).
57. The core data should be made available to interest groups in appropriate formats along with details of the methods used. Reports may present the data collected and/or contain specific recommendations for further inventory and data collection, or for management action.
58. At the same time, a meta-data record of the inventory should be made and added to a centralized file using a standardized format.
59. All reports should be made available to interested parties and other agencies in the shortest possible time through appropriate electronic and hardcopy formats.

Step 12 Review and evaluate the inventory

60. Throughout the inventory it may be necessary to review progress and make adjustments to the sampling regime, data management, and program implementation. The review and evaluation process should be developed and agreed as part of the planning and design phase of the inventory. The review procedures should establish that when changes are made they should be recorded and made known to all involved in the inventory.
61. The review procedures should also establish that at the end of the inventory, or after a predetermined time period, the entire process should be re-examined and necessary modifications made and recorded. The evaluation procedures should be designed to illustrate both the strengths and the weaknesses of the inventory, including necessary reference to the sampling regime and/or the data quality.
62. The evaluation can also be used to justify a request for ongoing funding. If the inventory has been a success and achieved its purpose and objective, this should be clearly stated and the program brought to an end. Conversely, if the inventory has not achieved its purpose and objective, this also should be clearly stated along with a recommendation as to whether it should continue, possibly in a revised form, or halted.

Step 13 Plan a pilot study

63. Before launching an inventory a pilot study is essential. The pilot study provides the mechanism through which to confirm or alter the time schedule and the individual steps within the chosen method. It also provides the opportunity to develop individual workplans for all personnel.
64. The pilot study phase is the time to fine-tune the overall method and individual steps and test the basic assumptions behind the method and sampling regime. Specialist field equipment should be tested and, if necessary, modified, based on practical experience. It is also the opportunity to assess training needs. The amount of time and effort required to conduct the pilot study will vary considerably – its importance will be shown by the improvements made to the schedule and design of the inventory.

65. The pilot study provides the final step before commencing the wetland inventory itself. Lessons learnt during the pilot study should be incorporated into the inventory method.

Implementation of the inventory

66. Once the method has been agreed by following all steps in the above Framework the inventory can be implemented with some confidence. Importantly, that confidence is dependent upon a suitable pilot study being undertaken and confirmation of all individual sampling and data management protocols. Any further changes to the agreed protocols should be recorded and, where necessary, discussed and formalized.
67. It should be expected that collection of the data for the full inventory will consume most of the time and resources available for the inventory. The steps in the Framework are designed to guide development an overall method and ensure that the inventory can be competently implemented.
68. All data collected during the inventory should be contained within the agreed data management system, which may include both hardcopy and electronic files and records. Steps should be taken to ensure that the data records are secure and duplicate copies kept in safe locations.
69. Whilst the steps in the Framework provide the basis for designing an inventory project for specific purposes and with specified resources available, it does not ensure that an inventory will be effective. This can only be done by the personnel engaged to undertake the inventory – the Framework provides an outline of the method, including necessary training and contingency in support of the method.
70. It must be stressed that all steps in the Framework are necessary, with the pilot study step providing an important feedback and an opportunity to refine the inventory before the main sampling effort commences. Similarly, the review and evaluation step provides an important check on progress and a formal opportunity to adjust or even halt the inventory.

Inventory methods

71. Standardized inventory methods are available and have been successfully used in different circumstances, countries or regions. Notable amongst these are the Mediterranean Wetlands Initiative (MedWet) inventory, the United States Fish and Wildlife Service national wetland inventory, the Ugandan national wetland inventory, the Asian wetland inventory, and the Ecuador national wetland inventory.
72. The characteristics of these examples are summarised below in terms of each of the 13 Framework steps. These examples have been chosen principally as they were considered comprehensive examples of existing methods, but also because they illustrate differences in approaches that could be used in different locations, for different purposes, and at different scales. The need for different methods and wetland classifications (see also Appendix IV) that enable local and national needs to be met must be stressed: this is illustrated by the range of examples below.

Mediterranean Wetlands Initiative (MedWet) inventory

73. This is a set of standard but flexible methods and tools, including a database for data management, for inventory in the Mediterranean region. Although not intended as a pan-Mediterranean wetland inventory, it has provided a common approach that has been adopted, and adapted, for use in several Mediterranean countries and elsewhere.

1. Purpose and objective	To identify where wetlands occur in Mediterranean countries and ascertain which are priority sites for conservation; to identify the values and functions for each wetland and provide a baseline for measuring future change; and to provide a tool for planning and management and permit comparisons between sites.
2. Information review	A process of consultation with an advisory group of experts from the Mediterranean and elsewhere. This group considered the experience and

	knowledge gained from other inventory and various Ramsar guidelines on managing wetlands.
3. Review methods	Considered database methods used elsewhere in Europe, United States and Asia. Compatibility with wetland databases being used in Europe was a key consideration, e.g. the CORINE Biotopes program. The method was designed to include both a simple and a complex data format.
4. Scale and resolution	Multiple scales for river basins, wetland sites and habitats have been adopted.
5. Core data set	Standard data sheets have been established for river basins, wetland sites (identification, location, description, values, status), habitat, flora, fauna, activities and impacts, meteorological data, and references.
6. Habitat classification	Ramsar classification can be used at a broad scale. For detailed information on sites the United States National Wetland Inventory classification has been adapted.
7. Method	Five steps: i) site selection; ii) Site identification through cartographic means or remote sensing with field assessment; iii) habitat classification; iv) data collection and management through standard data sheets and database; and v) map production using standard conventions.
8. Data management	Based on a standard database, initially developed in FoxPro in MS-DOS, and updated in 2000 in Microsoft Access. [Note. A further updated database, using MS Visual Basic software, and including mapping/GIS capability, due for release 2002.]
9. Time schedule and resources	Dependent on the complexity of the inventory. A simple inventory can be done with minor resources while a detailed inventory requires greater human and financial resources.
10. Feasibility & cost effectiveness	Assessed in France before being made available for on-ground pilot studies. The feasibility of the program is built around having a flexible approach that reflects the resources that are available for the inventory.
11. Reporting	Standardized data sheets provided for storing information and a database for ease of reporting. Specific formats for reports can be determined and included.
12. Review and evaluation	An inventory working group has been established to assess progress with undertaking and using the information from inventories using this approach, and to update the information and methods as necessary.
13. Pilot study	Undertaken in Portugal, Morocco, Greece, Spain and France.
Further information	Costa, Farinha, Tomas Vives & Hecker 1996 & 2001; Hecker, Costa, Farinha & Tomas Vives 1996. http://www.wetlands.org/pubs&/wetland_pub.html

United States national wetland inventory

74. A long running national program that has developed a classification and methodology for producing a map-based inventory.

1. Purpose and objective	To conduct a natural resource inventory of wetlands for use in wetland planning, regulation, management and conservation.
2. Information review	Reviewed the extent of wetland survey and inventory to determine the status of wetland protection and the availability of maps of wetlands.
3. Review methods	Reviewed existing wetland inventory and consulted with state and federal agencies to determine what inventory techniques were being used.
4. Scale and resolution	Maps produced at a scale of 1:80 000 or 1:40 000.
5. Core data set	Standardized data collection is undertaken in line with the information required for the habitat classification and production of standard maps for each state.
6. Habitat classification	Hierarchical classification developed as an integral part of the inventory to describe ecological units and provide uniformity in concepts and terms.
7. Method	Based on interpretation of color infrared aerial photographs, initially at 1:24 000 and more recently at 1:40 000 to 1:80 000 scale. The mapping unit varies according to the region and ease of identifying wetlands. The method includes

	field checking and stereoscopic analysis of photographs. Other remote sensing techniques are being tested.
8. Data management	Maps and digital data are made available online at www.nwi.fws.gov . Data is analyzed through GIS using ARC-INFO.
9. Time schedule and resources	Ongoing program since 1974. Maps are updated as needed and when funding is available.
10. Feasibility & cost effectiveness	Large scale program was extensively funded and a large proportion of the country is now mapped. A statistical design was incorporated to provide valid representative figures for selected areas.
11. Reporting	National wetland trends are produced periodically, based on statistical sampling. Mapping targets have been set through legislation that has periodically been revised.
12. Review and evaluation	The inventory has been under regular review and its outputs evaluated and new targets and priorities established.
13. Pilot study	An extensive phase of method development was undertaken before the inventory was considered operational. The classification system which underpins the inventory was extensively tested in the field.
Further information	Cowardin, Carter, Golet & LaRoe 1979; Cowardin & Golet 1995; Wilen & Bates 1995 www.nwi.fws.gov

Uganda National Wetlands Programme

75. The inventory is a component of an ongoing National Wetlands Program. It is largely carried out at the local level, using standard formats, and includes a training component.

1. Purpose and objective	To survey, describe, quantify and map all wetlands and provide decision-makers and planners, especially at district level, with information for management planning; to support policy implementation; to support economic valuation; and to support overall natural resource management planning.
2. Information review	Undertook literature review prior to the onset of the inventory.
3. Review methods	Carried out a review prior to the onset of the inventory process.
4. Scale and resolution	Uses SPOT imagery at 1:50 000 to cover the country.
5. Core data set	Bio-physical data encompassing site name, area, location, general description, seasonality, biota (vegetation types and animals present) and management data covering land-use, land tenure, conservation status, values, threats.
6. Habitat classification	Derived from landform, water regime and vegetation.
7. Method	GIS-based map analyses based on remotely sensed data alongside topographic maps of similar scale (1:50 000) as well as ground surveys. Uses standard data sheets. All wetlands are coded. Methods are documented in a wetland inventory guide. Activity is carried out on district basis with personnel from the district being designated to carry out the fieldwork and compile reports.
8. Data management	A computerized database using Microsoft Access was based on the standardized field data sheets. This database will be linked to the ArcView map database using wetland codes. The linkage between the two databases forms the National Wetland Information System (NWIS) which is already developed with ongoing data entry.
9. Time schedule and resources	An ongoing process with regular updates. The inventory is one of the main activities of a donor-funded National Wetlands Program with a number of partners.
10. Feasibility & cost effectiveness	Feasibility assessed through pilot studies. Cost effectiveness related to the complexity of the wetland systems, extent of areas being assessed, availability of remotely sensed images and capacity.
11. Reporting	Standardized data sheets used for storing information in a database for ease of reporting. Individual reports prepared at district level. These will be consolidated into a National Wetland Inventory.

12. Review and evaluation	Done within the project in consultation with a few external experts.
13. Pilot study	Undertaken in a few wetlands and then districts..
Further information	National Wetlands Programme 1999; Pabari, Churie & Howard 2000. www.iucn.org/themes/wetlands/uganda.html

Asian Wetland Inventory (AWI)

76. This approach has been developed in response to the recommendations contained in the Global Review of Wetland Resources and Priorities for Wetland Inventory report and presented in Resolution VII.20. The method is a hierarchy that can be implemented at four spatial scales. The method is based largely on a draft protocol developed in Australia, and has been tested in a pilot study in Japan. The pilot study has resulted in a manual being produced.

1. Purpose and objective	To provide a hierarchical database on coastal and inland wetlands in Asia
2. Information review	Undertaken in the extensive global review of wetland inventory conducted on behalf of the Ramsar Convention (see Resolution VII.20)
3. Review of methods	Undertaken in the extensive global review of wetland inventory conducted on behalf of the Ramsar Convention and refined through the development of a manual.
4. Scale and resolution	Hierarchical multi-scalar approach with four levels of analysis: level 1 at 1:10 000 000 to 1:5 000 000; level 2 at 1:1 000 000 to 1:250 000; level 3 at 1: 250 000 to 1:100 000; and level 4 at 1:50 000 to 1:25 000.
5. Core data set	Hierarchical multi-scalar minimum data at each level of analysis: level 1 – broad geology, land cover and climate for river basins; level 2 – geology, landforms, climate for wetland regions; level 3 – hydrological, climate, landform, physico-chemical, and biological detail for wetland complexes; and level 4 information on management issues and procedures included, in addition to site descriptions as per level 3
6. Habitat classification	Derived from minimum data on landform and water regimes and possibly supplemented with information on vegetation, areal size and water quality.
7. Method	GIS-based map analyses using remotely sensed imagery and maps augmented with ground surveys that are more intensive at levels 3 and 4. Prescribed data sheets and fields with agreed codes are available for each level of analysis.
8. Data management	The data management system is built on a computerized database engine with web, user/data interface and GIS capabilities. This serves as the primary data management/storage/retrieval component of the project. The system is based on the Windows platform using MS Visual Basic and Access 97 software. The website (www.wetlands.org/awi) serves as the main communication node for data collection, announcements and discussions.
9. Time schedule and resources	An ongoing process with regular updates of information obtained through national or local analyses. The program has been devolved through the regionalized structure of Wetlands International and its partners.
10. Feasibility & cost effectiveness	Feasibility assessed through project meetings and submission of funding applications that required targeted outputs etc. Cost effectiveness related to the extent of the areas being assessed and the extent of pre-existing inventory information, maps and remotely sensed images. The procedure was based on the Ramsar Convention's review of wetland inventory that found many inventories did not achieve their purpose through being over-ambitious and/or not applying tight data management and reporting procedures – all features that have been addressed.
11. Reporting	Standardized data sheets provided for storing information in a database for ease of reporting. Individual reports are provided through the devolved projects and where appropriate copies filed by Wetlands International on its web page (www.wetlands.org/awi).
12. Review and evaluation	Provided at the Wetlands International seminar "Wetlands in a Changing World" held in Wageningen, The Netherlands, 30 November 2001.

13. Pilot study	Undertaken in Japan – Hokkaido and Kushiro Marsh with maps produced in a GIS format.
Further information	<i>Finlayson, Howes, Begg & Tagi 2002; Finlayson, Howes, van Dam, Begg & Tagi 2002</i> www.wetlands.org/awi/

Ecuador wetland inventory

77. This is a national wetland inventory nearing completion that has been developed by the Ministry of the Environment, the Ramsar Bureau, and the EcoCiencia Foundation, and is designed to support Ecuador's implementation of the Ramsar Convention and the wise use of wetlands.

1. Purpose and objective	To provide information to assist in the management of globally important biodiversity in Ecuadorian wetlands, supporting Ecuadorian wetlands conservation through the identification, characterization and prioritization of wetlands for management and conservation.
2. Information review	Published documents and material on the internet and held by universities, research organisations and from a national workshop on the identification and status of wetlands was assessed.
3. Review of methods	Inventory methods used in Canada, Venezuela, Brazil and parts of Argentina were reviewed. Each method was considered to have limitations for application in Ecuador, including too resource and capacity demanding, too little background information available in Ecuador, lacking an ecosystem (catchment)-scale approach, or only reliant on secondary information sources.
4. Scale and resolution	Information was collected at 1:50,000 scale. As some wetlands were too large to use maps at this scale, large individual sites are presented at different scales but information on them held in the database at 1:50,000 scale.
5. Core data set	The data was collected using a quadratical-based matrix that included five selected general criteria, each validated through a series of analysed variables. Information was gathered on social, economic, zoological, botanical, limnological, ecological (including aquatic and terrestrial) features.
6. Habitat classification	The habitat classification followed two existing systems being used in Ecuador.
7. Method	The method includes the following steps: information collected using remote sensing; validation and delineation of zones using a numerical matrix; information on socio-economical and ecological aspects of wetlands derived from interviews; published information reviewed; primary information on ecological and social aspects of wetlands generated. Data was entered into a GIS containing physiographic layers so as to permit the production of recommended land-use strategy and management proposals for the wetlands within their catchments.
8. Data management	Cartographic information is managed by the department of Geographical Information Systems (GIS). Other information is maintained in digital formats by individual researchers. A database of wetland photographs is also maintained.
9. Time schedule and resources	The project began in 1996 with pilot studies in two provinces. Nation-wide coverage was intended to be completed by July 2002 but has now been extended to early 2003 for financial reasons. The total project cost is US\$ 1 million over the seven years of the project, with funding from the Ramsar Bureau, the World Bank, the Global Environment Fund, the MacArthur Foundation and the Ecuadorian Government.
10. Feasibility & cost effectiveness	Feasibility and cost effectiveness was assessed in the project development phase through the World Bank's incremental costs assessment procedures.
11. Reporting	Published reports will be produced, and data held electronically in the GIS database.
12. Review and evaluation	Six-monthly World Bank evaluation of the process and progress in achievements of targets. Final report will have pre-publication review by the Ramsar Bureau. The Ecuador National Wetlands Working Group will consider the final publication.

13. Pilot study	A pilot study was undertaken in 1996 of the lentic wetlands, in the Provinces of Esmeraldas and Manabí.
Further information	<i>Briones, E., Flachier, A., Gómez, J., Tirira, D., Medina, H., Jaramillo, I., & Chiriboga, C. 1997. Inventario de Humedales del Ecuador. Primera parte: Humedales Lénticos de las Provincias de Esmeraldas y Manabí. EcoCiencia/INEFAN/ Convención de Ramsar. Quito, Ecuador.</i> <i>Briones, E., Gómez, J., Hidalgo, A., Tirira, D., & Flachier, A. 2001. Inventario de Humedales del Ecuador. Segunda parte: Humedales Interiores de la Provincia de El Oro. Convención de Ramsar/ INEFAN/ EcoCiencia. Quito, Ecuador.</i>

Determining the most appropriate remotely sensed data for a wetland inventory

78. The following steps provide an outline procedure for assessing which is the most appropriate remote sensing technique for a particular inventory. The procedure is summarized graphically in Figure 1. Available remote sensing data sets applicable to wetland inventory are listed in Appendix III.
79. Much of the information required for this specific determination concerning use of remote sensing can be acquired by following the inventory Framework steps that lead to the choice of an inventory method.

I. Define the purpose and objective

80. Explicitly define the purpose and objective for the inventory (e.g., distribution of specific plant species on a floodplain wetland, baseline data for areas inundated by floodwaters, type of habitats to be mapped, etc.).

II. Determine if remote sensing data is applicable

81. Assess whether remote sensing technology can be applied successfully as a tool to the wetland issues defined previously. This decision will be based on a combination of wetland habitat structure and sensor characteristics and explicitly relates to the spatial and spectral resolution of the remote-sensing device. Expert advice may be needed.

III. Define the wetland characteristics within a remote sensing context

82. Determine the spatial scale most suitable for the habitat structure, the season for data collection, the spectral characteristics and resolution that are critical to sensor choice, and what data and sensors are already available. If multiple surveys are required, determine at the outset the most appropriate temporal scale (e.g., annually or over much longer time periods).

IV. Choose appropriate sensor(s)

83. Assess the spatial and spectral resolution of likely sensors and ensure that they can obtain the environmental information that is required for the defined problem/issue. In some cases several sensors may be required (e.g., Landsat TM fused with polarimetric AirSAR for the identification of salt-affected areas on floodplains dominated by tree species).
84. For each sensor ascertain whether or not it can revisit the site at necessary intervals and whether its application is dependent on seasonal conditions (e.g. optical or RADAR sensors) and that the costs of the image and its analysis are within the allocated budget.

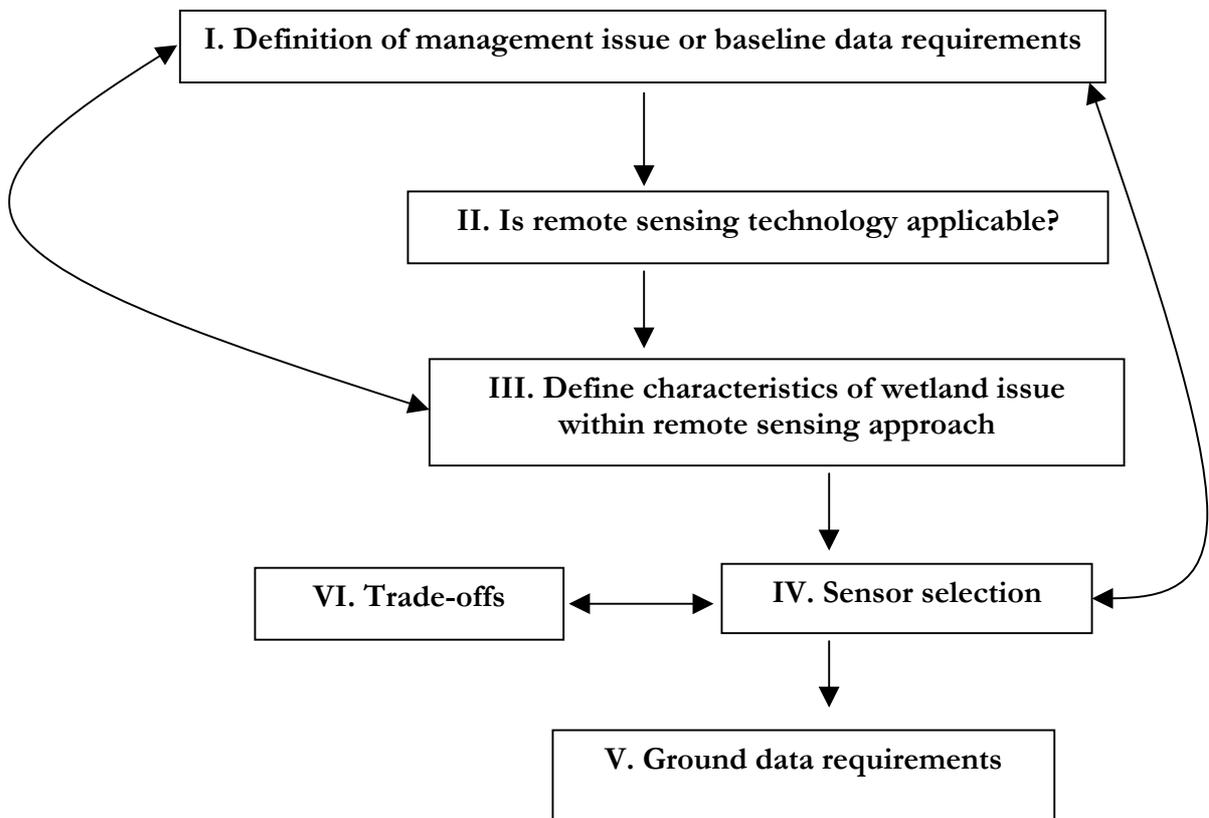
V. Ground data requirements

85. Determine a ground sampling strategy suitable for the sensor selected, including whether or not the collection of ground data should be done simultaneously with the acquisition of data from the sensor. Also determine any potential issues that may influence extrapolation from the ground data, such as scaling-up.

VI. Trade-offs

86. Ascertain if there are any trade-offs when using particular sensors (e.g., what advantages and disadvantages does one data source offer?) and whether these will affect the study (as defined at step I above).

Figure 1. Recommended steps in determining the most appropriate remotely sensed data for use in a wetland inventory.



Summary of remotely sensed data sets applicable to wetland inventory

SATELLITE DATA

Data Type	Spatial Resolution	Coverage	Spectral Resolution	Temporal Resolution	Contact
IKONIS	1m panchromatic 4m multispectral	100km ² (minimum)	Band 1 (blue) = 0.45-0.53μm Band 2 (green) = 0.52-0.61μm Band 3 (red) = 0.64-0.72μm Band 4 (NIR) = 0.77-0.88μm	1-3 days Not routinely collected Data capture must be ordered	Space Imaging http://www.spaceimaging.com/
Landsat 7 ETM	Bands 1-5 & 7 = 30 m Band 6 = 60m Band 8 = 15m	Typical full scene = 184 x 185km (Super scenes up to 60,000km ² and small scenes 25 x 25km are available)	Band 1 (blue) = 0.45-0.52μm Band 2 (green) = 0.52-0.60μm Band 3 (red) = 0.63-0.69μm Band 4 (NIR) = 0.76-0.90μm Band 5 (MIR) = 1.55-1.75μm Band 6 (TIR) = 10.40-12.50μm Band 7 (MIR) = 2.08-2.35μm Band 8 (pan) = 0.52-0.90μm	Every 16 days Data available since April 1999	EROS Data Center of the U.S. Geological Survey http://landsat7.usgs.gov/
Landsat 5 TM Due to be decommissioned	Bands 1-5 & 7 = 30m Band 6 = 120m	Typical full scene = 184 x 185km (Super scenes up to 60,000km ² and small scenes 25 x 25km are available)	Band 1 (blue) = 0.45-0.52μm Band 2 (green) = 0.52-0.60μm Band 3 (red) = 0.63-0.69μm Band 4 (NIR) = 0.76-0.90μm Band 5 (MIR) = 1.55-1.75μm Band 6 (TIR) = 10.40-12.50μm Band 7 (MIR) = 2.08-2.35μm		U.S. Geological Survey http://edcns17.cr.usgs.gov/EarthExplorer/
SPOT	Multispectral = 20m PAN = 10m	60 x 60km	Band 1 (green) = 0.50-0.59μm Band 2 (red) = 0.61-0.68μm Band 3 (NIR) = 0.79-0.89μm Band 4 (SWIR) = 1.58-1.75μm* <u>PAN</u> = 0.51-0.73μm/0.61-0.68* *= SPOT4 only	Every 26 days Data available since 1990	SPOT Image http://www.spot.com/

RADAR-SAT	10 – 100m (varies with angles and # of looks)	50 x 50km – 500 x 500km (varies with angles and # of looks)	Single frequency C Band 56 nm HH polarisation variety of beam selections	Data available since 1995 revisit times approx. 6 days at mid-latitudes	Canadian Space Agency (CSA) Canadian Center for Remote Sensing (CCRS) distributed by Radarsat International http://www.rsi.ca/
JERS 8 optical bands SAR L band Bands 3 and 4 provide stereo coverage	18m pixels	75 x 75km	<u>Eight optical bands</u> Band 1 (green) = 0.52-0.60µm Band 2 (red) = 0.63-0.69µm Bands 3 & 4 (NIR) = 0.76-0.86µm Band 5 (MIR) = 1.60-1.71µm Band 6 (MIR) = 2.01-2.12µm Band 7 (MIR) = 2.13-2.25µm Band 8 (MIR) = 2.27-2.40µm SAR BAND = L band 235nm HH polarisation	Data available covering years 1992-1998	EOC Earth Observation Centre, National Space Development Agency of Japan http://hdsn.eoc.nasda.go.jp/
ALI	10 m – PAN 30 m – MSS	37 km swath	PAN – 0.48-0.69µm Band 1 – 0.48 – 0.69µm Band 2 – 0.433 – 0.453µm Band 3 – 0.45 – 0.515µm Band 4 – 0.525 – 0.606µm Band 5 - 0.63 – 0.69µm Band 6 – 0.775 – 0.805µm Band 7 – 0.845 – 0.89µm Band 8 – 1.2 – 1.3µm Band 9 – 1.55 – 1.75µm Band 10 – 2.08 – 2.35µm	Data captured since November 1990 Captures must be requested Operation expected until 2002(?)	GSFC NASA’s Goddard Space Flight Center http://eo1.gsfc.nasa.gov/

HYPER-ION	30 m resolution	7.5 km x 100 km	<u>220 spectral</u> bands covering 0.4 – 2.5µm	Data captured since November 1990 Captures must be requested Operation expected until 2002(?)	GSFC NASA’s Goddard Space Flight Center http://eo1.gsfc.nasa.gov/
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ASTER Advanced Spaceborne Thermal Emission and Reflection Radiometer	VNIR (bands 1-3) 15m pixels SWIR (bands 4-9) 30m pixels TIR (bands 10-14) 90m pixels	60 km swath	<i>Band 1 - 0.52 - 0.60μm</i> <i>Band 2 - 0.63 - 0.69μm</i> <i>Band 3N - 0.78 - 0.86μm</i> <i>Band 3V - 0.78 - 0.86μm</i> <i>Band 4 - 1.600 - 1.700μm</i> <i>Band 5 - 2.145 - 2.185μm</i> Band 6 - 2.185 - 2.225 μ m Band 7 - 2.235 - 2.285 μ m Band 8 - 2.295 - 2.365 μ m Band 9 - 2.360 - 2.430 μ m Band 10 - 8.125 - 8.475 μ m Band 11 - 8.475 - 8.825 μ m Band 12 - 8.925 - 9.275 μ m Band 13 - 10.25 - 10.95 μ m Band 14 - 10.95 - 11.65 μ m	Coverage is sporadic Data can be downloaded free of charge	NASA / Earth Observing Data Gateway http://edcimswww.cr.usgs.gov/pub/imswelcome/
AVHRR Advanced Very High Resolution Radiometer	1.1km pixel	2700km swath width	5 bands 0.58-12.50um (varying bandwidths)	daily images	NOAA: Online requests for these data can be placed via the U.S. Geological Survey Global Land Information System (GLIS) http://edc.usgs.gov/Webglis/glisbin/gli_smain.pl
Orbview-4 Due for launch in 2001	Multispectral 4m pixel Hyperspectral 8m pixel Panchromatic 1m pixel	Multispectral 8km swath width Hyperspectral 5km swath width Panchromatic 8km swath width	Multispectral 4 bands VIS/NIR Hyperspectral 200 bands 0.4-2.5um Panchromatic 1 band in VIS	revisit 2-3 days	Orbital Science Corporation Army,Navy,Airforce, NASA http://www.orbimage.com/
ERS-1 SAR	12.5m pixel	100 km x 102 km	Single frequency C Band (5.3 GHz), Wave length: 5.6 cm; VV polarisation	Data available since 1991 to 1999 revisit times approx.: 3-day, 35- day and 176-day depending on the mode of operation	European Space Agency (ESA) http://www.esa.int

ERS-2 SAR	12.5m pixel	100 km x 102 km	Single frequency C Band (5.3 GHz), Wave length: 5.6 cm; VV polarisation	Data available since 1995 revisit times approx.: 3-day, 35-day and 176-day depending on the mode of operation	European Space Agency (ESA) http://www.esa.int
ERS-1 ATSR	1 km pixel	512 km x 512 km	4 bands: 1.6µm (visible) and three thermal bands at 3.7µm, 11µm, and 12µm.	Data available since 1991 to 1999 revisit times approx.: 3-day, 35-day and 176-day depending on the mode of operation	European Space Agency (ESA) http://www.esa.int
ERS-2 ATSR2	1 km pixel	512 km x 512 km	7 bands: four bands in the visible: 0.55µm, 0.67µm, 0.87µm; 1.6µm and three thermal bands at 3.7µm, 10.8µm, and 12µm.	Data available since 1995 revisit times approx.: 3-day, 35-day and 176-day depending on the mode of operation	European Space Agency (ESA) http://www.esa.int
ENVISAT ASAR	30 m, 150 m or 1km depending on the operational mode	Swath with of < 100km, > 400km and in 5km x 5km vignette, pedending on the operational mode	Single frequency C Band (5.3 GHz), HH and VV polarisation	Data available in 2002	European Space Agency (ESA) http://www.esa.int
ENVISAT MERIS	300 m (full reesolution) and 1200 m (reduced resolution)	1150km wide swath	15 spectral bands in the 390 - 1040 nm range of the electromagnetic spectrum	Data available in 2002	European Space Agency (ESA) http://www.esa.int
ENVISAT AATSR	1 Km	512 km x 512 km	7 bands: four bands in the visible: 0.55µm, 0.67µm, 0.87µm; 1.6µm and three thermal bands at 3.7µm, 10.8µm, and 12µm.	Data available in 2002	European Space Agency (ESA) http://www.esa.int

AIRBORNE DATA

HyMap	Typically 2.5m or 5m	Varies with pixel size 5m = 2.5km swath 2.5m = ~1.3km swath	<u>124 bands</u> covering 0.44-2.4µm	Unreliable – user defined and sensor availability	Integrated Spectronics Pty Ltd http://www.intspec.com/
HyMap MK1 (AIS)	Usually 5m	Varies with pixel size 5m = 2.5km swath	<u>98 bands</u> covering 0.50-1.1µm, 1.45-1.80µm, 1.95-2.45µm	Unreliable – user defined and sensor availability	Integrated Spectronics Pty Ltd http://www.intspec.com/
CASI Compact Airborne/Spectrographic Imager	Typically 1m	Depends on spatial resolution 1m pixel = ~500m swath	Variable bands (~19-288) (~2-12nm wide) 0.40-1.0um Typically 96 bands covering visible to NIR	Unreliable – user defined and sensor availability	Manufactured by Itres Research Ltd. http://www.itres.com/ BallAIMS www.ballaerospace.com.au
Daedalus	Spatial resolution determined by aircraft flying height. A 1000 metre increase in flying height = 2.5 metre pixel size increase.	Image swath = Flying Height x 1.6	<i>Band 1 – 0.42-0.45µm.</i> <i>Band 2 – 0.45-0.52µm.</i> <i>Band 3 – 0.52-0.60µm.</i> <i>Band 4 – 0.605-0.625µm.</i> <i>Band 5 – 0.63-0.69µm.</i> <i>Band 6 – 0.695-0.75µm.</i> <i>Band 7 – 0.76-0.90µm.</i> <i>Band 8 – 0.91-1.05µm.</i> <i>Band 9 – 1.55-1.75µm.</i> <i>Band 10 – 2.08-2.35µm.</i> <i>Band 11 – 8.5-13.0µm.</i> <i>Band 12 Band 11 X0.5 or X2 Gain.</i>	Unreliable – user defined and sensor availability	Air Target Services http://www.airtargets.com.au/index.html
AIRSAR Airborne Synthetic Aperture Radar	Slant range resolution of 10m Azimuth resolution of 1m	Ground swath = 10-15km	<i>P, L, C bands Interferometric with L and C</i> <i>Runs in several modes including high resolution 80MHz SAR, TOPSAR (data coregistered with DEMs, ATI mode (C and L bands along track))</i>	Unreliable, see PACRIM missions	JPL/NASA http://airsar.jpl.nasa.gov/

MASTER <i>Modis</i> <i>ASTER</i> <i>airborne</i> <i>simulator</i>	5-50m pixel (depending on flight height)	Swath varies with flying height	50 bands 0.40-13.0um	Unreliable, see PACRIM missions	JPL/NASA http://masterweb.jpl.nasa.gov/
AVIRIS Advanced Visible/ Infra-Red Imaging Spectrom_r	20m pixel	11.5km swath width	224 bands (10nm wide) 0.40-2.50um		NASA-JPL http://makalu.jpl.nasa.gov/
Airborne Digital Cameras	Spatial resolution determined by aircraft flying height. Typically 0.5 – 1 m resolution.	Swath of image depends on aircraft flying height	Typically colour (RGB) or colour infrared (IR, R, G)	Unreliable – user defined	Contact local companies. Example Specterra Systems Pty Ltd http://www.specterra.com.au/
Airborne CIR / Colour / Black and White photos	Spatial resolution determined by aircraft flying height.	Swath of image depends on aircraft flying height	Typically colour (RGB), colour infrared (IR, R, G), or black and white	Unreliable – user defined	Contact local companies. Example FUGRO Airborne Surveys http://www.fugro.com/
LIDAR	Absolute elevation accuracy of 15 cm.	User defined	Varies, depending on type of laser selected.	Unreliable – user defined.	A number of different LIDAR systems made by different manufacturers.

FIELD BASED

Spectro- meters	Varies – typically nanometres - metres	Varies – typically millimetres - metres	Continuous spectral curve. Range varies from UV-SWIR Typically 0.4 - 2.5µm	Unreliable – user defined and sensor availability	For hire contact local companies. For purchase contact Analytical Spectral Devices Inc http://www.asdi.com/
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Wetland classifications

87. A wide range of different wetland classifications are in use around the world. An annotated summary of some of these wetland classifications is given below, listed in order of their date of publication.
88. No single classification is likely to meet all needs of different wetland inventories. Rather it is recommended that a classification suited to the purposes of a particular inventory should be chosen or developed.
89. In some cases it may be possible to derive a classification from the core information collected in the inventory, such as proposed for the Asian Wetland Inventory, or to establish a mechanism to compile and present information on wetland types under several different classifications, as has been done for the MedWet inventory. However, it should not be assumed that an existing classification will suit all inventory purposes.

Name/title	USA national wetland classification
Description	Hierarchical classification containing 5 levels that describe the components of a wetland, namely, vegetative life form, substrate composition and texture, water regime, water chemistry and soil. It contains vegetated and non-vegetated habitats.
Reference	Cowardin, Carter, Golet & LaRoe 1979; Cowardin & Golet 1995
URL	wetlands.fws.gov/Pubs_Reports/Class_Manual/class_titlepg.htm and www.nwi.fws.gov/atx/atx.html

Name/title	Hydrogeomorphic classification – Australia
Description	Based on landforms and water regimes with further sub-divisions based on areal size, shape, water quality and vegetation features. A binary format for describing wetland habitats is provided.
Reference	Semeniuk 1987; Semeniuk & Semeniuk 1997.

Name/title	Ramsar Classification System for Wetland Type
Description	Hierarchical listing of wetland habitats loosely based on the USA national wetland classification. It has been modified on several occasions since introduced in 1989 so as to accommodate further habitats of interest to the Contracting Parties to the Ramsar Convention.
Reference	Scott & Jones 1995; Ramsar Bureau 2000.
URL	http://www.ramsar.org/key_ris_types.htm

Name/title	MedWet Mediterranean wetland classification
Description	Hierarchical listing of wetland habitats loosely based on the USA national wetland classification with modifications made to reflect the range of wetland habitats around the Mediterranean. Software that accompanies the methodology enables other classifications commonly used in the region to be generated from the database.
Reference	Hecker, Costa, Farinha & Tomas Vives et al 1996
URL	http://www.wetlands.org/pubs&/wetland_pub.html

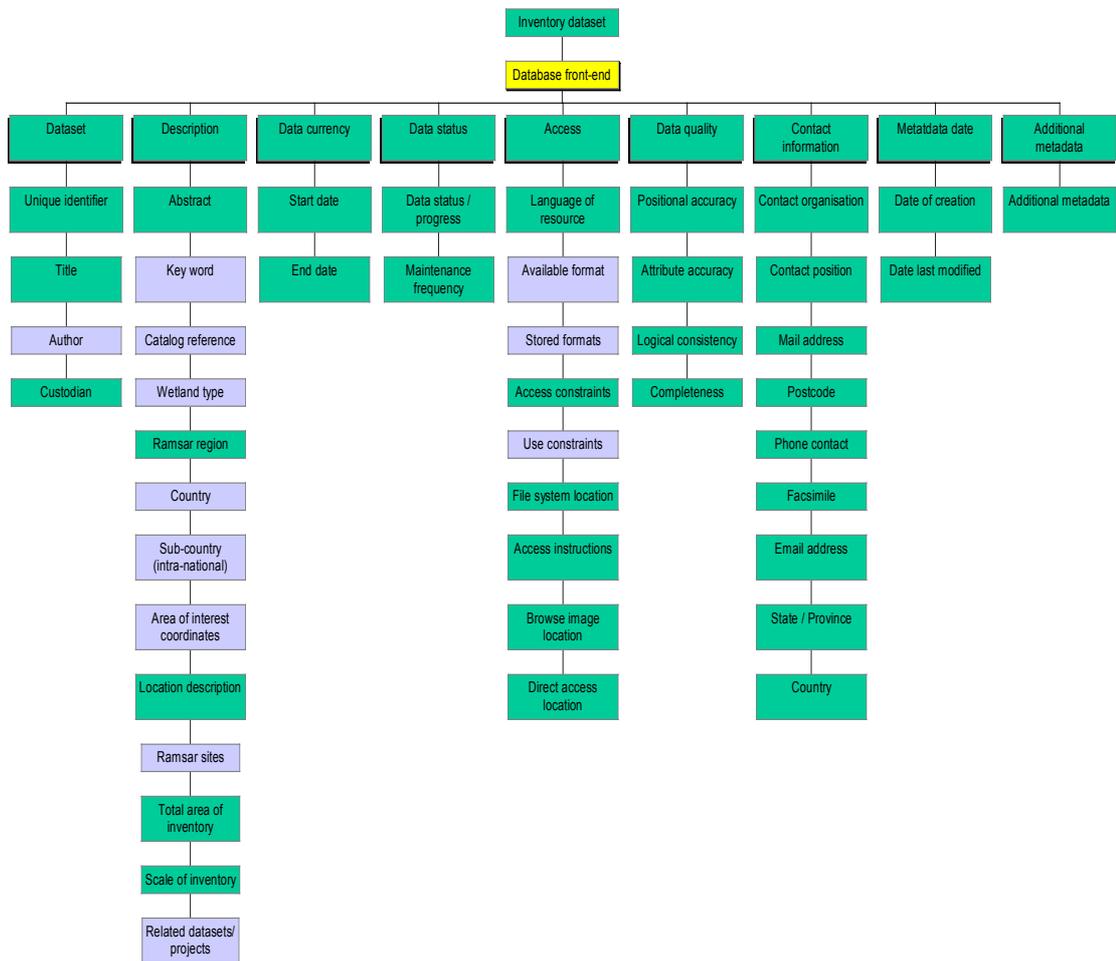
Name/title	Canadian wetland classification
Description	Hierarchical listing of habitats based on broad physiognomy and hydrology, surface morphology and vegetation physiognomy. Further characterisation is based on the chemical features of the habitat.
Reference	National Wetlands Working Group 1997; Zoltai & Vitt 1995.
URL	www.fes.uwaterloo.ca/research/wetlands/Publications.html

Name/title	South African wetland classification
Description	Adaptation of the “Cowardin” wetland classification developed in the USA. Includes adaptations to reflect the functional aspects of wetlands based on geomorphic and hydrologic features. It is hierarchical and able to accommodate all wetland types in the region.
Reference	<i>Dini & Cowan 2000</i>
URL	www.ccwr.ac.za/wetlands/inventory_classif.htm

Name/title	Asian wetland classification
Description	Based on landforms and water regimes. Classification can be derived from the core data fields and augmented with information on vegetation, areal size, and water quality.
Reference	Finlayson, Howes Begg & Tagi 2002 Finlayson, Howes van Dam, Begg & Tagi 2002.
URL	Web-based information not yet available

Recommended standard metadata record for the documentation of wetland inventories

90. The following figure and table summarize the standard structure of a wetland inventory metadata record, designed to assist all those undertaking wetland inventory in documenting and making publicly available information about their inventory, in line with Resolution VII.20.
91. The inventory metadata record is based on, and consistent with, global standards for metadata recording, and has been prepared for the Ramsar Convention by the Environmental Research Institute of the Supervising Scientist, Australia, with the financial support of the government of the United Kingdom, to support the development of the next phase of the *Global Review of Wetland Resources and Priorities for Wetland Inventory (GRoWI 2)*.
92. Further guidance on the application and use of this inventory metadata standard record for reporting wetland inventory is provided in Ramsar COP8 DOC. XX.



Single entry data field
 Multiple entry data field

Figure 2. Diagrammatic representation of the wetland inventory metadata framework.

Table 3. Description of the fields of the wetland inventory metadatabase

FIELDNAME	FIELD DESCRIPTION
UNIQ_ID	Unique identifier for each wetland inventory dataset
TITLE	Title of Inventory/ Dataset
AUTHOR	Author / dataset creator
CUSTOD	Organisation/ individual with custodial rights to the data
ABSTRACT	Abstract – summary or short description of the contents of dataset / inventory activity
KEYWORD	Words that may be used to search for a particular dataset. Choose three-five words that describe the key inventory activities i.e. remote sensing – vegetation, and which can be used to search on in database;
CAT_REF	Library catalog reference – e.g. ISBN number – if applicable to dataset
WETL_TYP	Type(s) / nature of wetland(s) being described in inventory
RAMSAR_R	Ramsar region – choose from standard Ramsar 4 letter codes i.e. EEUR; AFRI; etc
COUNTRY	Countries in area of inventory dataset – choose from standard 3-letter ISO country code http://www.bcpl.net/~jspath/isocodes.html
SUB_COUN	Intra-national regions, described in free text; corresponds with sub_nation field in Wetland Inventory metadatabase
COORDS	Bounding coordinates of area – entered as degrees-minutes-seconds for upper left hand, and lower right hand areas; alternatively, could put in series of coordinates which define the perimeter of the inventory area
LOC_DESC	Freehand description of area
RAMSAR_L	Name of Listed Ramsar sites in area – if appropriate
INV_AREA	Total area covered by inventory i.e. a few hectares; ‘000s of kilometres ²
SCALEINV	Textual descriptions to complement the inventory area values – for example, “large scale”; “small scale” inventory, which could be used as search features to locate particular datasets.
REL_DATA	Related datasets. Names of related files / datasets within the overall inventory.
INV_START	First date of information in the inventory dataset
INV_END	Last date of information in the inventory dataset
INV_STAT	Status of progress on the process of creation of the inventory dataset – complete / incomplete
FREQ_MAIN	Frequency of maintenance / changes / updates to the dataset – regular / irregular/ none planned
LANG_RES	The language in which the dataset was created in i.e. English; Spanish; Vietnamese
AV_FORM	The formats in which the inventory dataset is available in, specifically identifying whether the data is available in digital and/or hard copy formats; in the former case, including a list of forms it is available in i.e. Access database; ArcInfo coverage; Text file etc.
STORFORM	The form or formats in which the dataset is stored by the custodian.
ACC_CONS	Access constraints – e.g. may not be available to general public; use may require a license agreement to be signed
USR_CONS	User constraints – e.g. may not reproduce data without payment of royalty or signing of a license that outlines agreed usage of information
NFS_LOC	Dataset network file system locations – may be entered as a URL address
ACC_INST	Data Access instructions on how to access dataset
IMG_LOC	The location of a browseable image – if applicable to dataset
DIR_LOC	Locations on network from which dataset may be directly accessed – if applicable

DATA_LIN	Data quality – lineage. A brief description of the source(s) and processing / analytical steps and methodology which were used in the creation of the dataset.
POS_ACC	Positional accuracy – a brief assessment and description of the location of spatial features in the dataset relative to their true position on the earth. Information could include whether a differential GPS was used, for instance.
ATTRIB_ACC	Attribute accuracy – a brief assessment of the reliability assigned to features in the dataset, relative to their real world values. For example, was a particular sampling intensity utilized in mapping an area
LOGIC_CON	Logical consistency. A brief description of the logical relationships between items in the dataset. For spatial datasets, this may take the form of a topological consistency check, to ensure that all polygons are closed, nodes are formed at the end of lines, and that there is only one label within each polygon.
DATA_COM	Completeness. A brief assessment of the completeness of the dataset, classification, and verification.
CONT_ORG	Contact organisation (option of adding new organisation, or choosing from existing list of organisations)
CONT_POS	Contact position
MAIL_ADD	Mailing / Postal address for contact position and organisation
POSTCODE	Postcode of mailing address
CONT_PH	Phone number of contact position – should include international direct dial code (IDD), and specify whether local code includes a zero or not when using IDD (e.g. ++(IDD) (0) xx xxxx xxxx)
CONT_FAX	Facsimile of contact position – should include international direct dial code(IDD), and specify whether local code includes a zero or not when using IDD
CONT_EM	Electronic mail address of contact position.
CONT_STA	State / Province in which contact organisation located.
CONT_COU	Country of contact organisation.
META_NEW	Date metadata was created (automatically generated when file created)
META_MOD	Date metadata last modified (automatically generated when file modified)
META_CIT	Citations for metadata; list of other documents, products which cite or use the products described in the metadata record
ADD_META	Additional metadata – reference to other directories or systems that contain additional information about the dataset.; links to additional metadata records, particularly for GIS and remotely sensed products.

Reading list

- Biodiversity Conservation Information System 2000*. Framework for Information Sharing: Executive Overview. Busby, JR (Series Editor). Includes CD-ROM with full text of 8 Handbooks. Available from BCIS Program Manager (for contact details see: <http://www.biodiversity.org>)
- Costa, LT, Farinha JC, Tomas Vives P & Hecker N 1996. Mediterranean wetland inventory: a reference manual. MedWet Publication. Instituto da Conservacao da Natureza, Lisboa, and Wetlands International, Slimbridge, UK.
- Cowardin LM, Carter V, Golet FC & LaRoe ET 1979. *Classification of wetlands and deepwater habitats of the United States*. United States Fish and Wildlife Service, Washington, United States of America.
- Cowardin LM & Golet FC 1995. US Fish and Wildlife Service 1979 wetland classification: a review. *Vegetatio* 118, 139-152.
- Darras S, Michou M & Sarrat C 1999. *IGBP-DIS Wetland data initiative – a first step towards identifying a global delineation of wetland*. IGBP-DIS, Toulouse, France.
- Dini JA & Cowan GI 2000. *Classification system for the South African wetland inventory*. Second draft. South African Wetlands Conservation Programme. Department of Environmental Affairs and Tourism, Pretoria, South Africa.
- Finlayson CM & Spiers AG (eds) 1999. *Global review of wetland resources and priorities for wetland inventory*. Supervising Scientist Report 144, Supervising Scientist Group, Environment Australia, Canberra.
- Finlayson CM & van der Valk AG 1995. *Classification and inventory of the world's wetlands*. *Advances in Vegetation Science* 16, Kluwer Academic Press, Dordrecht, The Netherlands.
- Finlayson, CM, Davidson, NC & Stevenson, NJ (eds) 2001. Wetland inventory, assessment and monitoring: practical techniques and identification of major issues. Proceedings of Workshop 4, 2nd International Conference on Wetlands and Development, Dakar, Senegal, 8-14 November 1998. Supervising Scientist Report 161, Darwin, Australia.
- Finlayson, CM, Howes, J, Begg, G & Tagi, K 2002a. A strategic approach for characterising wetlands– the Asian Wetland Inventory. Proceedings of Asian Wetland Symposium, Penang, Malaysia, 27-30 August, 2001.
- Finlayson, C.M., Howes, R., van Dam, RA, Begg, G. & Tagi, K. 2002b. The Asian Wetland Inventory as a tool for providing information on the effect of climate change on wetlands in Asia.
- Finlayson CM, Davidson NC, Spiers AG & Stevenson NJ 1999. *Global wetland inventory – status and priorities*. *Marine and Freshwater Research* 50, 717-727.
- Hecker N, Costa LT, Farinha JC & Tomas Vives P et al 1996. *Mediterranean wetlands inventory: data recording*. Vol 2. MedWet/Wetlands International, Slimbridge, UK/Instituto da Conservacao da Natureza, Lisboa, Portugal. 99 pp.
- National Wetlands Working Group 1997. *The Canadian Wetland Classification System*. 2nd Edition. In BG Warner & CDA Rubec (eds), Wetlands Research Centre, University of Waterloo. Waterloo. 68 pp.
- National Wetlands Programme*. 1999. *Uganda Wetlands Inventory Guide, version 4*. Ministry of Water, Lands and Environment, Kampala, Uganda.
- Pabari, M., Churie, A. & Howard, G. (eds) 2000. *Wetland inventory training workshop, 6-9 December 2000, Kampala, Uganda*. Ramsar Convention on Wetlands, IUCN- The World Conservation Union & National Wetlands Programme, Kampala, Uganda.

- Phinn S, Hess L & Finlayson CM 1999. An assessment of the usefulness of remote sensing for wetland monitoring and inventory in Australia. In CM Finlayson & AG Spiers (eds), *Techniques for Enhanced Wetland Inventory, Assessment and Monitoring*. Supervising Scientist Report 147, Supervising Scientist Group, Canberra. pp 44-82.
- Ramsar Convention Bureau 2000. Strategic framework and guidelines for the future development of the List of Wetlands of International Importance, Wise Use Handbook 7. Ramsar Bureau, Gland, Switzerland.
- Scott DA & Jones TA 1995. Classification and inventory of wetlands: a global overview. *Vegetatio* 118, 3-16.
- Semeniuk CA 1987. Wetlands of the Darling system – a geomorphic approach to habitat classification. *Journal of the Royal Society of Western Australia* 69, 95-112.
- Semeniuk V & Semeniuk CA 1997. A geomorphic approach to global classification for natural wetlands and rationalization of the system used by the Ramsar Convention – a discussion. *Wetlands Ecology and Management* 5, 145-158.
- Wilen, B.O. & Bates, M.K. 1995. The US Fish and Wildlife Service's National Wetland Inventory project. *Vegetatio* 118, 153-169.
- Zoltai SC & Vitt DH 1995. Canadian wetlands: environmental gradients and classification. *Vegetatio* 118, 131-137.