THE ASIAN WETLANDS: BRINGING PARTNERSHIPS INTO GOOD WETLAND PRACTICES

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AEON Group Environmental Foundation
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PREFACE

This book is a collection of papers presented at the Asian Wetland Symposium 2001, which was held at the City Bayview Hotel, Penang, Malaysia from 27 August to 30 August 2001.

The scope of the Symposium covered almost all aspects of wetlands and focused on cooperation and partnership among the Asian participants. The Symposium also provided an avenue for participants to share their experiences with key figures from Canada, USA, Britain, Switzerland, Australia and Malawi.

Problems which were not anticipated have been encountered in the processing of editing and completing this book. Although the editors have done their very best, certain issues or enquiries could not be resolved or answered because of time constraints and lack of manpower. It became more difficult when a manuscript was incomplete and did not adhere to a given format. Inevitably therefore, diagrams and figures have to be deleted from some papers while other lengthy papers have been trimmed and shortened. Some authors did not comply with the instructions given and many did not respond to enquiries raised in time. Taking all these problems into consideration, the editors had no alternative but to make amendments or modifications in papers whenever that was necessary.

On behalf of the editors, I would like to take this opportunity to express my gratitude and appreciation to all the contributors and all the volunteers who have made this difficult task possible. I hope this book will fill the gaps in providing information and also in enriching the reader’s knowledge on Asian wetlands. It is an initial step to establish a concrete understanding on one of the world’s fragile ecosystems which faces the danger of a gradual destruction.

This is one of the most comprehensive texts on wetlands written in English which can be used as a reference for all levels of societies, in particular, those that deal with the conservation and wise use of Asian wetlands.

Finally, I would like to acknowledge the organisations and agencies such as MOSTE, USM, Ramsar Center Japan, Wetlands-International Malaysia, AEON and KNCF for rendering their valuable services and financial assistance. The project is also partly sponsored by ADB, Department of the Environment and Heritage, Australia, IGES, ILEC, KIWC, Maple Tours, SEKISUI, RICOH, UNEP/ROAP, the Ministry of the Environment, Japan, the Japan Fund for Global Environment of the Japan Environment Corporation and Wetlands International Japan and other organisations, agencies or individuals who have helped in one way or another. Their assistance is fully appreciated by the editors.

Thank you

Mashhor Mansor
Editorial Board
EXECUTIVE SUMMARY

This Executive Summary aims to provide the information gleaned from the presentation of the Asian Wetlands Symposium 2001. Generally, wetlands ranged all the way from coastal reef to highland peat swamp ecosystems. They are important natural resources to the people of Asia, although in the past wetlands have always been considered to be marginal ecosystems to be reclaimed and developed. Wetlands play many functions; ecologically and socioeconomically. They perform many hydrological and ecological functions such as flood control, nutrient and carbon sinks as well as being a repository of flora and fauna genetic pools. Socioeconomically they are part of the sociocultural, religious and economic fabrics of the local communities. For example, wetlands can provide sustainable fishery and forestry if they use wisely. Thus for wetlands, sustainable management should go in tandem with conservation. Wetlands management and conservation in the East and Southeast Asia must take into account the need and role of the stakeholders. Increasing awareness of the importance of wetlands should reduce, if not stop, the problem of wetland loss and degradation.

Water has always been a crucial part of life and survival in Asia. Various types of wetland ecosystems constitute many important parts of life and survival of many Asian countries. The quality of life depends not only on quality and availability of wetlands, for also on good management of our wetlands. The population pressure in many Asian countries requires that a good wetland management be implemented in water stress countries. There are many needs and requirements for good wetlands ecosystems out of each the most important ones would be domestic water requirement, urban pressure and agriculture

1. Good Practices of Wetland Conservation and Management
The plenary speech by Clayton Rubec discussed on the management tools for sustainable use of wetland resources. Other speeches talked about physical and chemical degradation, and restoration and conservation of wetlands. Rehabilitation and restoration are very important in wetlands landscape and conservation. Tools such as community modeling of organisms and impact of irrigation water quality are important in good wetland practices.

2. Communication, Public Awareness, Training and Education
Eugene Turner’s plenary speech was on globalization and the community of wetland scientists and managers. Other speakers talked about the future of wetlands on training and management, thus the need of “training for trainers”. Other requirements include education, public awareness and community rights. Financial valuation is also important in wetland economy

3. Biodiversity in Wetlands
Biodiversity is an important part of wetland ecosystems in Asia. The organisms such as fish and aquatic plants inhabiting the wetlands are important for local and even regional economies. Other organisms are important in maintaining the ecological diversity of the various wetland ecosystems such as lakes, mangroves, rice fields, rivers and coral reefs.

4. Strategic Partnerships on Wetland Conservation
The plenary presentation Tan Sri Razali Ismail was on the importance of strategic partnership. Good practices and strategic partnership is important in wetland management and conservation. People and communities should be involved in the monitoring of wetland biodiversity. Lessons involved in management and
conservation of wetlands allow wetlands managers to devise better wetlands practices.

5. Policies and Laws in Wetlands
Parvez Hassan discussed on legal framework for wise of wetlands, concentrating primary on the regional perspective. Policies, resolution and legal implications of the various countries such as China, Thailand, Australia, Malaysia and Japan are discussed. Lessons on peat land management and other wetlands ecosystems are also presented. The need of indigenous rights and wetlands conservation and management in terms of human rights perspective in wise use of wetlands was also discussed.

6. Capacity Building and Empowering Local Communities Including Indigenous People and Stakeholders in Wetland Management
Two case studies involving capacity building and empowering local communities in wetland management was done. Community utilization and valuation of wetland resources study was done for mangrove ecosystem and the economic value of fisheries resources was also carried it.

7. Climate Change
Fire was shown to be a main impact on wetlands ecosystems. Water and water quality impacts are also very important climate change, especially in areas of water excess and water stress. Stress such as water temperature, nitrogen and phosphorus are also important in climate change.

8. Women and Wetlands
Two case studies were presented. There is a need for more case study involving women in wetlands since they are one of the most important constituents of wetlands conservation and management in Asia. In many countries, they are the main provider of households’ economies.

9. Achieving Waterbird and Wetland Conservation
Waterbird session involved presentations on migratory shorebirds in areas such as China, India and Malaysia. The need for conserving important migratory shorebirds is shown by the paper from China. Finally, there is a need for Asia water bird census.

When the School of Biological Sciences, Universiti Sains Malaysia and Ramsar Center Japan first mooted the idea for the Symposium in late 1999, two main reasons were cited as the major enabling force.

The objective of the Asian Wetland Symposium 2001 is to highlight the need for good practices of conservation and sustainable management of wetlands through global networking and strategic partnerships. Thus, we hope that this Proceedings would achieve the results that we set out to do. Looking at the tremendous response of the Symposium, we are confident that the subsequent Proceedings would be another milestone in our effort to promote wetlands conservation and wise use in this region.

Thank you,

AHYAUDIN B. ALLI, Ph.D.
MESSAGE
From
Dato' Seri Law Hieng Ding
The Honourable Minister of Science, Technology and the Environment of Malaysia

With the benefit of knowledge over the years we are now more aware of the preciousness of wetlands both locally and regionally. They are indeed valuable not only for their ecological significance but more importantly for their economic worth. Notably, floods that have occurred where natural wetlands have been developed; have taught us very costly lessons in the need for more thought and diligence in the use of wetlands. The depleting stocks of fish reiterate the need for even greater care in the management of wetlands. Furthermore, wetlands are important stopover sites in the flyways of migratory birds and this is the main reason why the Ramsar Convention is established. These three aspects in particular have bilateral, regional and even international consequences. There needs to be close cooperation and understanding amongst countries on these aspects in order that the use and management of wetlands by nations are wise and sustainable in the interest of our common future.

This proceedings provides us an opportunity to gather knowledge on our common interests and responsibilities in the management of wetlands for the region. It will be useful in the Eight Triennial Conference of Parties of the Ramsar Convention. Perhaps, this text can guide the discussions at the conference to form global goals in the management of wetlands. Without doubt there are differences in national approaches to wetlands management both within and between regions because of the differences in the stages of development. It is important that regions identify these disparities so that common global objectives and responsibilities can be devised and implemented by all.
MESSAGE
From
Dato' Dzulkifli Abdul Razak
The Vice-Chancellor Universiti Sains Malaysia
and
Chair, The Governing Body

On behalf of the Governing Body, the International Steering Committee and the Local Organizing Committee, it gives me great pleasure in welcoming distinguished participants to this important Asian Wetland Symposium 2001 – "Bringing Partnerships into Good Wetland Practices". This Symposium is jointly organized by the School of Biological Sciences, Universiti Sains Malaysia; Ministry of Science, Technology and Environment, Malaysia; Ramsar Center, Japan; Wetland International Asia-Pacific and AEON Group Environment Foundation, Japan. This linkage between a university, governmental and non-governmental organizations is indeed the type of strategic partnership and global networking very much needed for global environmental issues such as wetland conservation and management.

In view of the current global scenario on environment, the theme selected for this proceedings is important and timely. The proceedings has generated an overwhelming national and international interest, and I am sure that the participants will gain valuable knowledge especially on many serious issues pertaining to wetland conservation and its wise use.

I also would like to take this opportunity to thank all those involved in making this proceeding a reality and a success. To the donors, Ministry of Science, Technology and Environment, Malaysia; AEON Group Environment Foundation; Keidanren Nature Conservation Fund; Japan Fund for Global Environment; the Japan Government Wildlife Protection Division; Environment Australia; Ramsar Convention Bureau; United Nations Environment Programme and the Penang State Government, I thank them for their generousities. To all the paper presenters, participants, chairpersons and rapporteurs, my sincere thanks for your invaluable contribution. I also would like to thank the media for their interest and support, and to all members of the Governing Body, International Steering Committee and Local Organizing Committee who have worked very hard to ensure the success of this Symposium.

I am very pleased that the organizers are publishing selected and peer reviewed papers from this conference in a proceedings. The proceedings will document several important studies, resulting from the four days conference. Finally, I wish the participants all the best particularly in their future endeavors.

Thank you.

PROFESSOR DATO’ DZULKIFLI ABDUL RAZAK
Vice-Chancellor
MESSAGE
From
Ahyaudin B. Ali
Chair, The Local Organizing Committee

First, I would like to extend my thanks and heartfelt appreciation to the Members of the Editorial Committee (MEC) for their help, support and cooperation, without which this Symposium would not have become a reality. With 115 manuscripts from over 30 countries, the preparation of this Proceedings have been one enormous undertaking.

When the idea for the Symposium was first mooted in late 1999 by the School of Biological Sciences, Universiti Sains Malaysia and Ramsar Center Japan, two main reasons were cited as the major enabling force. First, is to continue the good work resulting from Asian Wetland Symposium held in Otsu/Kushiro, Japan, in October 1992, and second, is to highlight the need for good practices of conservation and sustainable management of wetlands through global networking and strategic partnerships.

Thus, it is my sincere hope that this Symposium would achieve the results that we set out to do. More importantly, the output of the Proceedings of the Symposium would have a greater global impact on wetlands conservation and management in Asia as well as other parts of the world. Looking at the tremendous response that we have received from participants from the various countries and organizations, I am confident that the Symposium and the Proceedings would establish another milestone and benchmark in our effort to promote wetlands conservation and wise use in this region.

Finally, I would like to thanks all the organizers, sponsors and colleagues from Ramsar Center Japan, Wetlands International – Malaysia Programme, Wetlands International – Asia Pacific and School of Biological Sciences for their help and support in making this Symposium possible.
MESSAGE
From
Taej Mundkur
Regional Programme Director (Asia)
Wetlands International

In Asia as in other parts of the world, water plays a crucial role in the survival and development of our societies. The quantity, quality and availability of clean and fresh water available to people are intricately linked to the way we value and manage our wetlands. The increasing human populations and their needs continue to strongly influence the availability and quality of water and wetlands. With rapid urbanisation and industrialisation, the need for larger quantities of good quality water has increased. There is also an increased use of water and wetlands for relaxation and recreation by larger segments of society. Recurrent droughts, increasing incidences of floods, water pollution and over-harvesting of freshwater and coastal animal and plant resources are becoming common phenomena. Wetlands as an ecosystem directly play an ever-increasing role in our lives.

It is important that we share our experiences, methods, successes and failures in our efforts to promote the conservation of wetlands. The *Asian Wetlands Symposium 2001* was the first international event of its kind in the new millennium. The Symposium brought together prominent statesmen, national and state government representatives, international conventions, planners, eminent scientists, researchers, students, conservationists, the corporate sector, the press and other sectors of society from so many countries in Asia and the rest of the world. It thus provided the perfect opportunity in paving the way to develop novel and effective ways of thinking, planning and undertaking action to conserve our wetlands.

Wetlands International is greatly encouraged by the strong support from the other main organisers of this event -- the Ministry of Science, Technology and Environment, Malaysia, Universiti Sains Malaysia and the Ramsar Center Japan. We are very grateful to the funding organisations and institutions that have made this possible.

We are very pleased that these Proceedings contain full papers received and cover the range of topics discussed during the Symposium. We expect that the Proceedings will be well received and serve as a valuable reference for future conservation work.
MESSAGE
From
Toru Iwama
President, the Ramsar Center Japan

On behalf of the Ramsar Center Japan, one of co-organisers of AWS2001, I would like to express my sincere thanks and gratitude to the editing members of the Symposium proceedings.

More than 300 participants, including government officers, policy makers, researchers and academicians, NGOs, lawyers, media, students and others attended the Symposium. More than 170 papers were submitted under the nine themes which are quite relevant to a key concept of the wise use of wetlands of the Ramsar Convention. The previous COPs of the Convention have adopted several guidelines and guidance for the implementation of the concept and have urged Contracting Parties to implement them in the management of wetlands. It has been pointed out quite often that forums should be provided to exchange knowledge and experience on good practices of wetland management. In this regard, I feel very happy that AWS2001 was successfully held at the right time at the right place, Malaysia.

AWS2001 successfully adopted the Penang Statement on Regional Cooperation through Partnerships for the Wise Use of Wetlands; this statement, attached to the proceedings, includes 16 recommendations to be conveyed to the World Summit on Sustainable Development in August-September, 2002, in Johannesburg and the COP8 of the Ramsar Convention in November 2002, in Valencia. All participants in AWS2001 hope that the substance of such recommendations will be implemented in the respective regions of the world, particularly in the Asia-Pacific region.

The Ramsar Center Japan feels quite confident that a new and additional human network has been established among the participants in AWS2001 who share a common interest in the wise use of wetlands. I hope that such a network will be strengthened in the future to exchange expertise on wetland management.
MESSAGE
From
Takuya Okada
Chairman of the AEON Environment Foundation, JAPAN

I understand that the Asian Wetland Symposium 2001 made a notable contribution to strengthen effective partnerships to promote the wise use and conservation of Asian wetlands.

This success is due to the cooperation among organisations concerned, and I respect the role taken by the government, university and other organisations of Malaysia, the hosting country of this event.

I see that each Asian nation faces important challenges regarding the status of its wetlands. For example, Japanese citizens are showing great concern as some precious tidal flats face the threat of destruction due to recent social and economic developments in the country.

Having said that, although each country practices a different culture and economy and experiences a different climate, the Penang Statement adopted at the completion of the Symposium resulted in a universal consensus that international cooperation is necessary to conserve wetlands.

I believe that governments, industrial circles and NGOs of each country should make a great effort and cooperate internationally to conserve wetlands in line with the Penang Statement.

However, all the environmental issues are interrelated. From this standpoint, it is important that NGOs, corporations, and individuals first take action on environmental conservation at its own level. Furthermore, the broad-ranging understanding and participation of citizens are indispensable to carry out projects continuously and in this sense, I believe that it is crucial to disseminate information.

I strongly hope that the achievements of the Asian Wetland Symposium 2001 would be reported to the Ramsar COP8 as well as to the Johannesburg Summit to promote awareness to the people around the world and thus secure the commitment of a greater number of citizens.
MESSAGE
From
Takeshi Abiru
Vice Chairman
The Japan Keidanren Committee on Nature Conservation

I am truly delighted with the publication of the proceedings of the Asian Wetland Symposium 2001 and pay tribute to the great efforts of the concerned parties. The Japan Keidanren Committee on Nature Conservation is honoured to be given the opportunity to write a message for the occasion.

The Japan Keidanren Committee on Nature Conservation, through the mechanism of Keidanren Nature Conservation Fund (KNCF), assisted the Asia Wetland Symposium from the very beginning primarily because of the enthusiastic commitment of the Ramsar Center Japan. As you know, the Symposium materialised as one of the largest international wetland symposiums in Asia with 349 participants from 37 countries. Honestly speaking, I was surprised to see so many volunteers as well as Malaysian cabinet members attending the meeting, and at the same time, was truly impressed. I saw knowledge being shared and the foundation of a network of people to support future developments placed. I understand that this book of proceedings is to record such an achievement. As a matter of fact, KNCF will be assisting the subsequent activities such as the publication of these proceedings in addition to organising this Symposium. I keenly felt the importance of continuously exchanging dialogues by positively participating in such opportunities.

There has been a recent news report in Japan that the government would launch wetland restoration projects this year. I mentioned at the opening ceremony the previous year that swamps, ponds, and rivers used to be a children’s “playing wonderland” in the past; today, however, the wetlands are decreasing day by day due to aridification. Such a phenomenon is occurring not only in Japan, but all over Asia. The loss of the ecosystem would be a misfortune for future generations as well as for Asian migratory birds. However, the truth is, such a loss would also affect us and it is important to generate knowledge to utilise wetlands as wetlands.

In this regard, I hope the proceedings would be in the hands of people around the world, let alone in Asia, and be utilised fully. By placing the people who were involved in publishing these proceedings as its core, I sincerely hope that mid- and long-term actions would continue to be taken. I am very pleased to be able to write this message on behalf of the Japan Keidanren Committee on Nature Conservation.
MESSAGE

From

Tatsuo Tani

General Manager, Corporate Environment Division,

Ricoh Company Ltd, JAPAN

Congratulations on the completion of the proceedings of the Asian Wetland Symposium 2001.

The association between the Ramsar Center Japan and our company began in 1999. We first started to assist environmental education and afforestation activities conducted by the Bangladeshi NGO, the “Bangladesh POUSHI”, for which the Ramsar Center Japan served as the contact point in Japan. From the year 2000, our company has been aiding conservation and wise use activities for the pristine mangrove forests in Brunei Darussalam, which was the project of the Ramsar Center Japan. In 2001, we were lucky enough to visit the mangrove forest in Selirong Island, Brunei Darussalam. We were all deeply impressed to see the sturdy, tough roots and 30-40 metre high trees, which are extremely rare in the world. Members of our company strongly desire that this pristine forest will be enrolled in either the Ramsar Convention or the World Heritage Convention, and that this admirable natural environment will be inherited by our children and our grandchildren.

Since then, the Ricoh Group has contributed to many forest conservation activities in other places such as Japan, the Philippines, Malaysia, China, Sri Lanka, Madagascar, Ghana, and so on, in a tie-up with various environmental NGOs. The overall purpose is to conserve the biodiversity. We advertise these activities in magazines, so that more and more people will notice the significance of protecting the ecosystem and biodiversity of the earth.

We, at the Ricoh Group, consider protection of the natural environment as one of our company’s missions, introduce environmental awareness in every aspect of management, and carry out all possible measure to minimise the impact on the ecosystem so that it will not exceed the natural capacity. Furthermore, in order to enhance the natural capacity itself, we now actively participate in conservation activities of forest ecosystems.
MESSAGE
From
Yutaka Tatsumura
Executive Director of Sekisui Chemical Co. Ltd., JAPAN

It is a great honour for the Sekisui Chemical Co. Ltd., to have the opportunity of sending congratulations on the publication of the Asian Wetland Symposium 2001 proceedings. I would like to express my sincere gratitude to the members of the Ramsar Center Japan and all participants.

I have heard that the Asian Wetland Symposium 2001 was successfully co-organised by the Ramsar Center Japan (RCJ), the Keidanren Nature Conservation Fund (KNCF), and other agencies as the first Symposium for Asia by Asians. With more than 340 participants from over 37 countries, 270 research papers were presented in the Symposium. The results of the research work are now published as the AWS2001 proceedings. This Symposium successfully formulated Asian wetland initiatives and has ensured that the network and partnerships of wetlands in this region will be maintained. We, the Sekisui Chemical Co., very much appreciate the honour of supporting your projects.

On the occasion of our 50th anniversary in 1997, our company decided to make our nature conservation activities the main pillar of our social contribution. Outside Japan, we support, in cooperation with KNCF, the nature protection activities in the Asia-Pacific region that are implemented by the environmental NGOs. Inside Japan, each Sekisui workplace promotes nature protection activities with local communities. Because of the necessity for each of our workplaces to have willing leaders who are knowledgeable in these matters, we have regularly held our unique "Sekisui Chemical's Nature Study Course" since 1997.

The term Sekisui, meaning "a vast amount of accumulated water", comes from an ancient Chinese book, written in the 4th century BC by a famous authority on war tactics, Sun-tsu, after whom the book was named. So Sekisui has been interested in relations between water, wetlands and people, and its support is mainly focused on the conservation activities for wetlands and their biodiversity. We have always been impressed by the outstanding leadership RCJ has exercised not only in a variety of wetland conservation activities but also in expanding the Asian wetland conservation network. We, therefore, are looking forward to many of the Asian wetland initiatives adopted by RCJ.

Protecting the wetland ecosystem, which is one of the most important ecosystems on earth, is one of the fund's key interests, as its primary goal is "to protect biodiversity". The Asian region still remains a sanctuary for different types of ecosystems such as wetlands, rainforests and coral reefs. Most of them, however, are in danger of extinction.

In Japan, wetlands have been decreasing, as they get dry through land reclamation processes, lack of groundwater, accumulation of soil and sand brought by rivers, and so forth. We, one of the Japanese industries, strongly support the protection of wetlands and, through the exchange of information and cooperation with experts in other countries, hope to make our contribution.
In closing, I wish these proceedings will serve our common interests in providing information on aspects of wetlands and responsibilities in the management of wetlands in the Asian region. This will yield fruitful results and greatly contribute to the recovery of wetlands.
THE PENANG STATEMENT
of
ASIAN WETLAND SYMPOSIUM 2001
27-30 AUGUST 2001

The Penang Statement on Regional Cooperation through Partnerships for the Wise use of Wetlands

The Asian Wetland Symposium 2001 was held in Penang, Malaysia, from 27-30th August 2001 and was jointly organized by Ministry of Science, Technology and the Environment, Malaysia, the School of Biological Sciences, Universiti Sains Malaysia, Ramsar Center Japan, Wetlands International – Asia Pacific, the AEON Group Environment Foundation and Keidanren Nature Conservation Fund. The Symposium was opened by the Minister of Science, Technology and the Environment, Malaysia, Dato’ Seri Law Hieng Ding and was attended by 349 participants from 37 countries.

PREAMBLE

Commending Universiti Sains Malaysia for hosting the Symposium and the joint-organizers for their cooperation and support in holding the Symposium in Penang, Malaysia;

Recognizing the vital role of wetlands in the global ecosystems, their importance to the culture and livelihood of the local people, their role in the maintenance of biodiversity, their function in hydrology and ecology, and their critical role in the life cycle of many species;

Promoting the Convention on Wetlands of International Importance especially as Waterfowl Habitat (Ramsar Convention), and the framework it provides for the conservation and wise use of wetlands;

Aware of the important role of wetlands to the daily survival of many millions of people in Asia and the range of benefits they provide;

Concerned that wetlands are being degraded and lost, and the serious, on-going and impending threats to wetlands in the Asian region;

Commending region-wide initiatives such as the Asian Wetland Inventory and Asia-Pacific Migratory Waterbird Conservation Strategy: 2001-2005;

Recognizing the need to increase the human and financial resources currently allocated to the conservation and wise use of wetlands in the countries of the Asian region;

Appreciating the importance of cultural heritage, indigenous knowledge and local practices in the wise use of wetland resources, and local people’s role in the stewardship of these areas;

Welcoming the promotion of regional linkages, strategic partnerships and good practices in wetland conservation and management;

Conscious of the urgent need to establish new, and strengthen on-going, regional and international co-operation, linkages and strategic partnerships between governments, international agencies, universities, research institutions, non-governmental organizations, local communities, the private sector and individuals;

Acknowledging the need to involve private sector and regional economic development agencies in integrating the concept of wise use of wetlands in holistic development;

Noting cooperation and strategic partnerships for the wise use of wetlands is integral to the implementation of the environmental framework negotiated at the
Stressing the urgency to increase understanding and sharing of knowledge of wetland functions, values and good management practices; and
Determined to conserve and wisely use wetlands for the present and future benefit of humankind;

The Symposium urges governments, international agencies, intergovernmental organizations, local communities, universities, research institutions, non-governmental organizations, the private sector, other relevant bodies, civil society and individuals to:

WORK TOGETHER TO MAINTAIN WETLANDS AND PREVENT FURTHER DEGRADATION AND LOSS, TO ENSURE THEIR WISE USE, AND TO MAINTAIN AND RESTORE WETLAND BIODIVERSITY AND ECOSYSTEM FUNCTIONS THROUGH REGIONAL AND INTERNATIONAL PARTNERSHIPS TOWARDS THE WISE USE OF WETLANDS IN ASIA.

In order to achieve the said objectives, the Asian Wetland Symposium 2001 recommends that:

1. Regional and international cooperation and strategic partnerships be enhanced to assist countries in the Asian region to exchange knowledge, skills and expertise concerning wise use, conservation, management and restoration of wetlands and their biodiversity.

2. Greater efforts in the Asian region be placed on the preparation of national wetland inventories. Such inventories would be particularly useful to increase understanding of wetlands that support the livelihoods of millions of local people. These include ricefields, floodplains, peat swamps and mangrove ecosystems.

3. Efforts to promote cultural heritage, local practices and knowledge be supported through partnerships. These co-management arrangements will support local and indigenous communities in sustaining wetlands, maintaining biodiversity and avoiding adverse impacts on wetlands.

4. Education, awareness and understanding of wetlands remain a priority for all agencies and institutions charged with the management of wetlands. It is further recommended that the Communication, Education, Public Awareness Program of the Ramsar Convention is adopted. Development of human and institutional capacity is critical.

5. All non-member states in the region accede to the Ramsar Convention.

6. All Contracting Parties to the Ramsar Convention significantly increase the number of Ramsar sites and ensure effective management of all wetlands.

7. All states in the region adopt a National Wetland Policy and a National Wetland Action Plan.

8. Legislation and legal frameworks play an important role in the conservation and wise use of wetlands, and to this end, priority be given to the development of region-specific guidelines for national legislation consistent with the Ramsar Convention Resolutions, Recommendations and Guidelines, and the principles of international environmental law.

9. The special role of women in the wise use of wetlands be acknowledged and all wetland policies in the region place a high priority on their effective participation.

10. Strategic partnerships and good wetland practices be adopted through integrated river basin management incorporating hydrological, ecological and socio-economic concerns.
11. Developments that may potentially affect wetlands incorporate the views of stakeholders in the full project cycle. Detailed social and environmental impact assessments are considered critical in this process.

12. Governments, regional and international organizations, the private sector, development institutions, NGOs, and other organizations enhance regional linkages and strategic partnerships towards conservation and wise use of wetlands.

13. Urgent actions be taken to address the root causes of the loss of wetlands and their biodiversity. This is to be achieved through the establishment of protected areas and the better management of wetland ecosystems in the Asian region.

14. Further work be undertaken to better understand the linkage between climate change and wetlands and approaches to management and adaptive measures.

15. An Asian Wetland Symposium be convened periodically to review regional progress towards the wise use of wetlands in the Asian region and provide direction for future activities.

16. Governments, regional and international organizations, the private sector, development institutions, and other donors provide significant funds to meet the recommendations outlined above.

The Symposium proposes that the organizers seek the support and assistance of the Government of Malaysia to convey this Statement to Contracting Parties to the Ramsar Convention in the Asian region, and to the 8th Conference of the Contracting Parties to be held in Valencia, Spain in 2002 and to the World Summit on Sustainable Development to be held in Johannesburg, Republic of South Africa in 2002. Further the recipients of the Statement, participants, organizers and sponsors of this Symposium are urged to do their utmost to realize partnerships in wetland practices to achieve the conservation and wise use of wetlands in the Asian region.
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The International Steering Committee 1114

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PART I: GOOD PRACTICES OF WETLAND CONSERVATION AND MANagements
Management Tools for Sustainable Use of Wetland Resources

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ABSTRACT

Canada has developed and implemented a series of national and international wetland conservation initiatives. The authors draw on this experience to discuss mechanisms for protection and sustainability of wetland and peatland resources. Among these initiatives, Canada is contributing to guideline development under the Ramsar Convention. Guidelines for Development and Implementation of National Wetland Policies was published in 2000, with Canadian experience interwoven with that of other states and the non-government sector. This is complemented nationally by guidelines for the application of mitigation and compensation measures to foster sustainable wetland use in the planning process. This Canadian tool is proposed as a basis for guidelines suited to the Ramsar Contracting Parties, that would complement the publications in the Convention’s Tool Kit series. The evolution of the Ramsar Convention's Global Action Plan for Peatlands (GAPP) is another practical process of international cooperation that has been facilitated by Canada. The role Canada is playing in promoting the sustainable use of peatlands is examined. Canada is a partner in continental wetland conservation programming that supports Flyway agreements. The North American Waterfowl Management Plan (NAWMP) and the North American Bird Conservation Initiative (NACBI) are examined. These initiatives could be used by states in Asia looking to implement regional, continental and flyway programmes for wetland and migratory species.

IMPLEMENTATION OF NATIONAL WETLAND POLICIES

Implementation of national wetland policies is a key feature of the Wise Use Principles, a hallmark of the Ramsar Convention. These Principles help Contracting Parties improve institutional and organisational arrangements, address legislative and policy needs, increase knowledge and awareness of wetland values, inventory and monitor the status of wetlands, identify programme priorities, and develop action plans for specific sites as components of a National Wetland Policy. However, such a Policy remains an elusive goal for many of the 125 nations that today (August 2001) are Contracting Parties to this global environmental treaty. Wetland policy is valuable as countries seek to address the management and habitat requirements for wildlife and other natural resources, such as soil and water, as well as human needs.

Responding to recommendations by the Convention, in 1999 a team of writers completed preparation of the Ramsar Tool Kit publication entitled Guidelines for Developing and Implementing National Wetland Policies (Rubec et al. 2000). This Guidelines complements the Convention's guidance on wetland legislation (Shine and Glorve 2000). The following sections provide highlights of the Guidelines and reports on the status of wetland policy development around the world as summarised at COP7 of the Convention in May 1999.
The Ramsar Guidelines

The Guidelines reviews the key steps and issues that may arise in both developing and implementing a National Wetland Policy. These include over 20 detailed sections defining the purpose of such an initiative, organising a suitable process, deciding how to present the content of the policy document and developing strategies for implementation and monitoring. The Guidelines report includes seven Wetland Policy Essays: (a) Defining Stakeholders, (b) Consultations, (c) Wetland Policies within a Federal State, (d) Sectoral Policies and Legislation, (e) Compliance Strategies, (f) The Role of Non-Government Organisations and (g) The Development and Coordination Process.

A National Wetland Policy includes implementation strategies that demonstrate the priorities of the government and fosters the cooperation and involvement of other interests. Linkages between these strategies and national water, soil, biodiversity, and sustainable development policy initiatives are explored in the Guidelines. Some of the strategies used in selected National Wetland Policies or Action Plans are summarised in Table 1.

Table 1. Implementation strategies in selected national wetland policies.

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Policy strategies:

1. Management of national wetland networks
2. Integration with other policies such as water, soil, forests
3. Public awareness and education
4. Partnerships
5. Science, monitoring, assessment and research
6. International commitments
7. Managing special sites
8. Administration and Institutions, capacity building
9. Enforcement, regulation and legislation
10. Financial mechanisms
11. Restoration of degraded sites
12. Sustainable use and conservation

Status of Wetland Policies and Strategies Around the World

Significant progress is evident globally in the development of National Wetland Policies since the Ramsar Convention focused attention on this issue in 1987. Table 2 summarises the status of the development and adoption of National Wetland Policies or Strategies from 1987 through Ramsar's COP7 in May 1999. Further progress in this area is occurring but a full summary of this will not be undertaken until Ramsar's next meeting (COP8) in November 2002.
Table 2. Evolution of Ramsar Convention National Wetland Policies and Strategies*.

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* As of August 2001, the Ramsar Convention had 125 Contracting Parties and will next report on this issue in November 2002.

**National Wetland Policies.** As of May 1999, 42 of the 114 Ramsar Contracting Parties indicated that they were engaged in development or implementation of a National Wetland Policy. Over the 1987 to 1999 period, the number of nations with a National Wetland Policy officially adopted grew from zero to twelve. An additional 30 nations indicated that such a National Wetland Policy was in draft or under consideration.

**National Wetland Strategies and Action Plans.** National Wetland Strategies and Action Plans were also considered in this study. As of May 1999, some 94 of 114 nations were engaged in National Wetland Strategy initiatives. Over the 1987 to 1999 period, the number of nations that indicated they have implemented a National Wetland Strategy or Action Plans had grown from four to 48. An additional 46 nations had Strategies in draft or under consideration.

**IMPLEMENTATION OF WETLAND MITIGATION**

Canada has undertaken a national initiative for development of wetland mitigation guidelines (Cox and Grose 1998, 2000). This example could be used to guide development of international guidelines to address Recommendation VII.24 adopted at COP7 of the Ramsar Convention in 1999. This would also complement policy and legislative guidelines (Rubec et al. 2000, Shine and Glowka 2000) of the Convention in May 1999.

In adopting Resolution VII.24, the Conference of the Parties noted that "effective wetland protection involves the conservation of wetlands as a first choice within a three-step mitigation sequence, including avoidance, minimisation, and compensation, the latter only as a last resort." The delegates called upon the Contracting Parties to:

- Take all practical measures for compensating any loss of wetland functions, attributes and values, both in quality and surface area, caused by human activities.
- Integrate rules for compensation of wetland loss into their national policies on land and water planning.
• Incorporate a preference for compensating for wetland loss with wetlands of a similar type and in the same local water catchments.

The Conference of the Parties also invited the Standing Committee to define, in cooperation with the Scientific and Technical Review Panel and the Ramsar Bureau, and in consultation with the international organisation partners, criteria and guidelines for the compensation of wetland habitats in the case of unavoidable losses and to submit these for the approval of COP8. To-date, there have been no specific Ramsar initiatives on wetland project mitigation. The authors urge that the Ramsar Convention consider Canada's initiative here as a starting point for development of additional guidance to Ramsar Contracting Parties on the issue of wetland mitigation.

**Wellland Mitigation and Sustainable Development**

Advocating the use of a mitigation process to conserve wetlands fits squarely within the conservation paradigm of sustainable development. The use of the mitigation process as a conservation tool is based on the premise that the environment and the economy are inextricably linked. It recognises that some development is inevitable, that many developments have important economic benefits to society, and that wetlands have important environmental, social, cultural and economic values.

**Mitigation Defined**

Mitigation is one process in the much broader context of policy and planning that incorporates conservation activities at every stage and every level. The majority of North American wetland programmes related to mitigation support a single process with several components. Clearly defined terminology with a broad base requires definitions consistent with the two key positions – environmental assessment legislation and National Wetland Policy. Mitigation is thus defined as:

*Mitigation* is a process for achieving wetland conservation through the application of a hierarchical progression of alternatives that include:

• *Avoidance* of impacts.
• *Minimisation* of unavoidable impacts.
• *Compensation* for residual impacts that cannot be minimised.

A "mitigation sequence" described below should be followed if the mitigation process is to be successful as a tool for wetland conservation. In particular, the first two steps of the sequence should not be skipped for the sake of expediency. The steps between each stage are barriers that are only to be breached in rare circumstances. It is recognised that the science supporting some aspects of wetland mitigation is not well developed and contains a degree of uncertainty and inherent risk.

The first step, *avoidance*, involves the prevention of impacts, either by choosing an alternate project, alternate design or alternate site for development. It is the first, best choice of mitigation alternatives. Because it involves prevention, the decision to avoid a wetland or to redesign a project so that it does not affect a wetland must be taken very early in the planning process. It may be the most efficient, cost-effective way of conserving wetlands because it does not involve minimisation, compensation or monitoring costs.

The second step, *minimisation*, can only be taken once the decision has been made that a project must proceed, that there are no reasonable alternatives to the project, and that there are no reasonable alternatives to locating the project on a wetland. Minimisation involves the reduction of adverse effects of development on the functions and values of wetlands, at all project stages (including planning, design, implementation and monitoring).
The third step, compensation, the last resort in the mitigation process, is an indication of failure in the two earlier steps. It can only be considered for residual effects that are impossible to minimise. Compensation refers to a variety of alternatives that attempt to "make up for" the unavoidable loss of or damage to wetland functions and values, usually by actions off-site from the development. Preferred methods include restoration and enhancement of wetlands, creation of a new wetland, and purchase or other legal securment of a wetland of like kind and area as a replacement for lost or damaged wetland functions. A combination of compensation measures is often part of a negotiated deal with project proponents that may also include the financing of wetland-related research and education.

In the past, there has been a tendency on the part of both government and industry to take the expedient route and go straight to compensation rather than deal with potential impacts in the design stage or through avoidance. Large developers may prefer to pay for functional losses with a cash settlement or technological "quick fix." For example, it may be easier to pay for a fish hatchery rather than prevent or minimise damage to a spawning habitat. It is often in the proponent's interest to find a quick solution, write off costs, and proceed with the project. However, environmental impacts are seldom resolved by this approach.

**The Need for Ramsar Guidelines**

Cox and Grose (2000) have summarised national principles and guidelines for the Canadian mitigation process. This is based on several national focus conferences and consultations. Their published report will also be available on the Internet in the October-November 2001 period, in English and French versions (www.cws-scf.ec.gc.ca). Four specific guidelines direct when avoidance is appropriate, ten guidelines are used to determine minimisation measures, and twelve guidelines are used to determine appropriate compensation in project planning. An international version of this paper could form the basis of proposed Ramsar mitigation guidelines.

**Lessons Learned from Canadian Projects**

Canadian mitigation projects to-date offer insight in designing and implementing a mitigation process. No comprehensive document that pulls together global information on mitigation processes or examples exists. The principles, guidelines and framework for applying the mitigation process internationally will need research, consultation and practical application in collaboration with a wide range of interested parties in a variety of economic sectors. Some of the most critical steps and issues in the mitigation process, as outlined in detail in Cox and Grose (2000), are:

- Use of a functional approach is best.
- You cannot avoid the Avoidance step.
- A multi-disciplinary team of experts is essential.
- Pre-project baseline data is necessary.
- Ensure public and stakeholder participation.
- An environmental assessment should be part of the project design.
- On-site environmental supervision is required.
- Long-term monitoring and contingency planning are unavoidable.
- Learning and adaptive management improves success.

**GLOBAL PEATLAND CONSERVATION**

Canadian peatlands are extensive, covering an estimated 139 million hectares. They are recognised in Canada as an important economic and ecological resource. As the evolution
of a *Global Action Plan for Peatlands* under the Ramsar Convention has proceeded. Canada has been an active participant and facilitator. Canadian peatlands are seen to be important ecosystems contributing to global carbon conservation relevant to climate change, to biological diversity, to global water issues and to many wetland functions valuable to human communities.

Canada, through the programmes of the Canadian International Development Agency (CIDA) and other initiatives, is actively supporting peatland conservation programmes internationally. A major CIDA project involving peat swamp forest management in Indonesia for the 2001-2004 period has recently been approved in principle. These Canadian actions are focused on forest and peatland carbon sequestration relevant to the implementation of the Kyoto Protocol under the United National Framework Convention on Climate Change. The benefit, for instance, in conserving tropical peat swamps in Southeast Asia through fire suppression and sustainable land use practices is linked to ensuring and strengthening economies in the region.

In March of 1996, in advance of COP6 of the Ramsar Convention, Canada, with government and private sector partners, organised an International Workshop on Global Mire and Peatland Conservation. This was one in a series of international working meetings focused on drawing global attention to the need for action on peatland wise use and management in the context of sustainable development. Peatlands were subsequently recognised as an under-represented wetland type in the List of Wetlands of International Importance. With focused sessions on peatland conservation during the IUCN Global Biodiversity Forum 13 and Ramsar COP7 in 1999, peatlands have become mainstream elements in global wetland conservation. The cooperative efforts of government, industry and non-government organisations have now developed the draft *Global Action Plan for Peatlands* and are completing the *Wise Use Guidelines for Peatlands*.

The development of a *Global Action Plan for Peatlands* has followed a progressive path over several years. This reflects contributions by a host of expert scientific and technical bodies and international fora. Canadian partner agencies have been involved in this process since 1994. The linkage of biodiversity, climate change and carbon sinks, wise use and management of peatlands has formed the elements of a draft *Global Action Plan for Peatlands* under the Ramsar Convention in May 1999 in Recommendation VII.1. This initiative is expected to be fully inaugurated through endorsement of this GAPP at Ramsar's COP8 in 2002.

Several working meetings since the Ramsar COP7 have fostered redrafting of the Action Plan through the leadership of the Ramsar Scientific and Technical Review Panel (STRP) and extensive input by the International Peat Society, the International Mire Conservation Group, the IUCN Ecosystem Management Commission, Global Environment Network, Wetlands International and other organisations. This Action Plan is still undergoing review under the coordination of the STRP and its partners.

Peatlands are also becoming a significant issue being addressed by the Convention on Biological Diversity through its joint work planning process with the Ramsar Convention. Peatlands play an important role in conserving global biodiversity. These ecosystems are the refugia of some of the most rare and unusual flora and fauna species known. Peatland issues involving carbon sequestration and their recognition as additional sinks may also become elements for the implementation of the Kyoto Protocol of the Framework Convention on Climate Change and other international instruments and agreements.

**Canadian Experience with Peatland Use**

Canada has a vast peatland resource from which we derive significant economic benefits. There has been close cooperation between government regulators, resource users, researchers and environmental conservation groups in the 1990s on peatland sustainability. This has positioned Canada very well to develop programmes and policy that have acted as
guidance to the development of the *Global Action Plan for Peatlands (GAPP)*. Canadians understand the need for cooperation, not conflict, to achieve common objectives for the wise use of peatlands. Policy, regulatory and research tools are well developed in Canada for peatlands.

Peatland resources are used for a variety of purposes in Canada; these uses often have required the alteration of the natural state of the ecosystem. The harvesting of the peat in Canada, for example, supplies an expanding horticultural industry in North America. About 16,000 ha (0.01%) of the estimated 139 million hectares of peatlands in Canada are used for horticultural peat or peat moss products. The global market for peat products demands high quality, which is well met by Canadian producers.

Individual peatland developments are also used for vegetable production, pasture land and related purposes. Rubec et al. (1988) have estimated that the value of market gardening crops derived from these peatlands exceeds US$65 million annually in Canada. In total, Canada's wetlands and peatlands are estimated to provide over US$12 billion in economic benefits to Canadians each year. The value of Canada's forest products derived from peatlands, mostly during winter pulpwood operations and selected harvesting of hardwood tree species, is estimated to exceed US$350 million each year. Peatland drainage to enhance tree growth is not widely practised in Canada with less than 25,000 ha drained to facilitate forestry operations; most of this is within demonstration or research project areas.

The use of peat as a fuel source is virtually non-existent in Canada. To-date, economic factors and the availability of other energy sources have not resulted in peat becoming an attractive energy product in Canada. Energy use of peat is potentially highly consumptive of the resource and has been strongly opposed by environmental interests both from ecological and socio-economic perspectives. Major peatlands in parts of Canada have been flooded by hydroelectric reservoir construction. The total area of peatlands affected to-date is estimated to exceed 900,000 ha. Additional reservoir proposals could affect an additional one million hectares of peatlands or estuarine wetlands in Canada in the next decade.

**NORTH AMERICAN WATERFOWL MANAGEMENT**

For millennia, ducks, geese, and swans have migrated across North America's landscapes in an annual ritual that evokes a sense of wonder at the forces, mysterious yet consistent, that send millions of birds the length of a continent and back again. Yet among conservationists, the mystery of migration is accompanied by certain knowledge that waterfowl are dependent upon a complex and increasingly vulnerable chain of habitats extending across international borders. Underlying the spectacle of migration is a challenge of unprecedented proportions – the conservation of a migratory resource on a continental scale (Cox 1999).

In 1986, the *North American Waterfowl Management Plan (NAWMP)* responded to this challenge. It gave the wildlife conservation community the daunting task of coordinating and focusing the conservation programmes of three nations to measurably increase continental populations of a highly mobile, shared migratory resource waterfowl. First signed by Canada and the United States, the Plan was updated in 1994 with Mexico as a signatory and updated again in 1998. The Plan asked conservationists to develop coordinated site-specific habitat management programmes and projects that would prompt population responses on a continental scale. It is this biological foundation that sets the Plan apart from most other conservation efforts.

**NAWMP – A Conservation Legacy**

The NAWMP has recognised that land use practices and policies affecting extensive areas across the North American continent must be altered. Conservation efforts are moving
beyond the limits of public natural resource lands to deal with whole landscapes, including private and common lands. The Plan offers a platform from which waterfowl conservationists in both the public and private sectors have organised themselves into partnerships, called "joint ventures", to accomplish this task. Partnerships have launched wetland habitat conservation into a new era by changing the way conservation is delivered.

Between 1986 and 2001, Plan partners invested over US$1.8 billion to secure, protect, restore, enhance, and manage wetlands and associated uplands in priority landscapes; to conduct research and monitor specific waterfowl populations; and to provide environmental education and conservation planning with community involvement. Plan partners have worked within each country and internationally to influence agriculture, forestry, water, and trade policies that have indirectly affected a much larger portion of the continent's landscapes than have direct conservation projects alone.

The Changing Face of North American Wetland Waterfowl Conservation

For the past 100 years, wetlands and waterfowl conservation in North America has adapted to changing environmental, economic social and political forces. The institutional framework for international cooperation in conserving North America's migratory birds was established early in this century. In 1916, Canada and the United States signed a treaty for the conservation of migratory birds, and in 1936 the United States and Mexico signed a similar convention.

By the 1980s, a long tradition of international cooperation in waterfowl population surveys and harvest management was in place. Population data confirmed that accelerated conversion and degradation of habitat caused by human activities, and an extended period of below-normal precipitation on mid-continent prairie landscapes, had led to a series of record-low populations of most duck species. The need was clear – international cooperation in harvest management had to be extended to include habitat conservation. This need was answered by the establishment of the North American Waterfowl Management Plan in 1986 and by its update in 1994 and 1998.

The North American Waterfowl Management Plan is a major example of international cooperation in implementation of continental wetland habitat conservation objectives. The NAWMP is also the most ambitious continental wildlife conservation initiative ever attempted. It seeks to restore waterfowl populations in Canada, the United States, and Mexico to the levels recorded during the 1970s – a benchmark decade for waterfowl. Several factors have combined in recent years to bring waterfowl populations remarkably close to this goal today.

During the 1986-2001 period, tremendous achievements in habitat conservation – through the efforts of many the Plan's partners, new programmes for wildlife habitat conservation, changes in agricultural conservation policies and programmes, and exceptionally good hydrological conditions – all have contributed to a striking rebound in most populations of ducks, geese and swans in North America.

Canada, the United States and Mexico now share the responsibility and costs of implementing the Plan and share the significant benefits that flow to many economic sectors as a result of healthy North American migratory bird populations. More than 60 million people who watch migratory birds and 3.2 million who hunt waterfowl generate over US$20 billion annually in economic activity in North America. The Plan's focus is on the conservation of the waterfowl wetland and upland habitat. However, the benefits resulting from the efforts of Plan partners extend well beyond migratory bird conservation. Plan partners are increasingly modifying project designs to capture benefits for other wildlife, including endangered species, and for hydrology and water quality improvement.
NEW MIGRATORY BIRD INITIATIVES

Inspired by the success of the NAWMP, other international efforts such as the Western Hemisphere Shorebird Reserve Network (WHSRN), Partners in Flight, and Wings Over Water are now engaged in conservation planning on a continental scale, thus broadening the scope and vitality of migratory bird conservation in North America. A broad coalition of government, non-government organisations, and academia is now coordinating and integrating these bird conservation plans through the North American Bird Conservation Initiative (NABCI). The North American Commission on Environmental Cooperation is facilitating this effort.

The US Congress provided an incentive for Canada, the United States, and Mexico to accelerate cooperative migratory bird conservation efforts with passage of the North American Wetlands Conservation Act in 1989. The Act has a grant programme that encourages and supports partnerships to conserve wetland ecosystems and the waterfowl, other migratory birds, fish, and wildlife that depend upon these habitats in the three countries.

Canada, the United States, and Mexico also participate in other alliances in conservation and trade that directly affect waterfowl conservation, creating obligations, opportunities, and challenges for NAWMP partners. These include the Convention on Wetlands, the Convention on Biological Diversity, the North American Free Trade Agreement (NAFTA) and its parallel North American Agreement on Environmental Cooperation (NACEC), and the Trilateral Committee for the Conservation and Management of Wildlife and Ecosystems. Each of these initiatives reflects an increasing awareness of the economic and environmental benefits of international cooperation. Together they form an increasingly complex and diverse institutional context within which NAWMP and new initiatives must be implemented.

An important element of this continental alliance is the integration of the developing economy and environmental programmes of Mexico as a full partner in the conservation of North America's biodiversity. While wetland conservation programmes are common now in Canada and the USA, this has not been the experience of Mexico. Mexico is developing its involvement in NAWMP and NABCI, its overall conservation policies and infrastructure in tandem with national social and sustainable development goals.

Another element critical to the success of these initiatives is the role of the continent's aboriginal, Native American, indigenous, and local communities, for which migratory birds have cultural and dietary importance. Internationally, this is now acknowledged through the 1995 and 1997 amendments to the Canada-USA and USA-Mexico Migratory Bird Conventions, which recognise the importance of the traditional subsistence harvest of waterfowl.

CONCLUSIONS

- Development and implementation of a National Wetland Policy in the countries that have acceded to the Ramsar Convention is proceeding throughout the world. Canada has led by example in developing and implementing conservation wetland policies at the national level. The Convention's Wise Use Principles and Guidelines on National Wetland Policy (Rubec et al. 2000), complemented by guidelines for wetland legislation (Shine and Glowka 2000), are effective tools in fostering the completion and use of National Wetland Policies and Strategies as important cornerstones of this Convention.

- An additional tool that would benefit Ramsar Contracting Parties includes guidelines for implementation of wetland mitigation. A hierarchical approach developed in Canada for applying avoidance, minimisation and compensation principles in the planning process could serve as a model for such international guidance (Cox and Grose 1998, 2000).
The development of the Global Action Plan for Peatlands and Wise Use Guidelines for Peatlands are two additional examples of new operational tools to guide wetland conservation globally for which Canada has been supportive.

- The North American Waterfowl Management Plan is a clear and successful example of continent-wide international cooperation for wetland conservation. It has led to protection of over 800,000 ha of wetland and upland habitats that are fundamental to habitat needed for waterfowl and other migratory species. The NAWMP model is also now the framework for implementation of additional continental bird initiatives under the North American Bird Conservation Initiative (NABCI).

REFERENCES


Wetland Management in Thailand

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ABSTRACT

The Thais have earned their living in wetlands for a long time. Some of them work at the wetland sites near their villages while others, once in a while, go further. Many, including businessmen, earn the incomes by selling fish and vegetables or even transporting goods by boat from place to place. All wetlands have been invaded and illegally occupied continuously over the past three to four decades. We keep losing our wetlands yearly because of the absence of a strong policy and conservation management plan. In July 1993, the National Wetland Management Committee (NWMC) was established by the National Environment Board (NEB). A working group on the technical aspects of wetland management was set up to pool together knowledge and technical expertise on wetlands from related agencies. Thailand has actively participated in wetland conservation and development after the establishment of the National Wetland Management Committee. We have finished the wetland inventory for the entire country, formulated our own wetland classification in Thailand, the National Wetland Policy, Management Guidelines and Conservation Measurement Guidelines. Sixty-one wetland sites have been recognised as internationally important and 48 sites has been recognised as nationally important. They have been designated and approved by the NEB and the Cabinet on 19 May 2000 and 1 August 2000 respectively. Some individual wetland sites have also formulated their own development plans. Apart from this, we also have been working closely with other countries and international organisations. Denmark has been supporting Thailand on the wetland inventory project and the wetland management programme in two pilot sites under DANCED which will be implemented over the next five years. We have applied to be a part of the Ramsar Convention and a wetland has been considered a Ramsar site. Since 13 September 1998, Thailand has become the 110th country in the Convention. We are also working closely with the Wetland International and IUCN on the Mekong River Basin. We are promoting public awareness of wetland conservation and celebrating the "World Wetland Day" on 2 February each year in Thailand.

BACKGROUND

Wetlands have played an important role in the daily life of Thais since the Sukhothai period (1238-1350) when scriptures on stones depicted that "fishes in the water, and rice in the paddy field" could be found in all places in the kingdom, indicating the significance and richness of wetland resources in the area. Following the Ayutthaya period (1351-1767), rice farming, fishing and maritime trade in rivers, canals and offshore were the basis of the economy and livelihood. The Thais still earn their living from wetland resources till today.

As defined by the Ramsar Convention and UNESCO, wetlands are "areas of marsh, fen, peatland or water whether natural or artificial, permanent or temporarily, with water that static or flowing, fresh, blackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres" (UNESCO 1994).

According to this definition, one finds that wetlands cover extensive areas of Thailand ranging from mountain creeks, rivers, canals, riverine lakes with marshes, lowland rivers, floodplain lakes, river floodplains, rice fields, freshwater swamp forests, peat swamp
forests, mangroves, salt pans, shrimp ponds, mudflats, reef flats, seagrass beds and coral reef dropoff. There are approximately 3.5 million hectares of wetland areas in Thailand.

The benefits of wetlands and wetland resources form the very economic backbone of the country. Direct official values are estimated at 250,000 million Baht in 1996, which is about 8% of the GDP for Thailand. At the same time, little is known about the actual value of inland native fishes, frogs, snails, crabs, shrimps, etc. There are no real estimates either of the real or potential net earnings of, for example, the floating markets, beautiful beaches, bird sanctuaries, etc. Therefore, given values may be extremely grossly under-estimated.

Wetlands in Thailand today are either public or private. When talking about wetlands, most people think about marshes, swamps and the lakes, which, in general, are public areas. However, based on the existing classification (Table 1), the focus needs to be much broader than that; in reality the single largest type of wetlands is actually private, that is, the rice fields and shrimp farms. The status of being private or public has direct implications on how to manage wetlands for both government and individuals alike.

The Thai agricultural society extracts multiple benefits from the wetlands to sustain their staple food, rice and fish. These two commodities are the dominant ones among a wide range of wetland products.

ISSUES AND OPPORTUNITIES

Wetlands, predominantly located in the lowlands, are close to large concentrations of the human population and easily accessible. As a result, their resources are attractive targets and utilised or altered to suit human demands. Actually, the very reason for the concentration of people in the first place is the wealth of natural resources and suitability in terms of location. Undisturbed wetlands have been cleared and converted to agriculture, aquaculture, industrial sites and residential areas. Consequently, there are problems of flash and severe floods, sea water intrusion, sedimentation, wetlands drying out, forest fires, reduction of the ground water levels, increase in carbon dioxide in the atmosphere, and the decreasing economic value of wetlands.

The changes in land use have not been controlled or monitored properly to enable an assessment to be made on the cumulative effects of the development and sustainability of the resource base.

In the wake of land use changes, more public wetlands have been converted into private wetlands (for rice fields, shrimp ponds, housing, etc.) which creates some problems and threats.

The identified problems that directly relate to non-sustainable management of wetlands in Thailand can be divided into the following six focal elements:

- Inappropriate land use.
- Poor water management.
- Unsustainable harvesting practices.
- Socio-economic causes.
- Institutional/legal aspects at the national level.
- Local planning/implementation aspects.

The root causes behind the above listed problems have been identified as follows:

- The single sector approach to wetland planning and management at the national and local levels.
- Fragmented administration and implementation of policy framework for wetland management.

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• An inadequate information base for wetland policy, planning and management.
• Inadequate human and technical resources available for wetland conservation.
• A low level of awareness on sustainable use and value/importance of wetlands.

IMMEDIATE ACTIONS FOR WETLAND MANAGEMENT

The challenges of getting a common direction (policy) and coordinating efforts to utilise and conserve wetlands of various types to achieve maximum social and economic benefits for Thailand seem overwhelming. To regulate sector policies and economic potentials of such seemingly diverse sectors, such as energy (hydropower), tourism, inland fisheries and agriculture, implies large efforts of coordinated planning. The institutional arrangements needed imply a complex matrix of sector departments, general planning and area-focused departments as well as private sector and public interests.

Efforts are, however, being made and a Sub-committee for Wetland Management was established in 1993 under the National Environment Board with the Office of Environmental Policy and Planning (OEPP) as a member and secretariat. Members comprised representatives from relevant governmental organisations and the private sector. The roles and responsibilities of this Sub-committee are:

• Design a national policy and plan on wetlands.
• Monitor and evaluate the planned implementation of wetlands in line with the national policy.
• Support, supervise and monitor the planned implementation to be in line with the Ramsar agreements.
• Promote an addition of wetland management considerations into the formulation and implementation plan for the development and conservation of related natural resources.
• Support awareness and education on the value of wetlands and conservation.
• Support research on wetland issues.
• Coordinate with other concerned institutions both at national and international levels.
• Nominate a wetland working group in accordance with approved work plans.
• Work on other tasks assigned by the National Environmental Board.

STRUCTURAL AND INSTITUTIONAL WEAKNESSES OF WETLAND MANAGEMENT

The wetland areas in Thailand are subject to competing economic uses that have already led to a variety of environmental problems, which by their nature, cut across sectors. They arise from agricultural, fishery, urban, industrial as well as rural development projects. The management of wetlands, therefore, involves several stakeholders both at the central and local levels.

In the structural and inspirational arrangements of wetland management in Thailand, the following have to be readjusted:

• Overlap of policy making and management planning of two key institutions for wetland management, (a) the National Environment Board which designs the National Environmental Management Plan (ecology-concerned management), and (b) the National Economic and Social Development Board which designs the
National Economic and Social Development Plan (development-concerned management).


- Difficulties in coping with the effects of changes in land use (whether private or public wetlands) in terms of law enforcement and the continued persistence of the patron-client bureaucratic system.

INSTITUTIONS AND STAKEHOLDERS IN WETLAND MANAGEMENT

These are the following:

- MOSTE, which has the overall mandate to advise the government agencies on policy and planning issues, related to natural resources and the environment. MOSTE is the overall responsible agency in the implementation of the Ramsar Convention in Thailand.

- MOAC, which has the direct responsibility for the administration and management of most of Thailand’s natural resources.

- The Ministry of Interior (MOIn), which is responsible for issues related to the provincial and local levels and, therefore, has been given a key role in the ongoing decentralisation process including training of local authorities and implementation of participatory planning.

- The National Wetland Committee of Thailand (where both MOSTE and MOAC are represented) established by the National Environment Board in July 1993.

- Research institutions.

- Provincial and local authorities.

- Local communities in wetland areas.

- NGOs (a number of small NGOs exists in Thailand with activities and mandates related to NRE conservation).

- The Regional IUCN Office in Bangkok (which is presently formulating a regional GEF/UNDP wetland project that includes Thailand).

POLICIES, MEASURES AND THE WETLAND MANAGEMENT ACTION PLAN, 1998-2002

The National Wetland Management Sub-Committee and the Technical Wetland Management Working Group, appointed by the National Environmental Board, have designated policies, strategic measures and action plans for wetland management. These are as follows:

Policy on Wetland Management

To conserve wetlands for the maintenance of their abundant and ecological functions, and to develop them for sustainable economic and social benefits of Thailand.

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Strategic Measures for Wetland Management

Measure 1: Increased Awareness on Importance and Values of Wetlands

- Coordination to plan and implement programmes to increase the awareness of wetland importance.
- Establishment of a database and information centre on the importance and values of wetlands.
- Open opportunity for the public to have access to knowledge on policy and strategic measures of the government and public participation to consider and evaluate the implementation of wetland conservation plans.
- Utilisation of a process to increase awareness.
- Persistent public relations campaigns involving wetland conservation in order to initiate knowledge and understanding for the need to conserve and utilise wetlands in a sustainable manner.

Measure 2: Effective Management and Increased Coordination of Wetland Use and Conservation

- Education, survey and classification of wetlands in Thailand.
- Design of wetland management plans at all levels of public administration for wetland conservation and sustainable utilisation.
- Coordination of plan implementation in line with the policies, strategic measures and action plans among governmental organisations and concerned private enterprises with continued synchronisation towards a similar goal.
- Promotion and support of cooperation between public and private sectors to conserve, protect and rehabilitate the wetlands.

Measure 3: Improved Human Skills and Recruitment of Sufficient Number of Personnel

- Conferences, meetings and training on wetland conservation and relevant legal aspects of wetlands.
- Budget support for training and study visits on wetland conservation and management in order to increase advanced knowledge and experiences for concerned personnel.

Measure 4: Sufficient Promotion and Support for Education and Research to Obtain Baseline Data for Wetland Management

- Design major research plans for the conservation and management of wetlands for sustainable utilisation.
- Establishment of wetland research networks.

Measure 5: Imposition of Conditions for Wetland Utilisation and Proper Assignment of Private Rights to Own the Wetlands

- Control of illegal encroachment of wetlands.
• Monitoring and evaluation of wetland utilisation in compliance with existing laws and regulations.
• Supervision of the assignments of private land right titles of wetlands given to the public.

**Measure 6: Effective Enforcement of Laws and Regulations and Improved Efficiency of Concerned Institutions on Wetland Management**

• Enforcement of laws and regulations on wetlands, including amendment revisions and supplements, to existing laws and regulations for the purpose of effective wetland conservation and uses.
• Capacity building of all relevant institutions to serve the policy of wetland management.

**Measure 7: Increased Promotion of International Cooperation for Wetland Conservation**

• Promotion of national and international agreements such as the Mekong River Commission’s Agreement of 5 April 1995 on Cooperation for the Sustainable Development of the Mekong River Basin.
• Promotion of information exchange, information technology management and study visits.

**THE WETLAND MANAGEMENT ACTION PLAN, 1998-2002**

The Wetland Management’s Action Plan (1998-2002), which was approved by the Cabinet, is an implementation of the seven previously mentioned strategic measures in the form of developmental plans comprising 28 plans and 43 programmes from 14 institutions with a budget of 472.5 million Baht.

**Strategic Measures on Conservation of Wetlands of National and International Importance**

The Office of Environmental Policy and Planning has conducted a survey to prepare an accounting and database system of a National Inventory of Natural Wetlands in Thailand. The inventory prioritises levels of importance of natural wetlands as follows:

**Wetlands of International Importance**

These wetlands have unique regional or international characteristics. They are home to threatened and endangered species of flora and fauna. There are 61 natural wetlands of this level in Thailand.

**Wetlands of National Importance**

These wetlands have their national uniqueness. They are home to rare or near extinct or threatened species of flora and fauna. There are 48 natural wetland of national importance in Thailand.
Wetlands of Local Importance

These wetlands have played important roles in local cultures, social values, traditions, religious, beliefs, history, folklore and recreation. There are 19,295 natural wetlands of this level in Thailand.

Accordingly, the Office of Environmental Policy and Planning has prepared 13 strategic measures for the management of the wetlands of international and national importance which were approved by the Cabinet on 1 August 2000. They are as follows:

- Nomination of wetlands of international importance to become Ramsar sites.
- Gazetting wetlands of international and national importance as non-hunting areas or environmentally protected areas of conservation areas or equivalent classification.
- Issuing a Royal Gazette for public wetlands of international and national importance, and accelerating boundary markings to prevent encroachment of the wetland ecosystem.
- Rehabilitation of degraded internationally and nationally important wetland ecosystems for continuance of their ecological and hydrological functions.
- Designing a master plan for the management of internationally and nationally important wetlands both in the short and long terms with a zoning system (conservation zone, development zone and buffer strips), including specifications of permitted and prohibited activities.
- Requirement of Environmental Impact Assessment (EIA) for any development projects that may alter the internationally and nationally important wetlands.
- Strengthen public awareness and knowledge on values of wetlands of the local communities, and encouraging local participation in management planning of internationally and nationally important wetlands.
- Promotion of education and research on internationally and nationally important wetlands alongside information provision to the public.
- Continuous monitoring of wetland ecosystem changes with clear factors and indicators.
- The study and survey of wetlands and their biodiversity should be carried out on a continuous basis. Information on wetlands of international and national importance would be updated.
- Pollution control and prevention from non-point and point sources.
- Control measures of forest fires in the wetlands of international and national importance. For prevention, there would be regulation of water levels in forests, wet-line fire breaks according to royal initiatives and proactive public awareness to discourage local burning. For the extinguishment of fires, control stations in important wetlands, staff training and allocation of appropriate and effective equipment would be important.
- Physical and landscape planning in the surrounding wetland areas of international and national importance to conserve and rehabilitate wetland ecosystems both for short and long terms.
CONCLUSION

Thailand has carried out the following activities in order to manage the wetlands for sustainable development and conservation:

- The wetland classification of Thailand.
- A wetland inventory and mapping for the entire country.
- National strategic measures on the conservation of wetlands of national and international importance.
- The Ramsar Convention was ratified by Thailand on 13 May 1998, with the designation of Khuang Kee Sian at the Thale Noi Non-Hunting Area as the country’s first Ramsar site.
- Implementation of the Ramsar Convention, the Management and Protection of Wetland Area Project (Thailand has been signed an agreement with Denmark and the project will start this year).

Wetlands: Sustainable Management Opportunities

The future challenges for effective and sustainable wetland management as put forward by this document are the following:

- Putting policy and management strategies into effect at both institutional and field levels.
- Designing a strategic framework with the participation of all stakeholders in accordance with national policy and management strategic measures.
- Harmonising the developmental plans of sectors with the strategic framework and prioritising management programmes. Integrated spatial and process management, people participation, and evaluation and monitoring mechanisms are key approaches for the successful, continuous and effective implementation of the Wetland Management Action Plan.
- Generating and allocating finances and human resources to implement the plans and policies.
- Adjusting annual budget allocation procedures toward result/outcome of achievements and administrative development for peaceful resolution of wetland use conflicts.
- Collecting data/information for effective management of the wetlands as well as develop appropriate valuation techniques. Emphasis should be given to a continuous monitoring of plan/programme implementation, and a development of reliable indices to measure its success/failure at all implementation levels.
- Promotion of essential research and development of wetland management technologies.
- Appreciating and describing links between public and private wetlands and the need to address the management of private wetlands to sustain the public ones.
- Enhancing the public awareness process at all levels to complete participation and mutual learning among stakeholders for wetland management.
• Implementation of the New Constitution (1977), and Decentralisation Act (1999) to accelerate the decentralisation of responsibilities and authority to local administrative organisations. There is an urgent need to prepare and strengthen these local organisations for sustainable wetland management.
WETLANDS CLASSIFICATION

Type (Code) System (Code)

Subtidal (SMS)

1. Non vegetated (SMS1)
   - Natural
     a. Rock Bottom
     b. Unconsolidated Bottom

2. Vegetated/Coral (SMS2)
   - Natural
     a. Coral (Marine Subtidal Coral)
        - Artificial (m)
          a. Coral (Marine Subtidal Coral Farm)
     b. Seagrass (Marine Subtidal Seagrass)
     c. Seaweed (Marine Subtidal Seaweed)
        - Artificial (m)
          c. Seaweed (Marine Subtidal Seaweed Farm)
     d. Mariculture (Marine Subtidal Mariculture)

Intertidal (SMI)

1. Non vegetated (SMI1)
   - Natural
     a. Beach (Coastal Beach)
        - Artificial (m)
          a. Salt Work (Coastal Salt Work)
     b. Mudflat (Coastal Mudflat)
        - Artificial (m)
          c. Cliff (Coastal Cliff)
     c. Saltflat (Coastal Saltflat)
     d. Tidal pool (Coastal Tide Pool)

2. Vegetated/Coral (SMI2)
   - Natural
     a. Coral (Marine Intertidal Coral)
        - Artificial (m)
          a. Coral (Marine Intertidal Coral Farm)
     b. Seagrass (Marine Intertidal Seagrass)
     c. Seaweed (Marine Intertidal Seaweed)
        - Artificial (m)
          c. Seaweed (Marine Intertidal Seaweed Farm)
     d. Trees/Shrubs (Coastal Mangrove)
        - Artificial (m)
          d. Trees/Shrubs (Coastal Mangrove Plantation)

Nontidal (SMN)

1. Non vegetated (SMN1)
   - Artificial (m)
     a. Mariculture (Nontidal Mariculture)
     b. Salt Work (Nontidal Salt Work)

2. Vegetated/Coral (SMN2)
   - Natural
     a. Coral (Estuarine Subtidal Coral)
        - Artificial (m)
          a. Coral (Estuarine Subtidal Coral Farm)
     b. Seagrass (Estuarine Subtidal Seagrass)
     c. Seaweed (Estuarine Subtidal Seaweed)
        - Artificial (m)
          c. Seaweed (Estuarine Subtidal Seaweed Farm)
     d. Mariculture (Estuarine Subtidal Mariculture)

Intertidal (SBT)

1. Non Vegetated (SBT1)
   - Natural
     a. Beach (Estuarine Beach)
     b. Mudflat (Estuarine Mudflat)
     c. Cliff (Estuarine Cliff)
     d. Saltflat (Estuarine Saltflat)

2. Vegetated/Coral (SBT2)
   - Natural
     a. Coral (Estuarine Intertidal Coral)
        - Artificial (m)
          a. Coral (Estuarine Intertidal Coral Farm)
     b. Seagrass (Estuarine Intertidal Seagrass)
     c. Seaweed (Estuarine Intertidal Seaweed)
        - Artificial (m)
          c. Seaweed (Estuarine Intertidal Seaweed Farm)
     d. Trees/Shrubs (Estuarine Mangrove Swamp)
     e. Forbs (Estuarine Saltmarsh)

Nontidal (SBT)

COASTAL LAGOON (SC)

Coastal Estuarine/Brackish Lagoon
Implementing Sustainable Management Measures of Mangroves in Malaysia

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ABSTRACT

Among the best known wetlands in Malaysia are the mangrove forests. Mangroves provide rich and diverse habitats for a variety of plants and economically important species of finfish and prawns. They also play a vital role in protecting and conserving the coastal ecosystem, a source of valuable timber and wood, food and other medicinal products. Despite their many values, mangroves are coming under increasing pressure from threats such as industrialisation, agriculture, non-sustainable forestry practices, conversion to aquaculture ponds and pollution. Therefore, stringent management plans are needed and should be devised based on integrated approaches. However, sustainable management cannot be implemented due to insufficient data of their status and distribution. As such, innovative research programmes, comprehensive inventory, monitoring, awareness building and training are some of the important measures that must be implemented in ensuring that sustainable management can be achieved.

INTRODUCTION

Wetlands are among the most complex ecosystems in the world. They have high biological diversity. It is estimated that only about 6% of the earth's surface are covered by wetlands and yet they provide habitats for about 20% of known species (D'Cruz and Sebastian 1993). According to the internationally accepted Ramsar Convention definition, 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 (Davis 1994). Malaysia has a high diversity of wetland types, ranging from coral reefs in the shallow coastal waters, mangroves, mudflats, rivers, lakes, ponds and swamp forests.

The mangrove forests are among the best known wetland areas in Malaysia. Mangroves are normally found off sheltered, low lying tropical and subtropical coasts. The total extent of mangrove forests in Malaysia has been estimated to be about 0.59 million ha. About 0.11 million ha. occur in Peninsular Malaysia and 0.32 million ha. in Sabah and Sarawak. The major areas of mangrove forests in Peninsular Malaysia are found on the west coast in the states of Perak, Selangor, Kedah and Johor. Along the east coast only small patches of mangrove forests occur (Abdul Rashid Mat Amin 1996).

DIVERSITY AND VALUE OF MANGROVES

Mangroves are open ecosystems which are sustained by the flow of energy and nutrients from the marine and land systems. This type of vegetation provides habitats for a wide number of plants, animals as well as economically important species of finfish and prawns that have adapted to salty and inundated environments. Table 1 provides information on the species richness of groups associated with mangroves in Asia (Groombridge 1992).
Table 1. Species richness in groups associated with mangroves.

<table>
<thead>
<tr>
<th>Taxonomic group</th>
<th>Species richness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bacteria</td>
<td>10</td>
</tr>
<tr>
<td>Fungus</td>
<td>25</td>
</tr>
<tr>
<td>Algae</td>
<td>65</td>
</tr>
<tr>
<td><strong>Higher Plants</strong></td>
<td></td>
</tr>
<tr>
<td>Bryophytes</td>
<td>35</td>
</tr>
<tr>
<td>Monocotyledons</td>
<td>73</td>
</tr>
<tr>
<td>Dicotyledons</td>
<td>110</td>
</tr>
<tr>
<td><strong>Animals</strong></td>
<td></td>
</tr>
<tr>
<td>Protozoa</td>
<td>18</td>
</tr>
<tr>
<td>Sponges/Bryozoa</td>
<td>5</td>
</tr>
<tr>
<td>Coelenterata/Ctenophora</td>
<td>3</td>
</tr>
<tr>
<td>Non-polychaeta worms</td>
<td>13</td>
</tr>
<tr>
<td>Polychaetes</td>
<td>11</td>
</tr>
<tr>
<td>Crustaceans</td>
<td>229</td>
</tr>
<tr>
<td>Insects/Arachnids</td>
<td>500</td>
</tr>
<tr>
<td>Molluscs</td>
<td>211</td>
</tr>
<tr>
<td>Echinoderms</td>
<td>1</td>
</tr>
<tr>
<td>Ascidians</td>
<td>0</td>
</tr>
<tr>
<td>Fish</td>
<td>283</td>
</tr>
<tr>
<td>Reptiles</td>
<td>22</td>
</tr>
<tr>
<td>Amphibians</td>
<td>2</td>
</tr>
<tr>
<td>Birds</td>
<td>177</td>
</tr>
<tr>
<td>Mammals</td>
<td>36</td>
</tr>
</tbody>
</table>

According to Uthoff 1996, mangrove areas in different parts of the world differ clearly in numbers and diversity of species. The Indo-Malaysian group has the richest species diversity. Thus, Southeast Asia not only has the largest mangrove stands in the world but the mangrove ecosystems with the greatest species diversity.

Mangrove forests in Malaysia are areas with high diversity. There are around 60 species of mangrove trees, exclusive and non-exclusive species. Some of the exclusive species found in the Malaysian mangroves are *Avicennia alba*, *Lumnitzera racemosa*, *Rhizophora apiculata*, *Sonneratia alba*, *Xylocarpus granatum* and *Intsia bijuga* while some of the non-exclusive species are *Ammonia calcarea*, *Barringtonia asiatica*, *Cantium didymum*, *Eugenia kunstleri*, *Eudia roxburghii* and *Vitex pinnata*. There are also many marine organisms with economic value associated with the Malaysian mangrove ecosystems. These include fishes from the families of Belonidae, Carangidae, Chanidae, Dorosomidae, Latidae and Siganidae, crustaceans from the families of Palaemonidae, Panaeidae, Portunidae and Sergestidae and also Molluscs from the families of Arcidae, Cerithideidae, Potamidae and Sepiidae (Umali et al. 1987).

Apart from that, mangroves play an important role for humans. Fuelwood and hardwood, fisheries resources, food and medicinal products can be harvested from the forests. Mangrove habitats are ideal for tourism, education and scientific studies. They also play a vital role in protecting and conserving the coastal ecosystem, acting as nutrient, sediment and
toxicant traps, in the production of biomass and also in providing refuge for wildlife and fishes (Khan 1995, Mastaller 1996).

THREATS TO MANGROVE HABITATS

In Asia, the most important direct causes of biodiversity loss in wetlands are from hunting activities (42%), human settlement or encroachment (34%), commercial logging or forestry (30%), wood cutting for domestic use and drainage schemes (27%). It is reported that conversion of mangroves to many other uses is increasing every year. The mangrove forests are under threat from human activities and also natural processes. Mangroves are sensitive towards the effects of logging, encroachment and reclamations. These cause physical changes in the whole ecosystem due to sedimentation, pollution and change in water salinity.

In Malaysia, the destruction of mangroves is mainly due to development projects, increase in human population in urban areas, agricultural activities, unsustainable forestation methods, conversion of mangroves to aquaculture ponds, development in water catchment areas and domestic and industrial pollution. The rapid increase in development has resulted in demand for more land space so that in most cases, mangroves are being destroyed and converted for other uses. Apart from that, unsustainable logging activities also cause sedimentation. This pollutes the water catchment area and in turn, affects the mangroves (Hussain 1994).

MANAGEMENT OF MANGROVE FORESTS

Overall awareness on the importance of mangroves is still at a low level. Mangroves are being valued as the direct amount of profit gained and not by their indirect benefits. The mangrove forests need stringent management plans and these should be devised based on integrated approaches. This is vital if their diversity, resources and benefits are to be preserved (Mercer and Hamilton 1984).

To practise sustainable management, all aspects of the mangrove forests should be well understood. However at the moment, management plans cannot be implemented effectively due to insufficient data of their status, distribution and resources. Due to their relatively small distribution and total value, research activities on the mangroves have received low priority compared to inland forests. The value of the mangrove forests per unit area is much higher than the value of inland forests. However, the extent and the rate of destruction cannot be documented due to insufficient information (Burbridge 1994). It is necessary to develop and maintain databases for assessment and management of the mangroves (Paragraph 17.8 (a) Agenda 21, United Nations 1992). In view of this, research programmes, monitoring, public awareness and training must be planned and implemented to provide the necessary information for ensuring the sustainable management of these forests.

RESEARCH AND DATA COLLECTION

It is important to have primary data on the structure and function of the mangrove ecosystem. Apart from this, data on the biomass and productivity at certain trophic levels must also be known. The trophic level concept can be used to gather information on production and degradation processes in the ecosystem. Research on the nutrient cycle of all mangrove communities, the ecology and biology of invertebrate fauna and important species such as prawns, crabs and fishes, as well as their regeneration processes are also important. Taxonomic research on species with economic and ecological value towards the mangrove areas, such as the crab Scylla serrata and Mymenippe hardwicki which play important roles in the food web of the ecosystem, should also be studied. At the moment only a few studies have been done on these aspects (Chuang and Ng 1994, Tan and Ng 1994).
Studies should also concentrate on the importance of the mangrove ecosystem in maintaining resources such as fisheries. It has been reported that the fungi, bacteria, protozoa and detritus formed by dead mangrove leaves contain 80-90% of the food for crabs, worms, insec: larvae and fish which in turn are food for at least 60 species of big fishes. Research on mangroves should be multi-disciplined. The effects of environmental and anthropogenic pollution on mangroves from agriculture and industrial activities are still very minimal. However, these pollutants are toxic towards the living organisms in the mangrove ecosystem, affecting the species compositions and their reproduction (Tang et al. 1980).

Microbial activity is also affected by anthropogenic pollution. Bacteria form the base of all earth ecosystems and are responsible for the degradation processes, production of elements such as carbon, nitrogen and phosphorus, recycling of nutrients in the food web and maintaining essential elements. They are also a source of food for the protista and invertebrate where these organisms form the benthic food web (Findlay et al. 1990). In a habitat rich in organic substances, the growth rate of bacteria is higher. The abundance of bacteria depends on nutrients and the state of the environment (Moriarty 1989). Disturbances from the environment and anthropogenic effects cause nutrient loss and also introduction of toxic substances. Felling of trees, for example, can result in oxidation of pyrit (FeS₂) and the release of sulphuric acid (Table 2) (Alongi 1994).

These types of activities have caused destruction of many mangrove areas. As a result, mangrove flora and fauna, many of which are endemic species, are lost (Table 3) (Shamsuddin Ibrahim and Baharudin Abd. Ghani 1996).

The uses of mangroves, their interactions (Paragraph 17.5 (b) Agenda 21, United Nations 1992) and data on critical mangrove areas (Paragraph 17.7 and 17.86 Agenda 21, United Nations 1992) should also be collected. These data should contain quantitative information on biological, physical and socio-economic aspects of mangroves. Data should also include the area, its diversity and total revenue obtainable from it. With the availability of these data, monitoring of the area, decision making (Strategic Plan 1997-2002), conservation activity and also restoration of eroded habitats can be implemented wisely (Paragraph 17.6(h) and 7.75(e) and (f) Agenda 21, United Nations 1992).

<table>
<thead>
<tr>
<th>Types of disturbances</th>
<th>Effects on microbial processes</th>
<th>Effects on ecosystem</th>
</tr>
</thead>
<tbody>
<tr>
<td>Logging</td>
<td>Reduced food web biomass and nutrient loss</td>
<td>Unhealthy sediment erosion</td>
</tr>
<tr>
<td>Chemical effluents</td>
<td>Death of microbes and nutrient cycle stops</td>
<td>Loss of certain trophic levels</td>
</tr>
<tr>
<td>Redamation for agriculture/aquaculture</td>
<td>Soil oxidation, loss of anaerobic microbial biomass and high aluminium concentration</td>
<td>Release of sulphuric acid and acidification</td>
</tr>
<tr>
<td>Effluent, discharges and pollution</td>
<td>Change in aerobic and anaerobic microbial processes</td>
<td>Inefficient nutrient cycling, increased organic substances and release of toxic H₂S</td>
</tr>
</tbody>
</table>
Table 3. Areas of mangrove forest experiencing exploitation.

<table>
<thead>
<tr>
<th>Area</th>
<th>Threats</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hutan Simpan Bakau Kapar, Selangor</td>
<td>Developed to industrialised area based on sea activities</td>
</tr>
<tr>
<td>Sungai Selangor</td>
<td>Diversion work upstream</td>
</tr>
<tr>
<td>Pulau Indah, Pulau Ketam, Pulau Tengah, Pulau Carey</td>
<td>Construction of ports, reclamation of lands for agriculture, housing, industry and aquaculture</td>
</tr>
<tr>
<td>Hutan Simpan Merbok, Kedah</td>
<td>Cultivation of padi and aquaculture</td>
</tr>
<tr>
<td>Beaut, Sungai Pulai, Pulau Sedeli (Johor)</td>
<td>Agriculture, land reclamation, aquaculture and housing development</td>
</tr>
</tbody>
</table>

Monitoring

Evaluation and monitoring are important components in management and development. According to the Ramsar Convention (Article 3.1), plans for the sustainable use of mangrove resources should be well devised (Davis 1994). This includes making inventories on mangrove areas in Malaysia and implementing environmental impact assessments on coastal areas before a certain mangrove area can be exploited (Paragraph 17.8 (c) Agenda 21, United Nations 1992). Activities in managed mangrove areas must be observed and regulations enforced (Article 4.1 Ramsar Convention, Davis 1994). Observation and monitoring should also be implemented on major projects that have been started (Paragraph 17.5(d) Agenda 21, United Nations 1992). Meanwhile, EIA reports should also be reviewed and used in development plans (Wetlands International 1995, Strategic Plan 1997-2002).

It is also appropriate to apply methods that reflect changes in value resulting from development projects (Paragraph 17.5(c) Agenda 21, United Nations 1992, Wetlands International 1995). A project is beneficial if the outcome exceeds the ecological, economical and social loss (Pillai 1985).

Public Awareness and Training

Apart from that, public awareness of the importance of mangroves and threats to their survival is vital and this can be achieved through implementation of campaigns and information programmes (Paragraph 17.6(l) Agenda 21, United Nations 1992). The government and public sector should be encouraged to play a role in conserving the mangroves. The media as well as schools should emphasise the importance of conserving the mangroves to children at an earlier stage (Strategic Plan 1997-2002). Apart from that, officers involved in conservation should also be trained to do research, management and monitoring of activities that cause negative impacts on mangroves (Article 4.5 Ramsar Convention, Davis 1994; Paragraph 17.6(k) Agenda 21, United Nations 1992). Collaboration with other countries is also important as this will enable us to learn new techniques in conservation (Mastaller 1996).

CONCLUSION

The mangroves are important resources that must be conserved. Due to the gradual change from traditional to conversional uses of the mangrove ecosystem which causes direct conflict with conservation and resource utilisation by various sectors, it is clear that there is a need to formulate an integrated management system which is based on adequate information.
of its status, distribution, values and threats. As such, innovative research programmes, comprehensive inventory, monitoring, awareness building and training are some of the important measures that must be implemented in ensuring that sustainable management can be achieved.

REFERENCES


Degradation of the Wetland Ecosystem in Assam, India

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ABSTRACT

Assam is blessed with great water resources. The state has over 3,513 wetlands covering 1,012.31 square kilometres. Morphologically, these wetlands can be divided into different categories which are ideal habitats for feeding, nesting and breeding of fishes, birds and other aquatic animals as well as flora varieties. These wetlands are, however, degenerating and suggestions have been forwarded for their conservation and better management.

INTRODUCTION

Assam is blessed with a natural bounty of water resources. A truly riverine state amidst the hilly areas of the northeastern region of India, Assam is drained mainly by two river systems, the Brahmaputra and the Barak. The Brahmaputra, besides being the major river of the valley, is the only large drainage outlet of the entire northeast of India. In the floodplains of all the major rivers a large number of natural water bodies is found.

Broadly speaking, in the context of Assam, the lake-like areas that have clear water-spread areas in the middle are known as beels, while those covered with weeds, grasses etc. are called swamps or marshes. However, the swamps and marshes are generally known as jalch, doloni, pitoni, doha, hola locally. The wetlands in the state are the home of a large variety of fauna and flora, some of which are of extremely rare and endangered types while others are of great ecological or economic values.

The beels of Assam are traditionally used as natural fisheries which are potentially very rich in fish and other aquatic resources. The genesis and development of beels are closely related to the geomorphic and tectonic history of the region, the hydrologic behaviour of rivers and prolonged human use of the adjoining lands.

OBJECTIVES

The main objective of the study is to examine the major morphological characteristics and the process of degeneration of wetlands in Assam. The issues being addressed in this respect are:

- The present pattern of distribution and morphological characteristics of the wetlands.
- The origin and present status of the wetlands.
- Natural causes responsible for degeneration of the wetlands.
- Changes due to human interference.
- Potentialities for development of the wetlands.
METHODOLOGY

The wetlands in the state are initially identified on the survey of India topographical maps of 1:50,000 scale. The local names of such water bodies, their nearest settlements and geographical coordinates are taken from these maps. The present shape, size and area of these wetlands are measured from satellite imagery viz lands at 5 TM and IRS LISS II on the 1:50,000 scale. The changes taking place recently in all the wetlands under study are recorded by superimposing the satellite imagery of different years and also using the topographical maps. The land use pattern in the fringe areas of beels are mapped with the help of Landsat (TM) imagery. The water-spread area, sand, mud and vegetation covering in the beels are also estimated with the help of the imagery of various seasons and through extensive field surveys. Human interferences such as encroachments for building houses, constructing roads, railways, bunds across the wetlands are identified with the help of satellite imagery supplemented by field observations. The analysis of the water quality is done in the laboratory at the Pollution Control Board, Assam. The collected data are presented partly using computers and thorough standard statistical methods and cartographic techniques.

DISTRIBUTION OF WETLANDS

A satellite remote sensing survey of the wetlands of Assam has been able to identify and delineate the extent of as many as 3,513 water bodies in the state covering a total area of 1,012 sq km. Most of the wetlands (totaling 3,341) have sizes varying between 1 to 100 ha. There are twelve wetlands that are larger than 600 ha in area. The largest wetland in the state is the Son beel in the Karimganj district which covers an area of 3,010 ha. The Deepar beel, a large natural wetland located in the western fringe of Guwahati city covering an area of 40 sq km, has been identified as a wetland of national importance.

As many as 690 lakes and ponds exist covering a total area of 15,494 ha. They account for 15.3% of the total wetland areas of the state. There are 861 crescent shaped oxbow lakes and cut-off meanders. These cover an area of 15,460.6 ha i.e., around 15.3% of the total wetland areas in the state. The seasonally waterlogged areas constitute a major portion of the wetlands in Assam. They play a significant role in the state's economy as they are present in large numbers in the rural areas and sustain large amounts of fishes and other aquatic fauna and provide a habitat to a variety of migratory as well as domicile birds. Besides, they have remarkable potential for supplying irrigation water to the nearby agricultural field during the dry seasons. Altogether, 1,125 waterlogged areas are identified which cover 23,431.5 ha i.e. 23.15% of the total area under wetlands.

A swamp is an area intermittently or permanently covered with water, having shrubs and trees but essentially without the accumulation of peat. On the other hand, the term marsh is often restricted to waterlogged grounds that contain large mineral basins, in contrast to the peat of bog and fen. In Assam, 712 swamps and marshes cover 43,433.5 ha comprising more than 42.9% of the total area under wetlands. In addition, as many as 10 reservoirs and 115 large-size tanks are present in the state. The reservoirs account for 2.63% and the tanks 0.74 % of the total wetland areas of the state.

MORPHOLOGY OF THE WETLANDS

Morphologically, the wetlands of the state have been divided into five categories viz., linear, compact, discrete, irregular and oxbow shaped (Figure 1). The linear type of beels that is more ubiquitous in the state represents detached parts of river courses. These beels are different from the compact type because of their length-breadth ratio. Except in the case of oxbow beels, if this ratio is found to be more than 3 in a particular beel, it is considered as a linear type. Oxbow beels are found along most of the tributaries of the Brahmaputra and Barak rivers. Irregular types of wetlands are generally found amidst the hills. Usually these
wetlands have more feeder channels. Their shoreline is irregular and with more depth variation. It is probably due to the effect of the rugged nature of the land surface over which waters have accumulated. The discrete type of beels look like two or more separate beels. But these separate parts are generally connected by one or more narrow channels. These channels not only keep the water level the same in all parts, but also maintain homogeneity in respect of other hydro-ecological characteristics. Therefore, such beels are treated as unitary systems. Almost all categories of wetlands are closely associated with the rivers. All the ox-bow shaped and linear types of beels are formed mainly from the hydraulic action of rivers. As a result, the concentration of the wetlands is more towards the rivers. Although the origin of the other three types is different, their concentration is still more towards the river.

The wetlands in Assam are extremely rich in nutrients and have immense production potential for various types of flora and fauna. These wetlands, particularly the swamps, are greatly valued for their peculiar aquatic environment which provides ideal habitats for feeding, nesting and breeding of different types of birds and animals. The Deepar beel, Kaziranga National Park, Laokhowa, Orang, Manas, Sonai-Rupai and the Dibru wildlife sanctuaries are important both at the national as well as international level for their rich biotic resources.

The water quality of selected wetlands in Assam is discussed here based on some observed data. The pH of beel water ranges from 6.1 to 8.3 which indicates that the beels are highly productive wetlands from the fish production point of view. However, the pH value changes in different seasons. Turbidity is another physical parameter which controls the occurrence and distribution of aquatic flora and fauna. There are 2,877 wetlands in the state which have low turbidity, 346 have moderate turbidity while 178 have very high turbidity (Barua and Goswami 1998). High turbidity is more often found in waterlogged areas, swamps and marshes while low turbidity is observed in lakes and ponds. Among natural and man-made wetlands, turbidity is generally high.

Dissolved oxygen (DO) is found to be nil in the Ellenga beel, probably due to the discharge of effluent from the Nagaon Paper Mill that the beel receives. The BOD and COD levels are also very high in the Ellenga which indicate high degrees of pollution due to the waste disposal from the paper industry. In the case of the Morikalong and Deepar beels, the CO2 is relatively higher compared to those of the beels like Hawaipur which are located amidst the forests where human interference is negligible.

DEGRADATION OF WETLANDS

In general, the beels and swamps provide ideal habitats for feeding, resting and breeding of a large number of fishes, birds and various aquatic animals. But it has been observed that most of the wetlands of Assam are now being degenerated. The main factors responsible for degeneration of beels and swamps are: (a) inorganic bottom deposits, (b) organic bottom deposits, (c) the blockade of feeder channels, (d) unscientific construction of engineering structures, (e) encroachment and cultivation in marginal areas, (f) release of industrial and urban wastes, and (g) fishing methods and gears.

Inorganic bottom deposits include the accumulation of sand, silt, clay, pebbles and other inorganic materials. High seasonal rainfall, active seismicity, rapid channel aggradation, massive deforestation, intense land use and ad hoc types of temporary measures of flood control are the major factors of inorganic bottom deposits.

Most of the beels in Assam are infested with water hyacinth. The growth of this aquatic plant is normally very high due to the presence of high rainfall, high humidity, moderately high temperature and low sunshine. Except a few grazed by some herbivorous animals, most of the hyacinth become deposited at the bottom of the beels when they die. This process of accumulation of organic deposits over the years leads to the degeneration of wetlands.

The blockade of feeder channels is another cause of degeneration of wetlands. Usually the young and brood fishes enter the wetlands from rivers through the feeder
channels. But it has been observed that due to accumulation of putrefied substances over the years, these feeder channels have become shallow and hamper the autostocking process. The blockade of feeder channels due to construction of roads, railways, embankments etc. accelerates the degeneration of feeder channels as well as the wetlands themselves.

Due to tremendous increases of population in recent years, many of the wetlands are now being encroached for agricultural and other purposes. As a result, not only are the wetland areas reduced but they are also made less productive. Many of the wetlands become polluted mainly due to changing land use of surrounding areas.

The wetlands where human interference exists face the problem of pollution of many kinds. The condition is worse in the case of the wetlands which receive urban wastewater and industrial effluent (Sharma 1993).

Apart from deteriorating quality of water in most of the wetlands from over-fishing, use of nets with small mesh size, traditional gears and methods, poaching and hunting cause further deterioration of these precious resources of the valley.

CONSERVATION AND MANAGEMENT

In order to stop the present trend of degeneration of wetlands and improve their productive potential, the following administrative, socio-economic and ecological measures are suggested:

- As many of the wetlands are infested with the overgrowth of floating and submerged vegetation which reduces their productivity, it is necessary to remove such weeds from the wetlands on a regular basis.

- Indiscriminate construction of engineering structures across the wetlands by various departments for different purposes should be stopped.

- Wetland boundaries should be clearly demarcated and encroachment should be stopped. The unregistered beels should be registered so that some development measures can be taken.

- The use of nets of undersized mesh for fishing should be totally banned particularly during the months of May to August. Community poaching, which is a common practice almost in all the beels, is found to be very harmful. Therefore, this practice should be stopped without delay.

- The wetlands in Assam are at present controlled by four different departments of the state government. Over-lapping in departmental management creates various problems. Therefore, all the wetlands should be brought under a single managerial organisation.

- The beel water of Assam is comparatively more productive than the water of the reservoirs of other states of the country. Moreover, it has already been proved that the beels of less than 10 hectares can easily be developed but they remain grossly under-utilised at present as productive fisheries.

- All kinds of effluent from industries and liquid and solid waste discharge from municipality areas should be restricted from entering wetlands.

- As the siltation at the beel bottoms is becoming a serious problem leading to degeneration of these water bodies, the sediments should be trapped in the catchment areas through afforestation and the construction of contour bunds parallel to the shoreline with the accumulated silt in the littoral zones undertaken.
CONCLUSIONS

The wetlands of Assam are extremely significant from the points of view of biodiversity conservation, production of fish and other aquatic resources and more particularly in the control of floods. The wetlands help in groundwater discharge, recharge and water storage. If the wetlands, particularly the beels, are properly managed, this may bring about a revolutionary change in the economy of the state. Wetlands will also help in maintaining the ecological balance as well as environmental quality in the entire region. Many of the wetlands can be easily put on the tourist map of the country which has not been done so far. As such for overall development and management of these precious wetlands, coordination and cooperation among the various concerned departments are extremely vital without which neither the deterioration of wetlands can be checked nor their potential property utilised.

REFERENCES


Wetland Biodiversity Conservation and Sustainable Use in China

Lin Jin, Liu Guoqiang, Yan Chenggao, Darrell Sequeira and Li Sheng

GEFPO

ABSTRACT

China has over 65 million hectares of wetlands. However, 40% of the wetlands of international importance are currently under moderate to severe threats which have greatly reduced their ability to support the national economy and also resulted in serious environmental problems. As a result, China has united with global initiatives in an attempt to conserve the wetlands.

BACKGROUND

China has over 65 million hectares of wetlands, some of which are among the most important and unique wetlands in the world. It is quite difficult to over-state the global importance of China's wetlands. China has 192 of 947 internationally important wetlands in Asia defined according to the criteria of the Convention on Wetlands, covering over 16 million ha or over 20% of the area of wetlands of international importance in the region. Because of the extremely wide range of altitudes, latitudes and climatic zones, the diversity of wetland habitats in China is seldom paralleled in any other countries of the world and they support a large number of rare and endemic species. China is one of the key countries on both the East Asian-Australasian and the Central Asian-Indian flyways for migratory waterbirds. These two globally significant migration routes involve millions of birds each year belonging to approximately two hundred species, of which China's wetland sites provide crucial staging and breeding areas. Thirty-one of the 57 endangered waterfowl species for Asia are found in China while 10.8% of amphibians and 15.5% of fish are endemic to China.

China's wetlands have come under increasing pressure and threats due to the large population and rapidly developing economy. Reclamation for agriculture, urban encroachment and siltation have sharply reduced the wetland areas; large amounts of industrial and agricultural wastewater and sewage have caused serious pollution and destruction to wetland ecosystems; over-fishing has seriously affected the natural process of wetland ecosystems and irrational water conservation projects have led to unfavourable ecological changes in the lower reaches. According to a study, China has over 40% of all wetlands of international importance now under moderate to severe threats. All of these have greatly reduced the supportability of wetlands for national economy and resulted in serious environmental problems e.g., the reduction of wetland biodiversity.

Recognising the situation, the government of China has united with global initiatives to conserve and develop wetlands. A number of international agreements has been ratified. China joined the Convention on International Trade in Endangered Species of Wild Fauna and Flora in 1981 and the Convention on Wetlands in 1992 when it also ratified the Convention on Biodiversity.

The Chinese government has also signed the Sino-Japan and Sino-Australian agreements on migratory bird conservation and the Sino-Russian agreement on joint conservation of the Xingkai Lake. In connection with these agreements, China has strengthened the measures to conserve migratory waterbirds and their habitats.

China has cooperated in areas of wildlife conservation, wetland inventory, wetland nature reserve construction and staff training with international agencies such as the World
Wicé Fund for Nature (WWF), Wetlands International (WI), the United Nations Development Programme (UNDP), the World Conservation Union (IUCN), and the International Crane Foundation.


Relevant national laws and regulations are being implemented relevant to wetlands. These include the Forestry Law, the Control of Water Pollution Law, the Grassland Law, the Wildlife Conservation Law, the National Water Law, the Environmental Protection Law, the Terrestrial Wildlife Conservation Implementation Regulations, the Aquatic Animal Conservation Law as well as the Nature Reserves Regulations.

In order to protect waterfowl, the Chinese government has placed 11 species into first class protection and 22 species into second class protection. Breeding centres for some endangered and rare wildlife species have been established. Through the efforts of the last twenty years, 289 wetland nature reserves have been established covering a protected area of about 49,450,000 ha. Other activities include restoration of degraded wetlands and pollution control, wetland inventories and scientific research, legislation and public education and awareness.

The State Forestry Administration is the Ramsar Convention focal point. Other government institutions responsible for wetland management and conservation are the State Environmental Protection Agency, the Ministry of Agriculture and the Ministry of Water Resources.

INTRODUCTION OF PROJECT

Our project has taken up this challenge. Reference to the scope of this Symposium indicates that practically all the issues of international concern in wetland management have been incorporated into the objectives of our project. These include conservation of biodiversity, good practices for wise and sustainable use of wetland resources, wetland management, public awareness and education, staff training and capacity building, stakeholder participation and policy.

Our project is an ambitious endeavour to create an example of best practices for achieving a balance in the above objectives at four representative and diverse wetland sites, all with globally significant wetland biodiversity. The development objective of this project is to secure the conservation of globally significant wetland biodiversity in China. To this end, the project will combat threats to wetland biodiversity, promote sustainable development in and around wetland sites, and develop local and national capacities to integrate conservation into the development process.

The total budget for this project is US$34,578,324. The financial resources through UNDP total US$14,281,000, of which the UNDP/GEF input is US$11,689,000 and the AusAID input is US$2,592,000. Co-financing by the Chinese government is US$20,297,324. The project duration is five years.

The challenge is to achieve a balance of sustainable economic development, that meets the needs of the communities dependent on wetland resources, with national and global aspirations for the conservation and sustainable use of wetland biodiversity. This must be achieved in a complex socio-economic situation under constraints of limited and diminishing wetland resources. A multi-dimensional, holistic strategy has been adopted in project implementation.
The four representative but different wetland sites with globally significant wetland biodiversity that have been chosen are: the Sanjiang Plain in the Heilongjiang Province, a low lying alluvial flood plain originally consisting of sedge and reed marshes, wet grass meadows, ox-bow lakes, riverine scrub and wooded hammocks of birch and poplar; the Ruergai Marshes in the Sichuan and Gansu Provinces, at 3,400 to 3,900 m altitude, consisting of peat bogs, sedge marshes, lakes and wet and dry grasslands interspersed with low hills; the Yancheng Coastal Marshes of intertidal mudflats and salt marsh reed beds and the marshy grasslands in the Jiangsu Province and the Dongting Lake in the Hunan Province, a vast complex of fresh water lakes and inter-connecting river and drainage channels. The sites include eleven nature reserves.

The project will remove barriers at the four representative but different sites with high global biodiversity importance. A national coordination component will also ensure that lessons learned from this project will be appropriately transferred to other wetlands in China. To complement the protection of biodiversity, the project will work with local communities to develop improved, sustainable livelihoods and alleviate poverty in and around the wetland areas. GEF support will be closely allied with new government programmes that conserve biodiversity, ensure locally sustainable development and relieve future flooding events.

At the project sites, biodiversity is being analysed and described using GIS based biodiversity overlays. Nature reserve boundaries will be re-defined to include biodiversity hotspots. PAS management plans that are based on ecological, social, economic and political considerations, and include the participation of all stakeholders and increased community involvement, are being formulated and will be implemented. Integration of biodiversity conservation and sustainable use will be demonstrated. Biodiversity friendly land use planning and agricultural development outside the nature reserves will be demonstrated with the use of biodiversity overlays. Improved and alternative sustainable livelihoods aimed at poverty alleviation will be identified and developed for displaced members of local communities by provision of micro-credit and training. Public support will be gained by enhancing public awareness of wetland values and functions through environmental education. A staff training programme for institutional strengthening consisting of national study tours and workshops, international study tours, fellowships and courses is being implemented.

The training programme should improve appreciation of wetland values and functions, and capability and inclination to properly manage wetlands and make progressive wetland management policy. This should result in strengthened nature reserve management and sustainable use and conservation of wetland resources which will be disseminated nationally and internationally to influence policy, legislation and enforcement. A national coordination component will also ensure that lessons learned from this project will be appropriately transferred to other wetlands in China.

The international component in this work consists of a resident Chief Technical Adviser and the use of short-term specialists, 15 of whom have already been recruited. Each international specialist is assisted by a national counterpart adviser or specialist and others.

THE PROGRESS OF THE PROJECT

Our project is nationally managed and is to be implemented in five years starting from December 1999.

Management Arrangements

In accordance with the PD and prior to July 2001, under the coordination of the GEF Wetland Project Office, the Project Leading Group (PLG), the National Executing Agency (NEA) and the Central Project Management Unit (CPMU) were established and subsequently enhanced. In addition, the provincial Wetland Management Units (WMUs), headed by a vice-
secretary of the provincial government and provincial project offices (PPMUs) were established in the five project provinces. A wetland project office was set up in each selected nature reserve, headed by the Chief of each reserve. Staff were recruited to all the agencies. Until now, all the project management units are running well.

The United Nations Office for Project Services (UNOPS) and CICETE are co-implementers of the project. UNOPS is responsible for recruiting international specialists and CICETE for the implementation of Sub-contract 4.

**Project Inception Workshop and Meeting**

The GEF Wetland Project Office, SFA, organised a Project Inception Workshop in Beijing from 18-19 July 2000, and a Project Inception Meeting on 20 July, when the project was officially launched. At the workshop, the main topics discussed were review and modification of the Five-Year and Annual Work Plan from July 2000 to June 2001, relevant implementation methods and the overall arrangement of project inception and implementation. The Project Inception Meeting symbolically formalised the completion of the start of the project.

**Recruitment of International and National Specialists**

In accordance with the project design and annual work plan, international and national specialists were recruited. During this early phase of project implementation, recruitment of competent specialists was of critical importance and great care was taken in the preparation of their TORs and in the selection of specialists. As of now, 16 international specialists have come to China to work in the project. Thirty-four national counterparts/specialists have been recruited to work with the international specialists. In addition, more short-term international specialists will be recruited to work in the project.

**Training Needs Analyses (TNA)**

High priority was given to planning and implementation of the staff training programme as upgrading and specialisation of staff are considered to be critical to successful implementation of the project, future wetland biodiversity conservation and sustainable use of resources. The project planners have recognised these needs to be key components as 17.61% (US$2.5 million) of international donor support plus US$1 million Chinese government co-financing have been allocated to the staff training programme.

During the period, 16 October 2000 to 15 January 2001, four international specialists and their counterparts, in collaboration with the CPMU and PPMUs, separately conducted participatory Training Needs Analyses (TNA) of staff at each of the four project sites and the CPMU, namely, the Dongting Lake, the Ruogai Marshes, the Sanjiang Plains and the Yancheng Coastal Marshes. Based on four TNA reports, one of the TNA specialists was recruited to complete the training programme and schedule. The training will be conducted through national workshops, fellowships and study tours, and international study tours and fellowships.

**Training Workshops and In-country Study Tours**

Parallel to the TNA analyses and planning of the training programme, 12 national training workshops and two in-country study tours were conducted. These included computer basics and Internet application, basic knowledge of wetlands, accounting and financial management, formulation of nature reserve management plans, wetland biodiversity surveys, assessment and monitoring, biodiversity analyses and PAS management. The trainees were management and technical staff from the CPMU, the PPMU, the WMA, nature reserves, the
prefecture, and the county, local people and leaders of communities surrounding wetlands. A total of 453 persons were trained.

**Biodiversity Analysis and Protected Area System Management**

Specialist teams, consisting of international specialists in biodiversity analysis and management, PAS management, socio-economics and environmental economics, and their corresponding national counterparts, have started work at three of the four project sites. Their major work includes evaluation of different types of wetland ecosystems, analysis and evaluation of wetland biodiversity, identification of biodiversity hotspots, re-definition of nature reserve boundaries, analysis of wetland conservation issues in nature reserves and their solutions and PAS management. Several reports have been produced from this work, the most important ones being on biodiversity analysis and PAS management.

To-date, the international biodiversity and PAS management planning specialists for the Dongting Lake have completed their work and similar work in the Yancheng Coastal Marshes and the Ruoergai Marshes is in progress and will be completed by the end of this year. For the Sanjiang Plain, negotiations are currently underway to recruit a PAS specialist and an international biodiversity specialist.

**Equipment Procurement**

The process of equipment purchase was started in early 2000 and is continuing. The aim is to adequately equip all administrative and field units.

**Completion of Selection of Companies for the Sub-contracts**

The companies for Sub-contracts 1, 2 and 3 have been selected and negotiations are currently being conducted. Selection for Sub-contract 4 is still in progress.

**Project Auditing**

In March 2000, the State Auditing Administration, on behalf of UNDP, conducted an annual audit on project implementation for the year 2000 and made a positive assessment. The auditors visited PPMU of the Jiangsu Province, the Yancheng Nature Reserve, the GEF Wetland Project Office of SFA and the CPMU to audit account records, internal management systems and the project implementation status of executing and implementing agencies.

Based on Budget Revision D, the auditors confirmed that the project had a high implementation ratio of 88.87%, had progressed in line with the work plan and abided by the project document, government laws and UNDP regulations. It had made appropriate payments and had adequate receipts, had impartially and exactly manifested the financial status at the end of the audited period, managed equipment appropriately, and that the financial systems, internal management rules and accounting systems were appropriate.

**CHALLENGES**

**Policy**

The Chinese government policy towards the environment and the conservation of wetlands has become very positive since the last decade but the investment in nature reserves at the project sites seems to be inadequate as it does not meet the necessary requirements for

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proper management. This situation is in contrast to the commitment of the declared government policy. The project will supply equipment, a boat and vehicles but unless there is greater support from the government, sustainability of achievement of the long-term objectives of the project is under risk. The contribution from the government to the project sites is critical. This matter should be discussed with the WMA and a sustainable solution achieved.

The experts are reporting that law enforcement in and around the nature reserves, especially during critical periods for biodiversity, seems to be inadequate in some aspects and this jeopardises the conservation of wetland biodiversity and sustainable use of resources. This is a complicated matter and intractable because of the contradictions in the responsibilities of different institutions and their actual jurisdiction over wetland resources. Without adequate and sustained law enforcement, clear demarcation of nature reserve boundaries and the distinction of the rights of the nature reserves to manage the wetlands under their jurisdiction, it will be impossible to successfully implement the PAS management plan and achieve the project's objectives on the ground. It is urgent that this matter is discussed with the WMA and resolved.

Management

- Project implementation: The CPMU is of view that the project staff do not have much experience in the GEF/UNDP project implementation particularly at the initial stage. The first TNA analysis identified several gaps in the capabilities of the CPMU staff, including their level of the English language, and recommended training that included international fellowships. It holds that with further experience in the implementation of this project and training, there will be an overall improvement in project implementation capability.

- Recruitment of specialists: The technical input of the international and national specialists is very important for the project. It has taken longer than expected to recruit some of the international specialists, particularly during the first half of this reporting period. Some activities had to be delayed due to their unavailability and this adversely affected scheduling and expenditure. Specialist recruitment has recently improved. To-date, the specialist recruitment process is almost complete.

- Duration of bidding process: The project document has not given due consideration to the duration of the bidding process and the implementation of the sub-contracts. Pursuant to the project document and regulations of UNDP, all the four sub-contracts should be advertised internationally and approximately nine months be taken from recruitment of international and national bidding specialists to completion of the full bidding process. The project document has estimated the duration of Sub-contracts 2 and 4 each to be five years. Together with the nine months bidding process, the total duration of Sub-contracts 2 and 4 will each be longer than the full project duration of five years.

- Correspondence between the budget lines and activities: Project activities have not been directly linked with the allocation of expenditure in budget lines and this has caused great difficulties in project implementation. As the project has already started, there does not seem to be a solution to this problem unless a comprehensive revision is undertaken.

- Access to reference materials: Immediate access to maps and documentation produced by the project needs to be effected. Outputs in hard copies should be readily accessible to the specialists by, for example, providing them on a bookshelf in the PPMU office. After much effort, maps have been produced for the sub-contract bidding documents.

- Interaction and cooperation in project implementation between implementing agencies (CPMU/UNOPS/CICETE) can be greatly improved by clarity of responsibilities and arriving at agreements.
Biodiversity Projects

- The following problems have complicated the implementation of this project:
  - Four sites comprising 11 separate nature reserves each with its own biodiversity characteristics.
  - Work by five provincial governments (with two provinces for one of the sites).
  - Four sub-contracts (three cover work at all four sites).
  - Eleven or more short-term international specialists.
  - Up to six separate outputs at each site.
  - 140 separate activities.
  - The long distance between the sites and the central CPMU.

- The amount of time needed to prepare for, and carry out, the allocation of the sub-contracts.

- The lack of detailed budgets corresponding to the activities in the project document and the 12-month work plan.

- The need to coordinate technical work undertaken by the specialists and the sub-contracts at the four separate sites.

- The complexity of the project means there is a need for an effective monitoring system linked to efficient project management and this is being established in the CPMU.

LESSONS LEARNED

- The time frame should be sufficient to implement the project and achieve impacts. This project is still in the early stages of implementation but lessons learned can be identified. It is suggested that the time frames for biodiversity conservation projects should be lengthened to 6-8 years (also contained in UNDP/GEF "Emerging Lessons" Report LLR/1004).

- Project budgets have to be closely linked to all (not some) project activities.

- A specific time has to be allocated to the bidding preparation for major sub-contracts.

The first Project Tripartite Review Meeting was held in early August and the project has now entered a new implementation phase.

China is in need of good models of wetland management and it is expected that this project will provide such models. The lessons learned might also be relevant to other parts of the world, particularly the Asia-Pacific region. It is hoped that this presentation will result in open discussions and ideas on its implementation.
The Rehabilitation of Grassland Areas in Peat Swamp Forests in Peninsular Malaysia

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ABSTRACT

In 1992, there were about 0.23 million ha of logged-over peat swamp forests (PSFs) in Peninsular Malaysia. Some severely degraded PSFs are dominated by grass especially Imperata cylindrica and hence the areas are very susceptible to forest fires. Theses areas need to be enriched by planting with suitable tree species. A planting experiment was conducted in Compartment 101, the Raja Musa Forest Reserve in Kuala Selangor, Peninsular Malaysia. The main objectives of this study were to determine appropriate planting techniques and identify suitable species for rehabilitating grassland areas in PSFs. Four different planting techniques were conducted namely, open planting, open planting with mulching, open planting with topsoil and open planting with nurse trees. Six indigenous PSF species were used: Anisoptera marginata, Calophyllum ferrugineum, Durio corinatus, Gaaua motleyana, Gongostylus bancanus and Shorea platycarpa. Two supporting experiments on a light intensity study and foliar analysis were also conducted. Based on the results of the planting and supporting experiments, it was found that open planting is the best technique for rehabilitating grassland areas in PSFs. The technique produced more than 80% survival, lowest planting coss and it was found to be the easiest among the other planting techniques prescribed. The foliar analysis showed no differences in the macronutrient status for all different planting techniques at least six months after planting. It was also found that, out of the six species used in the experiment, four are suitable for rehabilitating grassland areas in PSFs. The species are Gaaua motleyana, Shorea platycarpa, Anisoptera marginata and Gongostylus bancanus that produced survival results of 92.19%, 79.69%, 79.17% and 73.44% respectively. The light intensity study showed that these species have good growth responses in moderate to open areas. The study also noted that forest fires are the main threat to planted trees in the grassland areas, especially during the dry season. Therefore, a specific study to determine the best prevention and control measures of forest fires in PSFs is very crucial.

INTRODUCTION

The extent of peat swamp forests (PSFs) in Peninsular Malaysia in 1981 was estimated at about 0.67 million ha (Shamsudin and Ismail 1991). The figure declined to 0.34 million ha in 1991. This reduction is associated with land developments where forested peatlands were cleared and developed for agriculture, aquaculture, industries and residential areas. Out of the 0.34 million ha, approximately 0.21 million ha are within the Permanent Forest Estate (PFE) while the remaining 0.13 million ha are outside PFE or are commonly known as stateland PSFs. In 1992, there were about 0.23 million ha of logged-over PSFs in Peninsular Malaysia (Chin et al. 1997). Some of the logged-over PSFs have been severely damaged and are categorised as highly degraded PSFs. The highly degraded PSFs are areas occupied by grass, mainly Imperata cylindrica (lalang) with no big trees and low residual vegetation. About 30% out of 72,816 ha of PSFs in North Selangor are categorised as highly degraded PSFs (Shamsudin et al. 1997, Anon 1997, Woon and Parid 1999).

It is important to improve the productivity of these areas by planting them with commercial tree species, in order to sustain their role as an important source of high quality
timber species. Otherwise, these areas will only be colonised by pioneer species and be susceptible to forest fires. Research on appropriate planting techniques using suitable commercial tree species needs to be conducted. This project acts as a preliminary investigation on how to rehabilitate such areas as not much work has been done in the past to rehabilitate degraded/logged-over PSFs (Ismail 1998).

OBJECTIVES

- To determine appropriate planting techniques for rehabilitating highly degraded PSFs.
- To identify suitable species for rehabilitating highly degraded PSFs.

MATERIALS AND METHODS

Raising Planting Materials

Planting materials of PSF species are difficult to get, either in government and private nurseries (pers. obs.). This is because PSF species have never been highlighted in any planting projects. Therefore, raising sufficient planting materials acts as an important component of this research project.

Planting materials of PSF species were raised using normal procedures applied to inland forest species (Aminah 1991, Aminah et al. 1997). Besides the collection of seeds (a common technique), other techniques used are wilding collections and vegetative propagation via stem cuttings. The management of the PSF species in the nursery is also similar to that of other inland forest species.

The Planting Experiment

Study Site and Experimental Design

Planting was conducted at Compartment 101, the Raja Musa Forest Reserve (FR). The area is under Degradation Class I (Table 1).

Table 1. Degradation classification of PSFs in North Selangor.

<table>
<thead>
<tr>
<th>Class</th>
<th>Description</th>
<th>Rehabilitation measures</th>
<th>Ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Highly disturbed PSFs: Cleared land/burnt area. Trees are generally cleared and areas dominated by grass (especially Imperata cylindrica or lalang). Recently logged-over forests with no big trees and low residual vegetation.</td>
<td>Replanting and enrichment planting</td>
<td>22,213</td>
</tr>
<tr>
<td>II</td>
<td>Medium disturbed PSFs: Some pole-sized trees as well as regeneration, but with very poor distribution and thick undergrowth.</td>
<td>Enrichment planting and liberation thinning</td>
<td>23,954</td>
</tr>
<tr>
<td>III</td>
<td>Low disturbed PSFs: Unlogged or selectively logged a long time ago. Good residual stand with regeneration but poor in commercial species.</td>
<td>Liberation thinning</td>
<td>18,823</td>
</tr>
<tr>
<td>IV</td>
<td>Undisturbed/intact PSFs: Unlogged areas.</td>
<td>Virgin forest reserve</td>
<td>7,826</td>
</tr>
</tbody>
</table>

Total 72,816

A survival and growth performance of seedlings using four different planting techniques was examined. The following planting techniques were prescribed in the experiment:

- Open planting
- Open planting with mulching
- Open planting with topsoil
- Open planting with nurse trees

The open planting technique involved clearing of existing plants especially the *Imperata cylindrica* to eliminate unwanted competition and provide easy access for planting work. The clearing was done in strips of 1 m width, using a parang and brushing machine. The direction of the planting strip was south to north; 2 m width of existing grass was left uncut to avoid direct sunlight falling on the planted seedlings.

A 100 gram of Christmas Island Rock Phosphate (15N:15P:15K) was put in the planting holes of 1 feet' prior to the planting. The existing peat was then used to cover up the planting holes. Basically, the same method was applied for the other planting techniques except with additional treatments through mulching, topsoil and nurse trees provided at the planting point. Fresh empty fruit bunches of oil palm waste was used as mulching material in the second method while *Hopea odorata* (Merawan siput jantan) of 2 m height were used as nurse trees in the last planting technique.

Six indigenous PSF species were used in this study. The species were selected based on their availability and commercial timber value. The species were:

- *Anisoptera marginata* (Mersawa paya)
- *Calophyllum ferrugenum* (Bintangor gambut)
- *Durio carinatus* (Durian paya)
- *Ganwa motleyana* (Nyatoh ketiau)
- *Gomystylus bancanus* (Ramin melawis)
- *Shorea plantycarpa* (Meranti paya)

A split plot design of 128 m x 121 m (1.55 ha) was used with three replications (36 m x 111 m) comprising all species and planting techniques. In each subplot, a total of 16 seedlings was planted at spaces of 3 m x 3 m. The total number of seedlings planted was 1,152 (192 seedlings/species).

The planting materials that fulfilled the requirement (Ang et al. 1992) were transported to the field where hardening was conducted on the seedlings before their transfer to the planting sites. During hardening, light intensity was increased while frequency of watering was reduced.

**Data Collection**

The data on survival and growth data (height, basal area/diameter) were collected every month. The physical and chemical characteristics of peat at planting sites were also collected.

**Project Limitations**

Work started in June 1999 and was completed in August 2000. The period taken to establish the plot was long because of forest fires. The area was also subject to floods during the rainy seasons especially from November to January.
It was observed that the best time for planting was one or two months before the rainy season (pers. obs.). It was also found (from the demonstration plot which was established earlier) that most seedlings survived even after the area was flooded for more than three months as long as they were not totally submerged.

Supporting Experiments

Two supporting experiments were conducted in the study namely, light intensity and foliar analysis. The light intensity study was conducted in the nursery at FRIM, whereas foliage samples taken from the nursery and the planting experiment in the Compartment 101, the Raja Musa FR, were used for the foliar analysis. Findings from these supporting experiments were used to support survival and growth results of the planting experiment.

The light intensity study was conducted to investigate and understand growth responses of these species to various light conditions. Three different relative light intensities (RLI) were used: 100%, 70% and 30%. Two shade chambers of 3 m height, 4 m wide and 12 m long were constructed and the chambers were fully covered with saranon nets that represent 70% and 30% RLI respectively. 20 seedlings of each species aged about one-year old were placed in the shaded chambers as well as in the open area. All seedlings, either in the shaded chambers or open areas, were given similar treatments with respect to watering, fertiliser applications and weeding.

The foliar analysis was conducted in three different stages; stage 1: before planting (in the nursery), stage 2: three months after planting and stage 3: six months after planting. The foliar analysis in stage 1 was to determine the status of nutrients in favourable growing conditions at the nursery. The seedlings were fertilised with 1 gram of nitrophoska blue (12N:12P:17K) every month throughout the duration of 12 months in the nursery.

Meanwhile, at the planting site, the foliar analysis was done to determine nutrient intake by seedlings under the different planting techniques at three and six months after planting. The leaves were not sampled immediately after planting to avoid more stress because according to Ahmad Zuhaidei et al. (1997), the first two months after planting are very crucial for the seedlings to establish themselves. Leaves from individuals at each planting technique were collected and pulled as one sample. In each exercise, 24 samples were collected. The samples of leaves were taken to the laboratory for the foliar analysis, at least 20 gram of wet weight or about 15 leaves being required for the analysis. Procedures of the foliar analysis to determine the nutrients have been described by Wan Rashidah et al. (1989) and (1990).

RESULTS AND DISCUSSION

Planting Technique Assessments

Table 2 shows that open planting resulted in the highest survival and lowest cost of planting per seedling. Open planting with mulching had the lowest survival and moderate cost (20% additional cost compared to the open planting) whereas open planting with topsoil also had high survival with moderate cost (additional 25% compared to the open planting). Open planting with nurse trees had high survival but it incurred the highest cost (additional 124% compared to the open planting). The high cost was attributed to tall seedlings acquired for planting as shade trees (2 m height of H. odorata about RM 6.00/sapling). Moreover, the cost of labour was also high because more seedlings (nurse trees) had to be planted in this planting technique.
Table 2. Summary of results based on the planting techniques.

<table>
<thead>
<tr>
<th>Planting technique</th>
<th>Survival (%)</th>
<th>Cost of planting/seedling (RM)</th>
<th>Additional costs (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open planting</td>
<td>83.33</td>
<td>8.08</td>
<td>0</td>
</tr>
<tr>
<td>Open planting + mulching</td>
<td>49.65</td>
<td>9.68</td>
<td>20</td>
</tr>
<tr>
<td>Open planting + topsoil</td>
<td>82.98</td>
<td>10.08</td>
<td>25</td>
</tr>
<tr>
<td>Open planting + nurse trees</td>
<td>81.94</td>
<td>18.08</td>
<td>124</td>
</tr>
</tbody>
</table>

The foliar analysis revealed that, in general, there were no differences in the macronutrient status in the different planting techniques. This means that different planting techniques do not affect the nutrient intake by seedlings at least for the period of six months after planting.

Open planting with mulching was found unsuitable for use as a planting technique for rehabilitating grassland areas in the PSFs. This was due to two main reasons: first, the fresh empty fruit bunches (EFBs) of oil palm used as mulching materials were attractive to wild boars, perhaps because of the fried-oil smell they produced. It has been observed that wild boars dig up mulching materials placed on top of planting holes. These would probably be mistaken as a new food source for them. This caused extensive damage to planted seedlings. It was observed that only seedlings planted under this technique attracted the wild boars.

Another reason is the fresh EFBs produced hot vapour in a normal decay process that subject leaves to hot air temperatures and become dried. Therefore, the fresh EFBs of oil palm should not be used as mulching materials; instead, the dried form of mulching mat may be more suitable. Wan Asma and Wan Rasidah (1998) reported that dried EFBs in the form of mulching mat were successfully used as mulching materials for planting seedlings of Tectona grandis (Teak).

Although open planting with topsoil and open planting with nurse trees had high survival rates, they incurred additional costs of 25% and 124% respectively. Therefore, the best planting technique for rehabilitation grassland areas in PSFs (Degradation Class I) is open planting. The technique produces high survival as well as incurs the lowest cost. Furthermore, the technique has been found to be the easiest method in the planting experiment (pers. obs.).

Species Assessments

As shown in Table 3, G. motleyana had the highest survival rate of 92.19% and the species preferred light conditions at 70% to 100% RLI or moderate to open areas for both basal diameter increment (BDI) and total height increment (THI). The second best performance in terms of survival was S. platycarpa at 79.69%, the species adapting very well to the wide range of light conditions (30% to 100% RLI).

A. marginata was third with a survival rate of 79.17% and adapted to light conditions of 70% to 100% RLI or medium to open areas. A study by Otsamo et al. (1996) on planting trials in grassland areas also found A. marginata to be the best among the dipterocarps species (S. platycarpa was not included in their study) with 80% survival two years after planting. It is a clear indication that A. marginata is suitable for use to rehabilitate grassland areas in PSFs.

Another species that showed good survival was G. bancanus with 73.44%, the species adapting very well at 100% RLI. Shamsudin and Ismail (1999) reported that 58% of G. bancanus still survive six years after being planted in open non-peat soil areas. The results showed that the species (G. motleyana, S. platycarpa, A. marginata and G. bancanus) are suitable for use to rehabilitate grassland areas in the PSFs.
Table 3. Summary of results based on the species.

<table>
<thead>
<tr>
<th>Species</th>
<th>Survival* (%)</th>
<th>Preferences of light conditions**</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>BDI (RLI)</td>
</tr>
<tr>
<td>A. marginata</td>
<td>79.17</td>
<td>100%</td>
</tr>
<tr>
<td>C. ferrugineum</td>
<td>56.25</td>
<td>70% - 100%</td>
</tr>
<tr>
<td>D. carinatus</td>
<td>66.15</td>
<td>70%</td>
</tr>
<tr>
<td>G. molleynana</td>
<td>92.19</td>
<td>30% - 70%</td>
</tr>
<tr>
<td>G. bancanus</td>
<td>73.44</td>
<td>100%</td>
</tr>
<tr>
<td>S. platycarpa</td>
<td>79.69</td>
<td>100%</td>
</tr>
</tbody>
</table>

Note: * In the planting experiment, BDI and THI were not significantly different.  
** In the light intensity study, survival was not significantly different.  
BDI = basal diameter increment.  
THI = total height increment.  
RLI = relative light intensity.

Another two species, D. carinatus and C. ferrugineum, had low survival with only 66.15% and 56.25% respectively. Furthermore, both species preferred low to moderate light conditions (30% to 70% RLI). Therefore, the species are not suitable to be planted in an open area such as the grasslands in the PSFs. However, both species are expected to grow better in Degradation Class II where the area is moderately disturbed (Shamsudin et al. 1997, Anon 1997, Woon and Mohd. Parid 1999).

CONCLUSIONS AND RECOMMENDATIONS

Conclusions from the studies are as follows:

- It was found that planting materials of PSF species could be raised through collecting of wildlings, seed and vegetative propagation via stem cutting using normal procedures applied to other inland forest species.
- The management of PSF species in the nursery is also similar to that of other inland forest species.
- Open planting was found to be the best planting technique to be used for rehabilitating grassland areas in PSFs (Degradation Class I).
- Four indigenous species of PSFs suitable for rehabilitating the grassland areas are Giuma molleynana, Shorea platycarpa, Antsopera marginata and Gonystylus bancanus.
- The study showed promising results on the rehabilitation of grassland areas using PSF tree species. Therefore, rehabilitation work in other less degraded areas (Degradation Class II) is expected to have better results.
- Forest fires were found to be the main threat to degraded PSFs especially in areas dominated by grass. More research needs to be conducted on mitigation measures that could be implemented to minimise fire occurrences. Probably, a control measure to regulate water levels would be a good solution to prevent fire hazards in degraded PSF areas.
The recommendations that can be made from the study are:

- Rehabilitation of logged-over PSFs should be conducted. In fact, rehabilitation is part of silvicultural treatments applied to other logged-over forests. Therefore, logged-over PSFs should also be included in the forest rehabilitation programme. The productivity of logged-over PSF areas could be improved and this will sustain the production of high quality timber species and reduce fire hazards.

- Permanent nurseries for raising planting materials should be established. The nurseries will ensure continuous supplies of planting materials at low costs.

- Sufficient large seed production areas in the PSFs should be identified and permanently demarcated. Although most PSFs in Selangor have been logged more than once, suitable areas for seed production can be identified.

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Report on the Development of Wetland Management in the Asia-Pacific Region: A Review

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ABSTRACT

The paper aims at initiating the process of self-evaluation to determine our responses to wetland conservation and management, especially regarding the recommendations (a total of 46 actions under 8 major headings) of the first-ever held Asian Wetland Symposium in 1992. In order to determine trends and efforts towards the implementation of these recommendations, the Ramsar Center Japan undertook a regional study in 1999. This paper is the result of data analysis and information received from this study, in which eight countries of the Asia-Pacific region participated. The study suggests that wetland conservation has received maximum attention on awareness raising, training, education and institutional development in the region. Innovative ideas such as interpretation centres and nature clubs have been widely used to raise awareness of the general public as well as that of school students. It was found that stakeholders have not been fully involved at all levels of project planning and implementation. Nor has there been any breakthrough in developing a systematic mechanism of wetland monitoring. There are voices for the formulation of a comprehensive law that addresses the issues of wetland conservation. Eco-tourism has received a momentum in providing alternative forms of livelihood to wetland-dependent people.

INTRODUCTION

The Asian Wetland Symposium held in Otsu, Japan, in October 1992 under the auspices of the Environment Agency of Japan (now the Ministry of the Environment), was the first monumental Symposium in sharing knowledge, experiences and expertise concerning wetland conservation and management in the Asia-Pacific region. The theme of the Symposium was identified as "towards wise use of the most productive places: wetlands". The Symposium provided a forum for regional wetland scientists and facilitators to exchange their views on the wise use of wetlands across the region. Over 1,000 participants, both from developing as well as developed countries, attended the Symposium and adopted 46 recommendations under eight broad headings\(^2\) from public awareness to law and policy, eco-tourism and institutional development.

Ten years after this watershed event, the Ramsar Center Japan in collaboration with Universiti Sains Malaysia (USM) of Malaysia is organising another symposium, entitled the Asian Wetland Symposium 2001 in Penang, Malaysia with the main theme of bringing partnership into good wetland practices. The International Steering Committee of the

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\(^1\) Keynote paper presented at the Plenary III in the Asian Wetland Symposium 2001: Bringing partnerships into good wetland practice, Universiti Sains Malaysia (USM), 27-30 August 2001, Penang Malaysia. Editorial assistance received from Grace Impey is gratefully acknowledged.

Symposium, in one of its meetings, decided to undertake a comprehensive study to review activities concerned with the wise use of wetlands in implementing the recommendations of the first Asian Wetland Symposium. As a result, the Committee assigned this task of reviewing wetland activities in the region to Prof. Hiroji Isozaki with technical and logistic support from Ms. Yuriko Harada of the Ramsar Center Japan. After having conducted many intensive consultations with experts, the Committee decided to address the extent to which responses have been made in the region to implement the recommendations of the first Symposium held in 1992. In order to deal with this issue, the paper attempts to review and self-evaluate wetland activities of the selected countries of the region especially undertaken after 1992.

METHODOLOGY

With a view to determine the methodology and approaches of the study, several brainstorming sessions were organised and important steps were identified, some of which are briefly described below.

- Out of the eight recommendations presented in the Symposium, six recommendations were taken into consideration as they were related to developing countries. The other two were related to external aid and assistance, which are not applicable to many countries of the region.

- After the selection of those six recommendations, a matrix of probable variables was prepared along with a pro forma to collect important information on the successful management of a wetland site, where recommendations have been applied for the wise use of wetland resources.

- The objectives and methods of the study were then intensively discussed in the meeting held in Bangkok. In the meeting, representatives from different countries were nominated to collect data and information. Participating countries3 and representatives included Bangladesh (Sanowar Hossain), India (Desh Bandhu, Ajit K. Pattnaik), Japan (Toru Takita), Nepal (Bishnu Bhanbdari), Philippines (Amado Tolentino), Myanmar (Hun Paw Oo), Malaysia (Ahyaudin Ali, Sundari Ramakrishna and Mahlsor Mansor), Thailand (Sansance Choowae), Korea (Gea-Jae Joq) and China (Chen Kelin). Reports from Korea and China were not available at the time this report was written.

- A detailed questionnaire was formulated based on comments received from participants.

- On the basis of reports furnished by the representatives, data and information were analysed, the results of which are presented in this paper. Representatives collected data using secondary sources of information as well as conservation activities in the wetlands of their own "jurisdiction".

RESPONSES TO RECOMMENDATIONS

This part summarises the activities of each participating country carried out in response to the implementation of the six recommendations.
Briefly describe the current activities to increase awareness of the importance of
wetlands among people in your wetland area.

The study suggests that there has been an extensive use of educational materials in the
implementation of recommendations concerned with public awareness. These educational
materials included videos, manuals, posters, talks, seminars, mass media, tours, exhibitions,
etc. in formal, informal, non-formal education as well as an open concept of education.
Moreover, activities such as cleaning wetland sites, plantation of degraded areas, rallies etc.
are used when observing events, ceremonies and national festivals. Many countries have been
publicising and promoting the idea of Ramsar sites, thereby enhancing the conservation of
wetlands and their resources. Wetland activities carried out by the participating countries are
briefly presented below.

- In Nepal, community discussion forums have been used in order to raise public
  awareness as well as to provide local communities with new knowledge, skills
  and competencies. Other strategies used to reach out to the critical mass include
  preparation of an inventory, collaborative management of wetland sites,
  organising field workshops, formation of a users' group, development of
  management plans, sensitisation, training of facilitators, door-to-door visits to the
  communities by wetland experts around and about the selected wetlands, etc.

- In Issahaya Bay, Japan, civilians initiated successful campaigns in stopping
  further reclamation of coastal wetlands and motivating local communities
  towards the wise use of wetlands and their resources.

- In Cambodia, NGOs are undertaking efforts to develop site-specific management
  strategies for wetlands. They are also involved in enforcing local rules and
  regulations jointly with local people in the Stung Treng Ramsar site. In order to
  enhance people's awareness and capability in the management of wetland
  resources, participatory action research has been initiated in the Koh Kapit
  Ramsar site.

- In Bangladesh, the establishment of a mini-sanctuary in Beel Chandra is a good
  example of how NGOs are attempting to protect the habitat of important flora
  and fauna. NGOs are also undertaking a community-based resource management
  approach to the conservation of the Madhumati floodplains and enforcing laws
  locally. Another good example of wetland conservation is the promotion of Baira
  (hydroponic garden), an option for the wise use of an area covered by water
  hyacinth. The floating bush of water hyacinth is a buffer zone to produce crops
  and vegetables in the inundated floodplains. Extension services such as fertilisers,
  technical advice and credit are provided to the cultivators of floating gardens.
  Women are actively involved to ensure their active participation in Baira
  cultivation.

- In the Keoladeo National Park of India, collaborative initiatives have been taken
  by stakeholders to reduce the illegal extraction of minor forests and other
  vulnerable resources. Local communities have been empowered with
  management responsibilities, a voice in management and monitoring,
  participation in decision-making activities and sharing of benefits. The concept of
  eco-tourism has been publicised as an alternative way of livelihood to the
  extraction of minor resources. The Orissa state government has established the
  Chilika Development Authority to protect the unique lake ecosystem of Chilika.
  In order to foster the process of public awareness and environmental education
  for school children, the Authority has established an Interpretation Centre in

3 Assistance and cooperation received from representatives of eight countries of the region are
gratefully acknowledged.
Chilika. Also, a research centre has been established to generate and promote wetland knowledge and education.

- In Malaysia, nature clubs are active in instilling in school children an appreciation of nature, and training modules are in place for motivators and facilitators. Also, the Putrajaya Wetland Centre provides training to wetland staff and guides.

- In Thailand, the government became the 110th contracting party to the Ramsar Convention in 1998. The Office of Environmental Policy and Planning organises an annual conference on 2 February for people from all spectra of the society. This is a good example of a government's commitment to raise general awareness as well as remind the general public about the importance of wetlands in their life. Mahidol University has already incorporated wetland education into its curriculum. A group, called the Freshwater Marsh Conservation Group, has also been formed to coordinate activities related to marsh conservation and management.

What are the recent institutional developments in wetland management in your country? (Include institutions/agencies established, training programmes launched as well as training materials developed).

This study shows that some positive efforts have been made in the institutional development of wetland conservation, some of which are summarised below.

- In Nepal, the IUCN Nepal office established a Wetland Section and facilitated the set-up of an Informal Wetland Group, with representatives from agencies and stakeholders in the country. IUCN Nepal has also assisted in the establishment of local NGOs, the Ghodaghodi Tal Conservation Committee in western Nepal and community groups in Gaidahawa Tal and Lumbini. The Department of National Parks and Wildlife Conservation, in cooperation with UNDP Nepal, has strengthened the Park-People Project around the Ramsar site of Nepal.

- In Japan, many NGOs have initiated the conservation of wetlands and their wise use. Wetland International-Japan has done some commendable work in organising workshops and seminars to raise public awareness as well as deal with current issues of wetland conservation.

- In Bangladesh, the Ministry of Environment and Forests has drafted a national wetland policy and the government also adopted the National Conservation Strategy. The Bangladesh Centre for Advanced Studies (BCAS) has developed the "Participatory Wetland Conservation and Management Action Plan for Chandra Beel" and has demonstrated that the people have the capacity, rights and responsibility to assess needs, develop plans and act on the management and conservation of wetlands in their area. There are also good examples of various voluntary agreements between CBOs and NGOs in conserving wetland resources.

- In Cambodia, the Ministry of the Environment has established a Wetlands and Coastal Office to coordinate management activities of Ramsar sites. Also, an Inter-sectoral Steering Committee, consisting of representatives of the Ministry of Tourism, the Ministry of Industry, Mines and Energy and the Ministry of Agriculture, Fisheries and Forests, has been formed to coordinate programmes and activities related to conservation and management of wetland resources. The Department of Fisheries is active in the management of wetlands, sustainable harvesting and capacity building of local people. The government is also seriously considering the establishment of a National Wetland Committee.
• Information from India indicates that there exists a large number of sectoral laws, which have bearing on wetland protection and conservation. As mentioned earlier, the creation of the Chilika Development Authority in Orissa is another good example of conservation and protection of the lake ecosystem. A National Committee on Wetlands has been constituted to address the specific issues of the wetland ecosystem and provide advice to the government on policy guidance. Also, state steering committees and district coordination committees have been established and the Ministry of Environment and Forests has identified nodal research institutes on wetland resources.

• In Myanmar, the formation of a National Wetland Committee and formulation of a national policy on wetlands have been strongly recommended by workshops and seminars but these have not yet materialised.

• The government of Malaysia has established the Tasek Bera Ramsar Management Authority for the integrated development of the Tasek Bera Ramsar site.

• Various activities suggest that wetland conservation has received the highest priority in Thailand. For example, in early 1990s, an integrated national wetland team was established to prepare an inventory and management of wetlands in the lower Mekong basin under the general guidance of the Department of Land. An inter-sectoral Sub-Committee for Wetland Management established under the National Environment Board has already formulated the National Wetland Policy for wetland conservation and management.

Describe the present wetland monitoring system in place (e.g., monitoring framework, involvement of international organisations, mechanism in place for involvement of different sectors in the monitoring process).

In the area of monitoring, there has not been any significant breakthrough except for efforts at the informal level. Some voluntary agreements among NGOs and CBOs are good examples of how to develop a monitoring mechanism in the wetland areas. In Japan, the Ministry of the Environment has some exclusive monitoring mechanisms for conservation of the environment, not specifically for the conservation of wetland resources. In Cambodia, an inter-governmental organisation, the Mekong River Commission (MRC), has been monitoring water flows and depth of the Mekong river for some years and the Ministry of the Environment routinely monitors Ramsar sites.

In India, the state steering committees are responsible for developing monitoring programmes for the implementation of the wetland activities, whereas in Chilika, a remote sensing technique has been used to monitor effectiveness of, and change in, the catchment area. In Malaysia, due to the multi-sectoral nature and characteristics of wetlands, different agencies are involved in monitoring wetland sites including the Department of Drainage and Irrigation (flood, drains and tidal flow), the Department of Forests (forests at the catchment area), the Department of Fisheries (fisheries and leasing), and the Department of Agriculture (rice fields). Some CBOs also monitor wetland sites that are close by and accessible.

In Thailand, the Pollution Control Department and the Department of Health have set up their own water quality monitoring stations and networks to routinely collect water samples and monitor water quality of rivers and coastal wetlands. The Office of Environmental Policy and Planning has formed a network representing 14 academic institutions. This network has developed wetland checklists, a wetland directory, database and a map to use as a basis for monitoring wetlands in the country. Yet key parameters as well as a standard method for monitoring have not been identified.
Explain the involvement of other sectors (NGOs, CBOs, academics and business sectors) in the wetland policy development and monitoring.

Although efforts are underway to involve stakeholders at the national level in a number of countries such as Nepal, Myanmar, Bangladesh, Philippines, India and Thailand, few concrete evidence is found at the specific site level. However, some efforts are underway to involve some agencies and CBOs in a few countries. In a country like Cambodia, the wetland is a new concept and no formal organisation responsible for wetland conservation and management exists. Only international agencies have been taking initiatives in the area.

In the Chilika Lake of India, stakeholders are involved in the management of resources in and around the lake. NGOs are involved in the National Committee on Wetlands and steering committees of the state government. Wetlands International-Malaysia has prepared a draft framework for a national policy on wetlands in the country. Academic and business sectors are called upon to do consultancy on water pollution, wetland monitoring and assessment studies. Thailand has encouraged the involvement of NGOs and CBOs in the preparation of a national wetland policy.

Are there wetland policies and legislation? Briefly state the policies and enumerate/expand on the legislation enacted.

In countries such as Nepal, India, Bangladesh, Myanmar and Malaysia, there are many sectoral laws related to wetlands and their conservation. A few examples are those related to national parks, wildlife conservation and forest conservation. In many countries, the Environmental Impact Assessment (EIA) has been established but there is no single comprehensive act exclusively dealing with wetlands. In Myanmar, consultation is still going on in designing an environmental law dealing with wetland conservation and management.

In Japan, coastal areas are generally controlled by fishermen and fisheries cooperatives, whereas catchment areas are overseen by the Ministry of Agriculture and Fisheries Agency. Despite their similar scope of work, there is no evidence of their working together to protect wetlands. In Thailand, there are many laws implemented by different agencies. The government has already endorsed the National Wetland Policy, which is dealt by 14 different government agencies, including NGOs.

Briefly explain the current situation of eco-tourism in wetlands, especially good practice, over-use and involvement of local communities.

The concept of eco-tourism is rapidly growing in the countries of the region. Because of these new frontiers, alternative ways of income generation and livelihood have emerged at the grassroots level. Many good examples of eco-tourism are found in and around the protected areas of the region such as the Royal National Chitwan National Park of Nepal, the Keoladeo National Park, the Chilika Lake of India and Lake Tonle Sap of Cambodia. The Keoladeo National Park Development Society has been formed to involve local communities in the eco-development of the park.

In Myanmar, some wetlands have been utilised for eco-tourism. The Mowingyi Wildlife Sanctuary is a typical example of successful eco-tourism, where tourists can enjoy boating, bird watching and studying the daily life of the local community. The Inlay Lake Wildlife Sanctuary is a major tourist site for bird watching, rafting and nature walks. An Eco-tourism Working Committee has been formed under the Central Tourism Management Committee to promote eco-tourism and sustainable resource utilisation in wetland ecosystem areas.

In Malaysia, there are many examples of good practices of eco-tourism in wetlands. Kampung Kuantan Riverine Fireflies is a good example. This venture shows that the local municipal council and boatmen are seen as beneficiaries of the project. It has been a sustainable eco-tourism venture and one that should be emulated in other parts of the country.
The Batang Air Project of Sarawak and the Sepilok Orang Utan Rehabilitation Project of Sabah are also good examples of sustainable eco-tourism managed in partnership with the local community.

Eco-tourism in wetlands is considered one of potential wise use activities in Thailand. Activities include nature education, board walking, bird watching, boating, canoeing, cycling, diving, etc. Local guides are trained for these purposes. Involvement in the production of local products and souvenirs from wetland materials such as fish scales, water hyacinth, reeds and cottage industries and fisheries products are being promoted as alternative occupations and sources of income especially for women. Eco-tourism development is anticipated to be a strategy to enhance awareness of wetland values and products.

SELF-EVALUATION OF ACTIVITIES

The collaborators were asked to review the activities of the wetland sites under their own "jurisdiction" but general information about wetlands was also requested. After a brief review of each activity, they were asked to rank their activities in a scale of grades A, B and C, where A denotes very good, B means good and C stands for "in need of improvement". This gives an idea of how they ranked their activities in terms of their responses to the Asian Wetland Symposium recommendations. The result of their self-evaluation is presented in Table 1.

According to Table 1, Thailand has shown a very good response (A) to three activities on the implementation of recommendations towards the wise use of wetlands and their resources. India has shown a very good performance (A) in public awareness. Cambodia, Malaysia and Nepal have also done relatively well in the implementation of these recommendations. Japan and Myanmar have self-ranked "need improvement" on their efforts towards the implementation of recommendations.

In public awareness, Thailand and India have been self-ranked highest. The Office of Environmental Policy and Planning of Thailand, along with other awareness activities, organises annual conferences on the occasion of World Wetlands Day for people of all strata of the society. India has been conducting many activities related to public awareness, especially organising camps on resource management, running demonstration projects and production of educational materials.

In the area of institutional development, Thailand has already formed an Inter-sectoral Sub-committee for Wetland Management and endorsed the National Wetland Policy for wetland management. About 14 agencies, including NGOs, are involved. Malaysia has demonstrated its commitment by establishing the Tasek Bera Ramsar Management Authority to undertake an integrated development of the area whereas Nepal has established an Information Wetland Group under the initiation of the IUCN Nepal office, which has played a catalytic role in the conservation of wetlands and their resources. The Group also has developed community-based management plans, a wetland inventory and action research in wetland resources.

The monitoring mechanism, however, has not received any priority in the region. Nevertheless, the data shows that Malaysia and India fare better than any other countries in the region. This is because many government agencies, along with some NGOs, are conducting monitoring activities and remote sensing techniques are also used to monitor the situation in the catchment areas in these countries.

The data also show that more efforts are needed in the involvement of other sectors to implement recommendations towards the wise use of wetland resources.

With regards to policy and legislation, there are many sectoral laws dealing with wetland conservation and management but any comprehensive law to deal with wetlands in totality is non-existent. However, as mentioned earlier, Thailand has demonstrated its commitment to the recommendation by endorsing a National Wetland Policy.

In the field of eco-tourism, India, Nepal and Cambodia have initiated some activities to provide alternative styles of livelihood in the region. Countries like Japan and Malaysia are
in the scale of "need of improvement". The reasons could be attributed to the fact that there are already good examples of eco-tourism in Japan and Malaysia. In that comparison, efforts on eco-tourism in a particular wetland site could have been very insignificant, whereas in other countries, no comparison has been made while self-ranking eco-tourism activities in the region.

Table 1. Self-ranking of wetland activities.

<table>
<thead>
<tr>
<th>Countries</th>
<th>Public awareness</th>
<th>Institutional development</th>
<th>Monitoring mechanism</th>
<th>Involvement of other sectors</th>
<th>Policy and legislation</th>
<th>Eco-tourism</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nepal</td>
<td>B</td>
<td>B</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>B</td>
</tr>
<tr>
<td>Japan</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>C</td>
</tr>
<tr>
<td>Cambodia</td>
<td>B</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>-</td>
<td>B</td>
</tr>
<tr>
<td>India</td>
<td>A</td>
<td>C</td>
<td>B</td>
<td>C</td>
<td>B</td>
<td>B</td>
</tr>
<tr>
<td>Myanmar</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>C</td>
</tr>
<tr>
<td>Malaysia</td>
<td>C</td>
<td>B</td>
<td>B</td>
<td>C</td>
<td>C</td>
<td>C</td>
</tr>
<tr>
<td>Thailand</td>
<td>A</td>
<td>A</td>
<td>C</td>
<td>C</td>
<td>A</td>
<td>C</td>
</tr>
</tbody>
</table>

Source: Self-evaluation Reports 2001

ETHICAL PERSPECTIVES ON SELF-EVALUATION

Each ranking was given a numerical score of 3, 2, and 1 for A, B and C respectively and a score of 1 to a blank response. In this scale, the highest score would be 3 and the lowest score 1. With the help of this scale, an attempt has been made to calculate three new variables.

- A composite achievement rank (mean value of ranking of all efforts on wetland conservation).
- Public awareness rank (mean value of ranking of three variables, (a) public awareness, (b) institutional development and training, (c) involvement of other sectors).
- Indicators for policy efforts (mean values of ranking of (a) policy and legislation and (b) monitoring mechanism).

Results presented in Table 2 show that Thailand has the highest score in the composite achievement rank in implementing the recommendations of the Asian Wetland Symposium. India and Nepal stand at 1.8 and 1.5 respectively. Data on the public awareness rank show that Thailand is ahead of all countries because of the formation of a national inter-sectoral committee, endorsement of a national wetland policy and the annual organisation of conferences on the occasion of World Wetlands Day. Cambodia, Malaysia and India stand third in their ranking. The public awareness rank shows Thailand securing the highest value of 2.3 because of the formulation of the National Wetland Policy, organising annual conferences and formation of a high level inter-sectoral committee on wetland management. Nepal and India have a ranking of 1.7 and because of many wetland activities such as the preparation of a collaborative management plan of wetland sites, formation of an informal wetland group and others in Nepal while India has conducted camps and demonstration projects.

In policy-related ranking, Malaysia stands high at 2.5 because many government agencies have set up their mechanism in wetland monitoring. Thailand ranks the second highest with a score of 2.0 because it has formed a network of agencies and developed a checklist, database, map, etc.
Data on eco-tourism indicate that India, Nepal and Cambodia have ranked high with the score of 2 each because eco-tourism activities have been very successful in providing an alternative way of income generation and livelihood to people dependant on wetlands and their resources (see Table 2).

**Table 2. Countries and achievement ranks.**

<table>
<thead>
<tr>
<th>Countries</th>
<th>Composite achievement rank</th>
<th>Public awareness rank</th>
<th>Policy efforts rank</th>
<th>Eco-tourism rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nepal</td>
<td>1.5</td>
<td>1.7</td>
<td>1.0</td>
<td>2.0</td>
</tr>
<tr>
<td>Japan</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Cambodia</td>
<td>1.3</td>
<td>1.4</td>
<td>1.0</td>
<td>2.0</td>
</tr>
<tr>
<td>India</td>
<td>1.8</td>
<td>1.7</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>Myanmar</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Malaysia</td>
<td>1.3</td>
<td>1.4</td>
<td>2.5</td>
<td>1.0</td>
</tr>
<tr>
<td>Thailand</td>
<td>2.0</td>
<td>2.3</td>
<td>2.0</td>
<td>1.0</td>
</tr>
</tbody>
</table>

Source: Self-evaluation Reports 2001

**NEW TRENDS IN THE WISE USE OF RESOURCES**

The numerical score for each item from the various countries was added to a total and its mean value calculated. Ranking was then given to these scores. The tendencies of efforts towards implementation of the Asian Wetland Symposium recommendations are summarised in Table 3.

**Table 3. Major variables and their ranking scores.**

<table>
<thead>
<tr>
<th>Achievement variables</th>
<th>Scores</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Public awareness</td>
<td>1.85</td>
<td>I</td>
</tr>
<tr>
<td>Institutional development</td>
<td>1.57</td>
<td>II</td>
</tr>
<tr>
<td>Monitoring system</td>
<td>1.28</td>
<td>IV</td>
</tr>
<tr>
<td>Involvement of other sectors</td>
<td>1.00</td>
<td>V</td>
</tr>
<tr>
<td>Policy and legislation</td>
<td>1.43</td>
<td>III</td>
</tr>
<tr>
<td>Eco-tourism</td>
<td>1.43</td>
<td>III</td>
</tr>
</tbody>
</table>

Source: Self-evaluation Reports 2001

The data in Table 3 lead us to infer the following tendencies towards the implementation of recommendations of the Asian Wetland Symposium.

- The highest priority has been placed on activities related to preparing educational materials, running demonstration projects, establishing interpretation centres at wetland sites, regularly organising seminars and workshops, etc. Raising the general public awareness accordingly received the highest priority.
- Efforts on institutional development received the second ranking in the wetland conservation and management of wetlands and their resources. Formation of an inter-sectoral committee and a wetland authority are good examples of efforts towards this goal.
• Agencies and organisations are aware of, and have shown concern with, non-existence of a comprehensive law covering wetland conservation and management of resources in the region. They have emphasised the importance of policy and legislation and the development of eco-tourism as alternative means of livelihood for people dependent on wetlands and their resources.

• Although wetland monitoring and involvement of stakeholders are attached high importance in the wise use of wetland resources, there have not been any concrete efforts towards these two vital processes.

It is obvious that the public awareness activity is receiving the highest priority in the region, because of our emphasis on education, training and public information. Likewise, the high ranking on institutional development is guided and influenced by the resolution of the Ramsar Convention, especially in the establishment of national wetland committees by each country. However, the formation of a national wetland committee does not ensure the development of a wetland monitoring mechanism and active and well-informed participation and involvement of stakeholders in wetland conservation and management.

CONCLUSIONS

As mentioned earlier, the primary goal of this paper is to initiate the process of self-evaluation to determine our responses to wetland conservation and management especially regarding the recommendations of the monumental Asian Wetland Symposium held in 1992. The Symposium called for urgent actions for the wise use of Asia’s wetland resources on the following eight areas: (a) awareness, (b) institutional capacity and training, (c) wetland monitoring, (d) consensus building, (e) policy and legislation, (f) international cooperation, (g) development assistance and wetland conservation and (h) eco-tourism. A total of 46 actions has been recommended for the wise use and management of wetlands and their resources.

In order to determine trends and efforts towards the implementation of the recommendations adopted in 1992, the Ramsar Center of Japan undertook a regional study in 1999. Some of its international advisors were asked to review conservation activities in their own country in general, or self-evaluate the activities at a particular site. This paper is the result of analysis of data and information extracted from the reports. The data and information presented here do not represent the whole country. They are, however, taken from a specific wetland site, where the network of the Ramsar Center Japan is actively involved. Thus one should be cautious in interpreting the contents of this report.

The findings suggest that wetlands conservation has maximised attention on awareness raising, training and environmental education in the region. Innovative ideas such as interpretation centres and nature clubs have been used to raise awareness of the general public as well as that of school students. Institutional development has also received priority to promote wetland conservation and management. To the extent possible, stakeholders have not been fully involved at all levels of project planning and implementation. There has also not been any breakthrough in developing a systematic mechanism of wetland monitoring in the region. Voices have been heard for the need of a comprehensive law that addresses all related components of wetland conservation. It is also quite heartening to know that eco-tourism is becoming popular in the region and wetlands are seen at sites of eco-tourism to generate income and provide employment opportunities to local communities. Yet the countries of the region have to go a long way to fully implement the recommendations of 1992, which are as valid today as they were ten years ago. Let us hope that this Symposium would enable us to accelerate the process of conservation and wise use of wetlands and their resources in the region.
The Wise Use Initiative of Ogii Lake, Mongolia

Ganbaatar, B.

Ramsar Centre Mongolia, P.O. Box 089, Post Branch 51, Ulaanbaatar, Mongolia

ABSTRACT

Ogii Lake was included as the second Ramsar site from Mongolia in 1997 and in the East Asian network of Anatidae sites in 1998. The lake supports over 170 species of migratory and other birds and is one of the potential sites for bird watching eco-tourism development. It also supported a significant fishery in the recent past. The lake is a very important breeding and staging area for a wide variety of waterfowl, particularly Anatidae. The idea of developing bird watching at the lake was initiated by the Ugii nuur soum government and supported by the Citizens’ Representative Hural of the soum and the governor of the Arhangai province. To manage and monitor bird watching eco-tourism, the Ugii Bird Watching Board headed by the Ugii nuur soum governor was established. The bird watching involves about 40 families of the local community in different activities and services to support visitors/bird watchers. It is estimated that about 40 people will be employed directly by the Board and 15 will serve as tour guides. The initiative itself is to promote development of the local community by involving the people in local eco-tourism and conservation activities. It is intended to demonstrate one of the potential ways to develop eco-tourism to benefit both the local community and the Ogii Lake in terms of conserving migratory birds, their habitats and the lake itself in close cooperation, and with the involvement of the local community. Two institutions, the Institute of Biology of Academy of Sciences (Scientific Advisor) and the "Tsenger Jigur" tourist company (Management Advisor) will assist to implement the wise use concept of Ogii Lake. Training for the local guides would be offered and this would benefit the local community, especially the 40 families that have settled around the lake. The Eco-tourism Guidelines for Ogii Lake, observed by the Ugii Nuur Bird Watching Board, establishes the basic requirements for tour operators, community members and visitors.

THE ECONOMIC AND SOCIAL VALUES OF THE OGII LAKE

Geographic and Ecological Characteristics

The following are the details:

- **Location:** 47°46’N, 102°46’E; in the valley of Orhon River, the territory of Ogii nuur soum of Arhangai aimag, 355 km west of Ulaanbaatar, 120 km north of Harhorin, the ancient capital of Mongolia (Figure 1).
- **Surface area:** 2,510 ha.
- **Altitude:** 1,280 m above sea level
- **Site description:** A shallow, mesotrophic, freshwater lake with an extensive alluvial area of grassland, river channels, pools and marshes at the western end. Three rivers flow through this marshy area into the lake. The maximum depth of the lake is 16 m but about 40% of the lake is less than 3 m deep, and 50% supports macrophytic growth. The surface water temperature in summer reaches 18°C; the conductivity is approximately 280 microSeimens/cm.
- **Climatic conditions:** Extreme continental climate.
- **Land tenure:** State owned.
- **Conservation measures taken:** None.
- **Land use:** Livestock grazing and intensive fishing in the recent past.
- **Fauna:** The benthoic fauna is diverse. The zooplankton is dominated by copepods and cladocerans. The fish fauna is dominated by a typically north Eurasian assemblage comprised of cyprinids, pike, and perch. The main species are *Esox lucius*, *Perca fluviatilis*, *Rutilus rutillus lacustris*, *Leuciscus iraceus baikalensis*, *L. idus*, *Phoxinus phoxinus*, *Carassius auratus gibelio*, *Noemacheilus barbatulus toni*, *Cobitis taenia*, *Parasiliurus asotus* and *Lota lota*, together with some *Hucho taimen*, *Brachymystax lenok* and *Thymallus arcticus*. The carp *Cyprinus carpio* haematopretus has invaded the lake from Orhon River.
- **Principal vegetation:** Most of the shores are erosion shores of gravel, but there are zones of macrophytes, one of five metres from the shore composed mainly of *Potamogeton spp.*, *Myriophyllum spicatum* and *Ceratophyllum demersum*. The dominant emergent in the marshes at the western end of the lake is *Schoenoplectus* (*Scirpus*) sp., and there is very little *Phragmites*. Other aquatic plants include *Polygonum amphibium*, *Potamogeton perfoliatus*, *P. preeolongus*, *P. vaginatus*, *Hippuris vulgaris* and *Batrachium eradicatum*. The phytoplankton is composed chiefly of diatoms. The lake is surrounded by grassy steppe.
- **Research and facilities:** Basic limnological data have been gathered and preliminary surveys of the avifauna have been made.

![Figure 1](image)

Figure 1. Location of Ogii Lake.
Economic and Social Values

The economy of Ogii nuur soum (village), where Ogii Lake is located, is based on almost 100% livestock breeding. It is well known that livestock is vulnerable to harsh winters and dry and stormy springs and risky sometimes. One example is that during the last winter and spring, the soum lost over 25,000 livestock. Some families were left without animals. There are no minerals found so far in the soum's territory to support its economy. No forest resources exist. The territory of the soum is characterised by hilly areas and vast steppe, sometimes with a Gobi-steppe landscape.

Ogii Lake is one of the most valuable natural resources of the Ogii nuur soum. The lake supports over 170 species of migratory and other birds and is one of the potential sites for bird watching eco-tourism development not only in the soum, but in Mongolia. The lake is a very important breeding and staging area for a wide variety of waterfowl, particularly Anatidae.

The lake also supported significant fishery in the recent past. Fishery is now stopped for both environmental and economic reasons.

Ogii Lake was included as a second Ramsar site from Mongolia in the list of Ramsar sites of the Convention of Wetlands of International Importance in 1997 and in the East Asian Network of Anatidae Sites in 1998.

Currently, some occasional tourists come to the lake to watch birds and enjoy the lake.

WISE USE INITIATIVE

The idea to develop bird watching at the Ogii nuur lake has been initiated by the Ogii nuur soum government and supported by the Citizens' Representative Hural of the soum and Governor of Arhangai aimag.

The initiative itself is to promote the development of the local community by involving the people in local eco-tourism and conservation activities. It is intended to demonstrate one of the potential ways to develop eco-tourism for the benefits of both the local community and Ogii Lake. As bird watching increases, protection measures are necessary to conserve the lake ecosystem including migratory birds and their habitats in close cooperation with, and involvement of, the local community.

Two institutions and some individuals with good tourism knowledge and experience will be supporting the bird watching activities at the request of the Bird Watching Board. The Institute of Biology of the Academy of Sciences is now providing support on all scientific aspects of bird watching development at Ogii and will continue to assist in both bird watching and community development. The "Birds" Tour Company had been requested to deal with marketing and attracting tourists who are bird watchers.

As bird watching is a new activity not only at Ogii Lake, but in Mongolia, it is strongly necessary to train young local guides to assist bird watchers. Therefore, the Board has requested the above supporters to offer training, and they have generously agreed to provide training for tour guides and other workers.

REALISATION OF INITIATIVE

Some initial activities to realise the initiative have been conducted during the past year. To manage and monitor bird watching activities, there has been established the Ogii Bird Watching Board headed by the Ogii nuur soum governor. As stated above, the bird watching is designed to be fully community-based and it is expected that about 40 people of the local community would be involved in the near future to support visitors/bird watchers. Fifteen young people have been selected to be trained as tour guides to supply basic services such as guiding bird watchers as well as additional services and activities which may, in
particular, include horse riding, kayaking, introduction of nomadic culture, maintenance of visitor rooms, etc.

The lake has already been surveyed three times by a team that comprises ornithologists, eco-tourism experts and international consultants. The team has determined all possible eco-tourism resources at Ogii Lake, including bird watching. From the surveys, it is found that bird watching is the most suitable and promising activity.

The team has also made a number of recommendations to the Board, including bird watching site selections, conservation and management zones (Figure 2). The Board selected a site in the northwestern shore of the lake, where thousands of migratory birds arrive and breed. Other potential sites are also determined.

The Board is now looking for investment opportunities, and marketing is well under way. A number of instructions including those on safety, communication, emergency medical aid, is being prepared.

![Figure 2](image)

Figure 2. Bird watching sites, conservation and management zones.

**WISE USE PRINCIPLES AGREED BY THE BOARD**

It is probably the first attempt in Mongolia to apply the wise use principle and conservation of lake through the development of eco-tourism.

The following four key principles have been agreed to, irrespective of the types of eco-tourism to be developed at and around the lake:

- Possible minimum impacts to nature.
• Contribution to nature conservation.
• Promotion of education on nature and nature conservation.
• Profit sharing with local community (if other tour companies participate).

All stakeholders must follow and respect the above principles and carry out their activities with the understanding that sustainable eco-tourism development is the main goal to achieve.

The Board has named four main stakeholders who would play a key role in maintaining the above principles. These are the Board itself, tour operators, community members and visitors.

For long-term sustainability and conservation of Ogii Lake, the Board is now recommending the following responsibility sharing for the main stakeholders:

The Board

• To be responsible for sustainable use of eco-tourism resources of Ogii Lake and to monitor eco-tourism activities.
• To prevent negative human impacts to Ogii Lake.
• To monitor the Ogii Lake ecosystem with special emphasis on the conservation of birds.
• Consider and approve tour operation programmes and permanent places to locate camps. After this approval, permission to run nature-based tourism activities at Ogii Lake would be issued by the Ogii nuur soum government/aimag government.
• To arrange that an appropriate scientific organisation determines the carrying capacity of Ogii Lake once every three years, and assesses conservation activities at the lake annually.
• To consider and agree on required nature conservation activities at Board's annual meeting.
• To receive nature conservation contributions from tour operators and use them on agreed conservation measures.
• To make recommendations to the local government on permission or suspension and cancellation of conducted eco-tourism activities at Ogii Lake.
• To require clean-up and other needed nature conservation actions from tour operators.
• To request tour operators to provide information on eco-tourism products and services, which are needed for planning and monitoring of nature conservation activities.

The Board will hold its annual meeting at the end of each tourist season.

Tour Operators

• To develop the following ecotour-related programmes and submit them to the Board for approval:
  • Overall tour operation programmes which include types of tourism, activities, schedule, location of camps, etc.
- Pre-departure programmes on visitor information and education.
- Guiding programmes on general principles of guiding tours, prevention of environmental and cultural impacts.
- Monitoring programmes on prevention of accumulated impacts of tourism.
- Management programmes on training, conservation contribution and local employment and jobs.
  • To keep the environment clean and not to carry out any activity which disturb any of the natural components of Ogii Lake.
  • To contribute 1% of their annual revenue to Ogii Lake conservation measures.
  • To provide information to the Board on eco-tourism products and services, which are needed for planning and monitoring of nature conservation activities.

Community Members
  • To follow work instructions given by general managers of Ogii tour camps.
  • To respect and serve visitors properly.
  • To keep the environment clean and not to disturb birds.
  • To respect the duties given to each individual worker.

Visitors
  • To respect the culture and customs of the local people and avoid introducing urban lifestyles.
  • Not to approach birds too closely or disturb them.
  • Not to pollute water and soil, and to take all litter back to camps.
  • To be close with nature and the local community.
  • To identify local environmental problems and give advice on the conservation of Ogii Lake.
Rehabilitative Treatment to Abandoned Shrimp Ponds in Khanom, Nakon Sri Thammarat, Thailand

1 Kansai Environmental Engineering Center Co. Ltd. 1-3-5 Tyuo, Azuchimachi, Osaka, Japan
2 Peat Swamp Forest and Related Wetland Research and Management Division, Royal Forest Department, Thailand
3 The Kansai Electric Power Co. Inc, Technical Research Center, 3-11-20 Nakoji Amagasaki Hyogo, Japan

ABSTRACT

In the coastal areas of Southeast Asia, there exist many abandoned shrimp farms. Most of these farms have been converted from mangrove forests, resulting in a depletion of natural resources. To-date, many attempts have been made to rehabilitate these abandoned shrimp farms. In this study, an abandoned farm, which was intensively operated for years, was used for several replanting trials. Two kinds of treatment were deployed: first, the destruction of a dyke to enable free water circulation and second, the application of soil conditioners. The addition of coconut fibre, shrimp wastes and charcoal appeared to have a positive effect.

INTRODUCTION

The problem of mangrove depletion in Southeast Asia is increasing. In the case of Thailand, 20 million hectares have been lost from 1961 to 1996 (Charuppat and Charuppat 1997). During this period, the highest reduction rate of mangrove forests was recorded between 1979 to 1986, which corresponded to a period of intensive shrimp pond construction. Although shrimp culture has brought about an increase of income for the local community, most shrimp ponds have been abandoned after some years due to several reasons such as degradation of water quality and a disease among shrimps. It is estimated that the total area of abandoned shrimp ponds in Thailand amounted to 2.4-3.2 million ha, its reutilisation is, therefore, an urgent issue to look into.

There are different kinds of shrimp ponds in Thailand; among these, intensive shrimp farms have been widely constructed since mid-1980 when its profitability was most promising compared to other types of shrimp farms. Compared to extensive shrimp farming, intensive shrimp farming has resulted in great modification of the environment. It is thus difficult to restore such abandoned shrimp farms although we have been trying to develop restoration techniques for them since 1999. This report illustrates some results we have obtained in the last two years.

STUDY SITES AND METHODS

Experimental plots were set up June 1999 in the Khanom district at the Nakon Sri Thammarat Prefecture, Thailand. The area had been abandoned after some years of use as a shrimp farm and left unutilised till the present time (Figure 3). Several trials of planting had already been done in the area but none of them succeeded. The abandoned shrimp pond whose size is approximately 1 ha, was closed by dykes to control water flow into the pond. In order to make water move freely, we removed these surrounding dykes with heavy
machinery. Then we applied shell, charcoal, coconut fibre, shrimp wastes and calcite as soil conditioners at the time of planting seedlings following the site preparation (Figure 1).

Figure 1 Rehabilitation plan for intensive shrimp pond

- Soil conditioner
  - shell
  - shrimp waste
  - charcoal
  - coconut fiber
  - calcite
  - shell + coconut fiber
  - shrimp waste + coconut fiber
  - control

- Species:
  - Rhizophora mucronata
  - Rhizophora apiculata
  - Bruguiera cylindrica
  - Ceriops tagal
Soil conditioners were selected, firstly, if they were available in local markets and inexpensive. This is important in terms of future implementation as costly materials will not be affordable. Secondly, they had to be as recyclable as possible. Shell and shrimp wastes are disposed of every year. As a consequence, their treatment is becoming a concern in coastal regions. Shell is composed mostly of CaCO₃. Although CaCO₃ has the ability of ameliorating acid soils, it is also expected to improve the physical condition of soils. Table 1 shows the pH value in the pond, which was measured in situ by a portable pH meter (Fujinara Co. Inc.). The pH value was measured at 32 divided blocks as shown in Figure 1. Values of pH tend to lower at sites where dykes previously existed. In the pond, the pH value was nearly neutral. Eh values which represent oxidative or reductive conditions were also low where the pond was before (Table 2). Taking into consideration the variable conditions of soil properties and the water regime in the abandoned shrimp pond, the planting species selected were Rhizophora apiculata, Rhizophora mucronata were planted in the previous pond site and Ceriops tagal, Bruguiera cylindrica were used where the dykes were previously located.

Table 1. pH value at each block.

<table>
<thead>
<tr>
<th>Block</th>
<th>pH</th>
<th>Block</th>
<th>pH</th>
<th>Block</th>
<th>pH</th>
<th>Block</th>
<th>pH</th>
</tr>
</thead>
</table>

Mean 3.80 6.75 5.95 6.14

Table 2. Eh value at each block.

<table>
<thead>
<tr>
<th>Block</th>
<th>Eh</th>
<th>Block</th>
<th>Eh</th>
<th>Block</th>
<th>Eh</th>
<th>Block</th>
<th>Eh</th>
</tr>
</thead>
</table>

Mean 230 -356 -394 35

Calcite is known to have a reverse effect on mangrove growth since it hardens soils because Ca²⁺ reacts with SO₄²⁻ and acts as cement. Although it has a negative effect under mangrove conditions, we still included it as one of four soil conditioners because calcite is a very well-known soil conditioner in the market.
EXPERIMENTAL RESULTS

Table 3 and Figure 2 indicate the results in the experimental site of intensive shrimp ponds. The size of circle shows the survival rate of planted mangroves after one and a half years. Although the survival rate varied between treatments, it should be noted that destruction of the dykes which resulted in free water circulation had a favourable effect on mangrove plants (Figure 4). Rhizophora spp. grew well at the sites where soil conditioners were applied. In general, the growth rates of Ceriops spp. were comparatively lower, which may be explained by the fact that at the Ceriops planing sites, there had been a dyke before this experiment, that is, where soils were highly acidic because of the acidification of sulfate in them. The application of calcite seemingly had a positive effect on the Ceriops site although it had a negative one on the Rhizophora site. A difference in the calcite effect may have originated from the occurrence of cementing at the site. Calcite tends to play a cementing agent on more inundated places like the Rhizophora site. In the case of Rhizophora mucronata, coconut fibre attributed to a better growth. As such, each soil conditioner reacted differently on different mangrove species.

Among the species, Rhizophora apiculata showed the highest growth (Figure 5), coconut fibre having a good effect. In Ceriops spp, shell and calcite induced raised growth rates. This may be because of the improved acidic soil conditions of Ceriops spp sites.

Table 1. Survival rate (%) of planted mangrove species at 1.5 years after planting.

<table>
<thead>
<tr>
<th>Soil conditioner</th>
<th>Rhizophora mucronata</th>
<th>Rhizophora apiculata</th>
<th>Bruguiera cylindrica</th>
<th>Ceriops tagal</th>
</tr>
</thead>
<tbody>
<tr>
<td>shell</td>
<td>47</td>
<td>67</td>
<td>74</td>
<td>11</td>
</tr>
<tr>
<td>shrimp wastes</td>
<td>55</td>
<td>45</td>
<td>75</td>
<td>24</td>
</tr>
<tr>
<td>charcoal</td>
<td>63</td>
<td>69</td>
<td>76</td>
<td>34</td>
</tr>
<tr>
<td>coconut fibre</td>
<td>70</td>
<td>53</td>
<td>74</td>
<td>34</td>
</tr>
<tr>
<td>calcite</td>
<td>18</td>
<td>27</td>
<td>40</td>
<td>38</td>
</tr>
<tr>
<td>shell coconut fibre</td>
<td>45</td>
<td>49</td>
<td>64</td>
<td>42</td>
</tr>
<tr>
<td>shrimp waste coconut fibre</td>
<td>69</td>
<td>51</td>
<td>70</td>
<td>58</td>
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<tr>
<td>control</td>
<td>34</td>
<td>53</td>
<td>82</td>
<td>27</td>
</tr>
</tbody>
</table>
Figure 2. Results of soil conditioner treatments

<p>| | | | |</p>
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</tr>
</tbody>
</table>

Note: Size of a circle indicates a rate of survival rate in each treatment. Notations used in this figure are the same as indicated in Figure 1.
Figure 3. Abandoned shrimp pond before treatment (June 1999).

Figure 4. Changes in abandoned shrimp pond after treatment (October 2000).
CONCLUSIONS

- The breaking of the dykes resulted in free water circulation, this having a favourable effect on mangrove growths.
- *Rhizophora mucronata* grew well at the sites where soil conditioners were applied especially at the blocks treated with coconut fibre and shrimp wastes.
- In the case of *Rhizophora apiculata*, charcoal and shell treatment had a good effect on growth.
- The application of soil conditioners had no significant effect on *Bruguiera cylindrical* while the survival rate of *Ceriops tagal* was increased by the treatment of shrimp wastes plus coconut fibre.
- As expected calcite had a negative effect on all species.

REFERENCE

Modelling Fish Community Dynamics in the Florida Everglades: The Role of Hydroperiods and Trophic Interactions

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ABSTRACT

The Everglades of South Florida is known to be the second largest and most extensive wetland ecosystem in the world. It is a mosaic of urban, agricultural, marsh and forest habitats in a vast neo-tropical wetland. The Everglades fish community is an important ecological component because of its level in the food chain as intermediary between the lower producers and the higher consumers, such as the wading birds; this is cited as an indicator of the health of the ecosystem of the Everglades. The water level is a crucial aspect in the Everglades because it controls the dynamics of aquatic organisms including the fish community. Precipitation and evapo-transpiration are the major factors affecting the timing and extent of water level fluctuations. These processes result in a seasonal pattern of rainfall and water levels, which are high during rainy seasons, followed by a decline during drought seasons. This seasonality induces different drought periods within a year and from year to year, i.e., different drought periods and different drought frequencies. In this paper, the impacts of droughts and lower trophic community fluctuations on the fish community will be studied. A fish population dynamic model is developed. Simulation time step and age class are set to be five days while the simulation period is set to be 40 months. The following three different scenarios representing the drought factor have been simulated:

- Different drought periods within one year.
- Different drought frequencies, i.e., different number of drought periods in a one-year cycle.
- Different continuous drought periods in the whole simulation period, ranging from 300 to 500 drought days.

In the first scenario, the model shows an inversely proportional relation between the annual drought period and fish density characterised by an S-shape curve. In the second scenario, the drought frequency is also inversely proportional to the fish density. In the third scenario, the model shows that a period of 15 months is the maximum period of drought for the fish to recover to a satisfactory density level.

INTRODUCTION

It is quite important to understand the climatic conditions and changes of the Everglades when trying to explain changing population or community patterns; hence, we can clearly identify the relevant climatic parameters and be aware of how they vary in time. This variability in the system is likely to be a crucial aspect of the Everglades that controls the survival of living organisms. The water level is an important climatic factor and fish are the most sensitive living organisms in the Everglades.
DROUGHTS DYNAMICS

The Everglades exists where the water depth is at times above and other times below the ground surface for different periods during an average annual cycle. Precipitation and evapo-transpiration are the major factors affecting the timing and extent of this fluctuation on sites with a natural hydrologic regime (Duever et al. 1994). These processes result in a distinctive pattern of heavily rainfall and high water level during the summer months, followed by a slow decline during winter and a much more rapid decline during spring. Climatic conditions are such that the wet season rainfall more than compensates for the high summer evapo-transpiration rates. When the wet season ends, fall and winter temperatures are relatively low and vegetation use of water is reduced; thus, while rainfall is low, evapo-transpiration is also low and the water depth declines slowly. During the spring, however, temperatures increase and vegetation use of water increases, while rainfall does not, resulting in a rapid decline in the water depth. An analysis of the precipitation and water level relationships in the Everglades indicated that the surface water level in any particular wet or dry season reflected the amount of rain that fell during the respective wet or dry season (Duever et al. 1975). Thus, a wet season with abundant rainfall had high water levels for extended periods, but water levels in the subsequent dry season were high or low based solely on the amount of rain that fell during the dry season (Duever et al. 1994). The same applied to a dry season following a summer-wet season when little rain fell and water levels remained low.

As a result, it is not easy to predict long-term water levels in the Everglades. Alternatively, several water level scenarios would be adapted when modelling techniques are needed to assess the influence of some climatic changes on the Everglades ecosystem.

A hydroperiod is defined (Loftus et al. 1990) by a combination of site characteristics: the length of time since last dry-down; duration in days of the last dry-down; the frequency of dry-downs since mean wet and dry season depths. Dry-down is defined as the period during which marsh water depths fall below a fix depth (usually 5-7 cm) (Loftus, US Geological Survey, unpublished data).

Before discussing the effect of water level fluctuations, a review of the dynamics of the lower trophic level (Ooi et al. 2000) in the marsh areas of Everglades is discussed here.

LOWER TROPHIC DYNAMICS IN THE EVERGLADES

The growth of fish populations is determined by the abundance of their food. This lower trophic community consists mainly of five energy compartments (periphyton, macrophyte, mesoinvertebrates (or zooplankton), macroinvertebrate and detritus). The equations of their biomasses are described below and they are based on empirical data from Browder (1981, 1982) and Browder et al. (1984).

\[ \frac{dB_1}{dt} = \eta B_1 - \varphi B_1^2 - \epsilon (\rho B_3 + \sigma B_4) B_1 \]  
\[ \frac{dB_2}{dt} = \gamma B_2 - \delta B_2^2 \]  
\[ \frac{dB_3}{dt} = A \rho B_1 B_3 - \chi B_3^2 \]  
\[ \frac{dB_4}{dt} = A \sigma B_1 B_4 - \tau B_4^2 \]  
\[ \frac{dB_5}{dt} = e (\varphi B_1^2 + \delta B_2^2 + \chi B_3^2 + \tau B_4^2) - \xi B_5 \]
where

\[
\begin{align*}
B_1 &= \text{biomass density of periphyton, g dw m}^{-2} \\
B_2 &= \text{biomass density of macrophyte, g dw m}^{-2} \\
B_3 &= \text{biomass density of mesoinvertebrates (zooplankton), g dw m}^{-2} (< 1 \text{ mg}) \\
B_4 &= \text{biomass density of macroinvertebrates (zooplankton), g dw m}^{-2} (> 1 \text{ mg}) \\
B_5 &= \text{biomass density of detritus, g dw m}^{-2} \\
c &= \text{inverse of assimilation rate of macroinvertebrates and mesoinvertebrates} \\
\eta &= \text{periphyton growth rate, d}^{-1} \\
\varphi &= \text{periphyton mortality rate, m}^{-1} (\text{g dw})^{-1} (\text{d})^{-1} \\
\rho &= \text{zooplankton feeding rate, m}^{-2} (\text{g dw})^{-1} (\text{d})^{-1} \\
\sigma &= \text{macroinvertebrates feeding rate, m}^{-2} (\text{g dw})^{-1} (\text{d})^{-1} \\
\tau &= \text{time, d} \\
A &= \text{assimilation rate of the zooplankton and macroinvertebrate} \\
\chi &= \text{zooplankton mortality rate, m}^{-1} (\text{g dw})^{-1} (\text{d})^{-1} \\
\tau &= \text{macroinvertebrate mortality rate, m}^{-1} (\text{g dw})^{-1} (\text{d})^{-1} \\
B_5 &= \text{biomass density of detritus, g dw m}^{-2} \\
e &= \text{proportion of death compounds converted into detritus} \\
\xi &= \text{lost rate of detritus, d}^{-1}.
\end{align*}
\]

At flooding seasons, the previous parameters will fluctuate seasonally, but when water level drops to a certain level, the growth equation would be replaced by a die-off dynamics depending on the water level.

The proportion of the drought die-off to their current respective stocks at current depth for all living compartments (all compartments excluding detritus) is calculated from Equation (6):

\[
PROP = \frac{\text{UPPER} - \text{DOWN}}{\text{DRYDEP}} \tag{6}
\]

where

\[
\begin{align*}
PROP &= \text{proportion of drought die-off} \\
\text{UPPER} &= \text{depth of water at the beginning of each time step, m} \\
\text{DOWN} &= \text{depth of water at the end of each time step, m} \\
\text{DRYDEP} &= \text{depth at which drought die-off begins, m} \\
\end{align*}
\]

(which is 7 cm in our model).

Consequently, total biomass of die-off of the living compartments \( DB_i(t) \) is calculated by Equation (7). The die-off biomass is then subtracted from its initial stock but added to the detritus compartment.

\[
DB_i(t) = PROP \times B_i(t), \quad i = 1, \ldots, 4 \tag{7}
\]

\[
B_5(t) = B_5(t - \Delta t) + \sum_{i=1}^{4} DB_i(t) \tag{8}
\]

where

\[
\begin{align*}
DB_i(t) &= \text{total drought die-off biomass density of living compartment } i \text{ at time } t, \text{ g dw m}^{-2} \\
B_i(t) &= \text{total biomass density of living compartment } i \text{ at time } t, \text{ g dw m}^{-2} \\
\Delta t &= \text{simulation time step.}
\end{align*}
\]

90
FISH DYNAMICS DURING DROUGHT PERIODS

The Everglades fish community does face annual fluctuations in water level (Loftus and Kushlan 1987). If water level drops to low levels, a massive loss in fish density will occur. But in the Everglades, there are many refuge areas that (some) fish can go during the dry periods: creek channels, alligator holes and solution holes which are those permanent shelters that fish find during dry periods since they are water covered throughout the year. Actually, these remaining fish are the ‘seeds’ for the next generation in the Everglades when it recovers from a dry season.

When water depth is 'suitable' for all functional groups (FG) of fish, the fish move freely in the marsh and pond areas in an Everglade cell, but when water depth decreases, deep water body ponds may be the only existing shelters for large fish, and solution holes for small fish. As water levels rise again, small fish move out of their shelters to the flooded marsh areas followed by large fish if water levels are suitable.

The hydrological conditions (water level relative to the cell elevation) are simulated from a sinusoidal annual function (Equation 9 and Figure 1). This model is able to produce several important characteristics of the hydroperiod such as the duration and frequency of drought, as well as the water depth. The conceptual hydrologic model is:

\[ WL = AVEDEP + AMP \cos(\sigma t) \]  

where

- \( WL \) = actual water level, \( m \)
- \( AVEDEP \) = mean annual water level, \( m \)
- \( AMP \) = amplitude of sinusoidal variation of the water level, \( m \)
- \( \sigma \) = frequency of the water level variation, \( \text{day}^{-1} \)
- \( t \) = time, \( \text{day} \).

![Figure 1. The use of Equation 9 in a two-year cycle.](image)

SIMULATION PATTERN

Several scenarios were adapted. Different water depths were simulated to see the effect of the hydroperiods on the fish biomass and population density in the marsh areas. Simulation begins at the wet season (no droughts or above 0-depth of water level); hence the fish move freely in the marsh areas of the cell, each time step water depth being assessed. Each species is assigned a species-dependent water depth; when the water level in the marsh area drops below this level, this species cannot survive. Three fractions of fish have been assumed:
• Fish that go to pond areas.
• Fish that go to solution holes.
• Fish that die.

The percentiles of these fractions are assumed to be 0.2, 0.7 and 0.1, respectively. Dynamics in solution holes are almost similar to those in the flooded marsh areas, except (besides changes in the water level) that crowding is limited to a maximum number of fish due to lack of prey or oxygen needed in a single solution hole. When the water depth increases to a level that allows fish to survive in the marsh areas, surviving fish leave their shelters.

During the simulation period where fish encounter several wet and dry seasons, the model stores several outputs, including fish population (number of fish per metre square) and biomass densities (weight per metre square) for each age class and for the summed age classes for each functional group. These calculations are done in the freshwater marsh areas each time step. The (small) fish of marsh areas are divided into two functional groups, FG 1 and FG 2.

The stimulation period is set at about 40 months, but for a part of the calibration process, the model was tested to periods up to 50 years to make sure that fish densities do not go into extinction.

STUDY SCENARIOS

Three scenarios were studied in this simulation:

• **Scenario 1:** This scenario is based on different continuous drought days for a one-year cycle. Different water depths are proposed; in other words, different drought periods per one year are analysed to relate these changes to fish densities. Figure 2 shows water level fluctuations in this scenario.

• **Scenario 2:** This scenario discusses the frequency of droughts on a one-year cycle. Three cases are assumed: one, two and four drought cases in a one-year cycle. This is to assess the effect of the number of annual drought periods on fish population. Figure 3 shows the assumed scenario.

• **Scenario 3:** This scenario aims to assess maximum drought periods that are not allowed to exceed, so that the fish population would return to its normal levels. Several cases are discussed where several long drought periods are assumed. The time needed for the fish population to return to its normal densities is also studied.
Figure 2. Five assumed intra-annual water depths scenarios for the spatial cell, with minimum depth in cm (A) 10 (B) 0 (C) -10 (D) -20 (E) -30.

Figure 3. Scenario No. 2: three cases of water level fluctuations in the freshwater marshes of Everglades in a one-year cycle.

SIMULATION RESULTS AND DISCUSSIONS

The results of the model are an important indicator for the ecological status of the Everglades ecosystem; fish is an intermediate food trophic level and its biomass density plays an important role as food of a higher trophic level of the important community of wading birds and as a predator to the lower trophic level.

Before proceeding to model results, several points have to be clarified:

- The assumption made that fluctuations in the prey base are not as an important in determining fish abundances as fluctuations in water depth.
• Fish FG 1 and fish FG 2, which form the small fish community in the Everglades, are the only fish presented in the marsh areas (in addition to zooplankton community of functional group 4).
• Fish population (fish number/m$^2$) and biomass (total kg dw) densities in the marshes areas have been assessed in the model, as a main output.
• Fish population density is restricted to fish older than 30 days.
• Fish population density is averaged over the whole cell area.

**Scenario 1**

Figures 4 to 7 show different responses of small fish densities to the different water level cases. For cases C, D, and E dry-down cases for different periods occur (Figure 2). In case C, the drought period lasts 59 day, case D lasts 85 whereas the drought in case E lasts 105 days; this drought period is inversely proportional with fish population densities resulted in the simulation. A continuous annual 59-drought day is coupled with a fluctuating population and biomass densities that have maximum values of 5.5 fish/m$^2$, 15 kg dw for fish functional group 1, and values of 7.0 fish/m$^2$, 15 kg dw for fish functional group 2.

![Graphs](image-url)

*Figure 4. Fish population (up) and biomass (down) densities in the marsh area for FG 1 (left) and FG 2 (right), at mean water depth = 0.5 m.*
Figure 5. Fish population (up) and biomass (down) densities in the marsh areas for FG 1 (left) and FG 2 (right), at mean water depth = 0.6 m.

Figure 6. Everglades population (up) and biomass (down) densities in the marsh area for FG 1 (left) and FG 2 (right), at mean water depth = 0.7 m.
Figure 7. Everglades fish population (up) and biomass (down) densities in the marsh area for FG 1 (left) and FG 2 (right), at mean water depth = 0.8 m.

Apparently, the water level is the most important driving force that determines fish densities in the marsh areas. This is consistent with results of studies done by Loftus and Eklund (1994). In flooding seasons, the small fish mean population density is about 18 fish/m$^2$ where biomass density is 4g/m$^2$ dry weight. These densities are measured on a whole cell basis (25 ha). Loftus and Eklund (1994) sampled fish populations in the Everglades in flooding seasons from 1978 to 1985 and found that mean annual densities of small fish range from 15.5 to 17.1 fish/m$^2$ and 3-5 grams/m$^2$ during that period. When drought periods increase, fish densities decrease. Tables 1 and 2 show the details of the simulation for selected drought periods for fish functional groups 1 and 2, respectively. The Sigmoid curve characterising fish density-drought period relations is shown in Figure 8. The model results in different drought periods are consistent with the ALFISH model which is developed for the entire Everglades landscape. ALFISH shows a mean density ranging from 0.5 to 6 fish/m$^2$ in the period from 1965 to 1996. This model also demonstrates the variability in fish densities from one year to the next as well as from one region to the next based on water level differences. As a result, long-term predictions of fish biomass and population densities due to drought are possible. The drought period also determines the time required for the fish community to go back to a satisfactory level, in which it could recover after that from the influence of that drought. As long as a drought period is, it takes that long to reach this level. Table 3 shows this relationship for the small fish community.
Table 1. Fish functional group 1 response to different hydroperiods.

<table>
<thead>
<tr>
<th>Drought period (days)</th>
<th>Scenario or average water depth</th>
<th>Total biomass (kg dw) (maximum)</th>
<th>Total biomass (kg dw) (mean)</th>
<th>Fish/m² (maximum)</th>
<th>Fish/m² (mean)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>A (Flooding)</td>
<td>53</td>
<td>21.5</td>
<td>46</td>
<td>9.66</td>
</tr>
<tr>
<td>5&lt;sup&gt;b&lt;/sup&gt;</td>
<td>B (0.8)</td>
<td>20</td>
<td>4.0</td>
<td>9</td>
<td>1.4</td>
</tr>
<tr>
<td>19</td>
<td></td>
<td>19.3</td>
<td>3.8</td>
<td>8.4</td>
<td>1.28</td>
</tr>
<tr>
<td>27</td>
<td></td>
<td>18.9</td>
<td>3.65</td>
<td>8.06</td>
<td>1.21</td>
</tr>
<tr>
<td>33</td>
<td></td>
<td>18.12</td>
<td>3.38</td>
<td>7.7</td>
<td>1.14</td>
</tr>
<tr>
<td>42</td>
<td></td>
<td>17</td>
<td>3.04</td>
<td>7</td>
<td>1.02</td>
</tr>
<tr>
<td>59</td>
<td></td>
<td>15</td>
<td>2.43</td>
<td>5.5</td>
<td>0.8</td>
</tr>
<tr>
<td>73</td>
<td></td>
<td>13</td>
<td>2.06</td>
<td>4.6</td>
<td>0.7</td>
</tr>
<tr>
<td>85</td>
<td></td>
<td>11</td>
<td>1.4</td>
<td>4</td>
<td>0.47</td>
</tr>
<tr>
<td>105</td>
<td></td>
<td>0.7</td>
<td>0.1</td>
<td>0.2</td>
<td>0.03</td>
</tr>
<tr>
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<td>0.515</td>
<td>0.075</td>
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<td>0.023</td>
</tr>
<tr>
<td>139</td>
<td></td>
<td>0.045</td>
<td>0.012</td>
<td>0.02</td>
<td>0.007</td>
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<tr>
<td>155</td>
<td></td>
<td>0.04</td>
<td>0.011</td>
<td>0.0197</td>
<td>0.006</td>
</tr>
</tbody>
</table>

<sup>a</sup>: Calculations in this scenario are based on 89 months results; other scenarios are on 49 months.  
<sup>b</sup>: This is equal to the time step used in the model.

Table 2. Fish functional group 2 responses to different hydroperiods.

<table>
<thead>
<tr>
<th>Drought period (days)</th>
<th>Scenario or average depth</th>
<th>Total biomass (kg dw) (maximum)</th>
<th>Total biomass (kg dw) (mean)</th>
<th>Fish/m² (maximum)</th>
<th>Fish/m² (mean)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>A (Flooding)&lt;sup&gt;a&lt;/sup&gt;</td>
<td>42</td>
<td>18.7</td>
<td>29</td>
<td>8.35</td>
</tr>
<tr>
<td>5&lt;sup&gt;b&lt;/sup&gt;</td>
<td>B (0.8)</td>
<td>19</td>
<td>3.7</td>
<td>8.5</td>
<td>1.4</td>
</tr>
<tr>
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<td>8.1</td>
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</tr>
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<td>3.03</td>
<td>7.88</td>
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<td>2.72</td>
<td>7.7</td>
<td>1.03</td>
</tr>
<tr>
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<td></td>
<td>15</td>
<td>2.2</td>
<td>7</td>
<td>0.8</td>
</tr>
<tr>
<td>73</td>
<td></td>
<td>11</td>
<td>0.97</td>
<td>3.9</td>
<td>0.34</td>
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</tr>
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<tr>
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<td>0.02</td>
<td>0.008</td>
<td>0.013</td>
<td>0.006</td>
</tr>
</tbody>
</table>

<sup>a</sup>: Calculations in this scenario are based on 89 months results; other scenarios are on 40 months.  
<sup>b</sup>: This is equal to the time step used in the model.
Figure 8. Scenario 1: Fish population (right) and biomass (left) densities in the marsh area for FG 1 (up) and FG 2 (down), subject to different drought days in one year.

Table 3. Fish functional group 1 and 2 responses to different hydroperiods.

<table>
<thead>
<tr>
<th>Drought period (days)</th>
<th>Scenario</th>
<th>FG 1 Time to reach biomass level of 0.515</th>
<th>FG 1 Time to reach population level of 0.14</th>
<th>FG 2 Time to reach biomass level of 2.8</th>
<th>FG 2 Time to reach population level of 1.24</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>A (Flooding)</td>
<td>296</td>
<td>216</td>
<td>391</td>
<td>396</td>
</tr>
<tr>
<td>5</td>
<td>B</td>
<td>311</td>
<td>246</td>
<td>661</td>
<td>606</td>
</tr>
<tr>
<td>59</td>
<td>C</td>
<td>326</td>
<td>336</td>
<td>671</td>
<td>636</td>
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<tr>
<td>85</td>
<td>D</td>
<td>541</td>
<td>426</td>
<td>731</td>
<td>841</td>
</tr>
<tr>
<td>105</td>
<td>E</td>
<td>1051</td>
<td>996</td>
<td>1071</td>
<td>1086</td>
</tr>
<tr>
<td>123</td>
<td>F</td>
<td>1081</td>
<td>1056</td>
<td>1086</td>
<td>1086</td>
</tr>
</tbody>
</table>

Scenario 2

Three frequencies have been studied here: 2, 4 and 8 drought periods with the results from our previous work, in which only one drought period is assumed. The model shows a large decline in fish population and biomass density when drought occurs more than once in a year and this density is proportional to drought frequencies; nevertheless, fish can recover in the next flooding season if enough time is available.

Scenario 3

Three drought experiments have been simulated, in which the flooding season is followed to assess the maximum drought period that is durable for fish. Drought periods of 500 days or longer will make small fish of the Everglades go into extinction. Shorter drought periods will not lead to extinction but on the other hand, the fish community will take a longer time to recover depending on the length of the drought period.

Recovery time is the time required for a fish functional group to reach a reference density level since the beginning of the flooding period that comes after drought. Reference density is a user-defined parameter and it is chosen to be a moderate density value that can be
seen as a recovery level. The optimum choice in our model for this reference density is the maximum (population or biomass) density that a functional group can reach before the beginning of the drought period. Generally,

\[ \text{recovery time} = \text{time to reach reference density} - \text{flooding start time} \]  

(10)

Fish recovery time is longer when drought periods are longer and vice versa, until fish are unable to recover at periods of drought threshold. This can be depicted in Figures 9, 10 and Table 4. It is worth mentioning here that if the fish community manages to recover, fish densities will reach (sooner or later) levels of the flooding season studied in scenario 1.

![Figure 9](image1.png)

**Figure 9.** Fish population densities in the marsh area for FG 1 where drought begins at day 500 and last until day (a) 800 (b) 900 (c) 950 (d) 1000 followed by permanent flooding. The figure also shows recover time; time need (after drought finish) to return back to a level of 9.94 fish/m².

![Figure 10](image2.png)

**Figure 10.** Fish population densities in the marsh area for FG 2 where drought begins at day 500 and last until day (a) 800 (b) 900 (c) 950 (d) 1000 followed by permanent flooding. The figure also shows recover time; time need (after drought finish) to return back to a level of reference density.
Table 4. Fish functional group 1 response to different hydroperiods.

<table>
<thead>
<tr>
<th>Drought period (days)</th>
<th>FG Recovery reference biomass density of 29.6 kg dw</th>
<th>1 time</th>
<th>FG Recovery reference population density 9.95 fish/m²</th>
<th>1 time</th>
<th>FG Recovery reference biomass density of 17 kg dw</th>
<th>2 time</th>
<th>FG Recovery reference population density 6.75 fish/m²</th>
<th>2 time</th>
</tr>
</thead>
<tbody>
<tr>
<td>300</td>
<td>410</td>
<td>345</td>
<td></td>
<td>370</td>
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<td>315</td>
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<tr>
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<td>510</td>
<td>475</td>
<td></td>
<td>510</td>
<td></td>
<td>475</td>
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<tr>
<td>450</td>
<td>620</td>
<td>555</td>
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<td>495</td>
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<td>575</td>
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<tr>
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<td>No recovery</td>
<td></td>
<td>No recovery</td>
<td></td>
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</tr>
</tbody>
</table>

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