PROCEEDINGS OF THE INTERNATIONAL SYMPOSIUM AND WORKSHOP ON TROPICAL PEATLAND
PALANGKA RAYA, 20-24 SEPTEMBER 2005

"Restoration and Wise Use of Tropical Peatland: Problems of Biodiversity, Fire, Poverty and Water Management"

Symposium participants visiting restoration site in block C of the ex MRP

Editor

J.O. Rieley

Professor of Geography, School of Geography, University of Nottingham, United Kingdom

Chairman of Organizing Committee

Suwido H. Limin

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Layout and Editorial Assistance

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Faculty of Agriculture, University of Palangka Raya, Central Kalimantan, Indonesia

January 2007

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INTERNATIONAL SYMPOSIUM AND WORKSHOP ON TROPICAL PEATLAND
Palangka Raya, Central Kalimantan, Indonesia
20-24 September 2005

"Restoration and Wise Use of Tropical Peatland: Problems of Biodiversity, Fire, Poverty and Water Management"

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CIMTROP, University of Palangka Raya and Indonesian Peat Association (International Peat Society)

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Indonesian Peat Association
Provincial Government of Central Kalimantan
Regency Governments of Kapuas, Pulang Pisau, Kasongan and Palangka Raya, Indonesia

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INTERNATIONAL SYMPOSIUM AND WORKSHOP ON TROPICAL PEATLAND
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"Restoration and Wise Use of Tropical Peatland: Problems of Biodiversity, Fire, Poverty and Water Management"

CONTENTS

C. POSTERS

Closing Addresses

Report of the International Steering and Monitoring Committee

INTERNATIONAL SYMPOSIUM AND WORKSHOP ON TROPICAL PEATLAND
Palangka Raya, Central Kalimantan, Indonesia
20-24 September 2005

FOREWORD

Approximately 12 percent of the global peatland area occurs in humid tropical zones, mainly in mainland East Asia, Southeast Asia, the Caribbean and Central America, South and southern Africa. Peatland in Indonesia covers between 16 to 27 Mha. These ecosystems are vitally linked to conservation issues such as carbon sequestration affecting global climate change, and provision of key habitats for a diverse range of the world's flora and fauna. They also are the source of a significant portion of the freshwater and many economic resources vital to human survival. In addition, peatland ecosystems are important for water resources conservation since their ability to store water is very high and can be up to 8 times of the peat volume. Tropical peatlands, however, are also subject to land use pressures including forestry development and agriculture as well as extraction for energy and horticulture. In 1996, 1.5 Mha of Peatland in Central Kalimantan were developed for rice production. This project failed and was closed down in 1999 but left a legacy of habitat destruction and fire occurrence.

Conservation of these vast peatland areas for the carbon stored in them as well as for water protection may be solutions for the future. It seems, however, that even if conservation shows a great and significant success, the loss of forest will still occur at an alarming rate. The involvement of local communities therefore is important to the success of conservation of tropical peatland.

I am really sure that through this Symposium and Workshop we have produced important conclusions and recommendations for peat restoration and also utilization, especially in Central Kalimantan. These conclusions as well as the Symposium Statement that was agreed by all participants attending on the final day will strengthen the “Guidelines for Wise Use of Peat” which have been produced through the research cooperation of the previous STRAPEAT Project.

Finally, I would like to thank Prof. Jack Rieley, who persuaded many peat experts to attend this event, for his hard efforts to obtain funding support, so that the Symposium and Workshop could be undertaken with such considerable success. To all participants and speakers, I also would like to express my thanks, for their active participation during this symposium. To the Finland Embassy, Netherlands Embassy, VAPO Oy - Finland and U.S. Fish and Wildlife Service, I render thanks for their financial support, that has been very important to enable these meetings to take place and for the future development of Central Kalimantan, especially for the improvement of human resources at the University of Palangka Raya.

Suwido H. Limin
Director CIMTROP
University of Palangka Raya
Central Kalimantan, Indonesia
January 2006

INTERNATIONAL SYMPOSIUM AND WORKSHOP ON TROPICAL PEATLAND
Palangka Raya, Central Kalimantan, Indonesia
20-24 September 2005

PREFACE

Tropical peatland covers approximately 45 million hectares, or 12%, of the global peatland resource by area. Indonesia, Malaysia and Vietnam contain nearly 70%. Indonesia, with 22 Mha has about one half of the total area of peat in the tropical zone. Natural peat swamps in SE Asia are recognized as important reservoirs of biodiversity and scientific information and they exhibit a range of important ecological and natural resource functions. Peat swamp forests are the last refuges for several rare and endangered animals, especially orang-utan, while streams and rivers draining from peatlands are important fish habitats. In their natural state tropical peatlands are carbon sinks and stores, but drainage and forest clearance rapidly converts them to carbon sources. Rapid population growth, deterioration of existing land, especially owing to erosion and increasing competition from industry and urbanization, are exerting continuous pressure for peatland deforestation, drainage and development. However, local communities that depend on this ecosystem for cash income are experiencing poverty. In the last 30-40 years, tropical peatlands in Southeast Asia have been subjected to increasing pressure from systematic logging as dry land forest has become depleted and, more destructively, land conversion for human settlement and agriculture. The latter involves clear felling of the forest followed by land drainage and crop planting. The legacy of the ill-fated Mega Rice Project (MRP) is a treeless, non-productive, degraded, peat-covered landscape. The network of over 4600 km of malfunctioning drainage and irrigation channels has resulted in rapidly oxidising peat, an impoverished biodiversity, a terrain susceptible to subsidence and outbreaks of large-scale fires in the dry season and flooding in the rainy season. The adjacent large, forested peatland catchment, centred on the Sabangau River, has been subjected to intensive illegal logging since 1998 with disastrous effects upon this newly designated National Park. Hundreds, perhaps thousands of kilometres of timber extraction canals have been excavated across the surface of this landscape destroying its hydrological integrity by causing excessive and rapid drainage. The only way of reversing these impacts is to maintain a high water level, by retarding the rate of water flow using dams and other forms of obstruction, which must be carried out as part of a holistic restoration implementation strategy that addresses the problems of biodiversity, fire, poverty and water management.

OBJECTIVES:

This international symposium and workshop forms an important part of the EU funded RESTORPEAT Project and it will address problems of restoration of large expanses of tropical peatland by focusing on field techniques for fire control and water management. These will be linked to sustainable livelihoods of local people in order to alleviate poverty and reduce natural resources and environmental degradation. It will provide an important forum where experts in peatland restoration from the Boreal and Temperate zones can relate their experiences and methods to those involved in tackling the enormous problems of restoration of tropical peatland. The workshop will assess the situation and incorporate the views of specialists in biodiversity maintenance, water management, fire control and poverty reduction into a holistic approach to tackle these critical issues.

PRESENTATION TOPICS:

Technical and breakout sessions were held on the following aspects of tropical peat and peatlands with special focus on their restoration and wise use linked to major problems of biodiversity, fire, poverty and water.

- Impacts of the Mega Rice Project, locally and globally
- Biodiversity of peat swamp forest
- Natural resource functions of tropical peatland
- Problems of fire control on tropical peatland
- Problems of water management on tropical peatland
- Problems of illegal logging and other resource exploitation on tropical peatland
- Problems for sustainable livelihoods on and around tropical peatland
- Lessons on peatland restoration from Boreal and Temperate zones
- Proposals for future land use in the Mega Rice Project area
- Wise use principles for sustainable management of tropical peatland
- Problems of rehabilitating the Mega Rice Project area: options, constraints and dangers
- Problems facing the new Sebangau National Park
- Other relevant topics

FUNDING SPONSORS

The Organizing and International Steering and Monitoring Committees are deeply indebted to the generosity of the financial sponsors of this important series of meetings. This shows their sincere commitment to restoration and wise use of tropical peatland.

Professor Jack Rieley
Editor
School of Geography
University of Nottingham
United Kingdom

January 2007

INTERNATIONAL SYMPOSIUM AND WORKSHOP ON TROPICAL PEATLAND
PALANGKA RAYA, 20-24 SEPTEMBER 2005

WELCOMING AND OPENING ADDRESSES

(The Chair of Organizing Committee)

Excellency Mr. Governor of Central Kalimantan, Deputy Ministry of Research and Technology, Mr. Rector University of Palangka Raya, Chief of Parliament of Central Kalimantan, Muspida of Central Kalimantan, All Informal Leaders, All Participants of Symposium and Guest.

In this opportunity, I congratulate happy for us all that gather in this place, to together to think of, how to use the peat wisely.

To the Governor of Central Kalimantan, I say thank you with appreciation, and I feel a special bliss, because you sir could come amongst all these experts who wish to make a contribution according to their expertise for the acceleration of a development programmme in Central Kalimantan.

All speakers and participants, those coming from outside Central Kalimantan, and especially from abroad, I thank you, because you will join with us in this place, although I know you have had a hard effort to reach and arrive at Palangka Raya. It should be known that the participants of this symposium and workshop have come from 15 countries including Indonesia. There are 14 speakers for the symposium and 18 speakers for the workshop, and also 10 posters.

Attendees whom I respect. This symposium is the second symposium which was carried out in Palangka Raya following the first International Peat Symposium, 4 - 8 September 1995 in Palangka Raya although there have been many seminars and workshop during this time involving UNPAR as organizer, that have been carried out not only in Central Kalimantan, but also Jakarta, Bogor and Bali. Besides, at the beginning of this symposium I wish to highlight the intensive research cooperation of the EU funded RESTORPEAT (Restoration of Tropical Peatland to Promote Sustainable Use of Renewable Natural Resources) Project that consists of 14 partners, namely, UNPAR, UGM, UNSRI, BPPT-JAKARTA, Nottingham University, Leicester University, Wageningen University, Munich University, Helsinki University, Vapo Oy-Finlandia Company, Cantho University-Vietnam, Universiti Sains Malaysia (USM), Universiti Malaysia Sarawak (UNIMAS), and Malaysia Agriculture Research Development Institute (MARDI)-MALAYSIA.

Research cooperation under RESTORPEAT is a follow-up and step from several previous research cooperations that focused on finding information concerning the unique characteristics of tropical peat. During this time, especially since 1993 / 1994, UNPAR has conducted research cooperation on peat (Ecology and Economic Value of Peat swamp Forest in Central Kalimantan) within the mission statement of UNPAR. To focus this research activity, BPPT Jakarta, LOCAL GOVERNMENT of Kalteng and UNPAR agreed to establish the Natural Laboratory of Peat Forest (NLPF) with an area of 50,000 ha in the upper catchment of Sg. Sabangau, following one of the recommendations of the International Peat Symposium held 10 years ago in Palangka Raya. The existence of NLPF in Central Kalimantan has become known at national and international level, and proven by the opening of the facilities of NLPF as a Research Centre by the Minister of Research and Technology/Head of BPPT (Prof. Dr. Zuhal, M.Sc, E.E) on 9 July 1999. At the international level, NLFP has research and tourism objectives and recognition, because not less than 50 visitors from abroad per year use the facilities, including students and researchers for their studies. Base camp provides accommodation from 1 week to 1 year or more, and since early on we have announced NLFP as one of the cebtres for what we call " SCIENTIFIC ECO TOURISM". I need to tell you also that the NLFP have been able to attract the interest and involvement of universities abroad, as shown by the success of UNPAR in signing MOUs with Nottingham University-UK and Hokkaido University-Japan. Nowadays NLFP is used as a research base for the Indonesian Science Institute (LIPI), Bogor Agriculture University, University of Brawijaya, University of Sriwijaya, Gadjah Mada University, and others. Some Senior High Schools in Palangka Raya have utilized the laboratory for their study, while at the same time undertaking what we call ***Environmental Education.*** Therefore, we thank Dr. Bambang Setiadi who nowadays occupies the esteemed position of Deputy Minister of Research and Technology and is also President of the Indonesian Peat Association, for his initiative, effort and commitment to develop the NLFP in Central Kalimantan.

Governor and participants whom I respect.
Through the existence of NLFP and of the MOUs mentioned above, we have obtained many advantages and benefits, through the many opportunities to improve our human resources. However, I as coordinator of the collaboration still do not see special attention yet from all parties, how to strengthen and extend the cooperation, because it is not easy to obtain and start or braid a cooperation like this.

Honourable guests,
The second International Symposium in Palangka Raya is not without reason. Especially the reason that I need to tell that "WE DO NOT HAVE THE GUIDELINES FOR UTILIZATION OF PEAT YET". In other words, one decade ago we did not have the knowledge for utilizing the peat. Strong evidence of my statement, that we can remember again the scenario of development of the wetland area including peatswamp forest of more than one million hectare for the agriculture and plantation as called Peatland Project or Mega Rice Project (MRP). The main target of MRP was to produce rice which was mentioned as "Rice Estate" In reality nowadays this has become the source of the calamity we can call the "Haze Estate". Therefore, I as a local person and local scientist feel sorrowfull, because up to now I always got bad marks, because: First ; in a Meeting about the MRP in BAPPEDA Province of Central Kalimantan in December 1995, I was dubbed as a Communist, because I protested about the design of the canals that were carving up the peat domes that filled the landscapes between the rivers of Barito-Kapuas-Kahayan-Sabangau. At that time I said that later will happened a big problem, if the design implemented by government, that was : "wet area become dry", " dry area become wet", and " there is an area where both will happen (monotone)". Second, when I attended a meeting of the Ad Hoc Team of the MRP in BAPPENAS in 2004, because I suggested that "it is better to stop sending new transmigrants to Central Kalimantan, especially to the MRP". If the government has enough funds, it is better to improve the existing transmigrants' area, that still has many problems, to address the target of the transmigration programmes that have been formulated already. This means, if the location of transmigrants has in reality been wrong (not suitable, socio culture not acceptable), it is better to move the location to one which is suitable from various aspects. If settlement of new transmigrants is still to be carried out whilst old ones still have problems, the situation will become a major burden for the local government of Central Kalimantan and at the same time become a burden for local society. The local government is running out of time, energy, and money to overcome the problems of transmigrants, whereas the needs of local residents fall into oblivion. For these opinions, I have been dubbed as Anti NKRI.

Governor, and honourable attendant,
This symposium and workshop are really important, because we are facing the process of planning the rehabilitation of the ex MRP and that is not easy. That way also protects the remaining peat swamp forest. Thereby and to make optimal the goals which we

wish to reach through this symposium, on 20 September 2005 a National Seminar was held by the Indonesian Peat Association (HGI), in order to formulate important inputs to our deliberations and at the same time to support the symposium event and workshop of the next day. Up to now, we have witnessed that utilization of peat relies more on money than on science (example: the case of MRP). Besides, many other parties who use trial and error in managing peat with only small knowledge gathered from reading the results of other research or by only conducting small or brief research projects (i.e. not comprehensive). According to me, it is better that the government would bring in a group of researchers who have conducted much more comprehensive studies, to assist in formulating and/or specifying a programme for utilization of peatland. This strategy is important, so that both parties do not blame each other, if the programme happens to fail. The important matter of applying this strategy is to anticipate the misuse. Because, if all USERS only read a brief recommendation which has been submitted by researchers, then the interpretation can differ from what the findings support.

Governor and all participants,
To inform the experts and also the participants, yesterday (21 September 2005) we invited all participants to visit two contrasting locations, that was NLFP Sabangau which still has good peat swamp forest, and Kalampangan in Block C of the ex MRP that has been damaged by fire. Nowadays the big canals in Block C of the ex PLG have started to be blocked with the construction of dams through research cooperation of KEYTROP and RESTORPEAT. Therefore, I request Mr. Governor please have the pleasure to give instruction, and spirit to the participants of symposium and at the same time open ceremonially the International Symposium and Workshop that is being held from 20 to 24 September 2005.

Thank you so much and God bless us.

Palangka Raya, 22 September 2005 The
Chair of OC,

SUWIDO H. LIMIN

INTERNATIONAL SYMPOSIUM AND WORKSHOP ON TROPICAL PEATLAND
PALANGKA RAYA, 20-24 SEPTEMBER 2005

WELCOMING AND OPENING ADDRESSES

(Deputy Minister of Research and Technology)

Excellency Mr Governor of Central Kalimantan, Parliament Members of Central Kalimantan, Unsur Muspida, Mr. Suwido Limin as OC and Prof Jack Rieley (International Peat Society).

Let us to muse deeply what the meaning is of this event today and the attendance of peat experts from Europe, USA, Canada, Japan, Vietnam and also those from Indonesia who are involved in the Indonesian Peat Society. Why did they come to Palangka Raya today from far away by their one budget without one Rupiah from the Indonesian Government? There is only one reason they came to this province and that is because of peatland.

Actually, Mr Teras Narang should be the happiest Governor in Indonesia, because has available about 3 million hectares of peatlands in Central Kalimantan. If asked, all of the international experts present here today would agree, clearly and exactly, peatland is a great natural resource.

I would like to explain why some experts including myself and my colleagues from the Indonesian Peat Society want to devote their long life for learning about peat. Some of them have only spent just five years doing this, but others of them have been doing it for more than 30 years - thinking about and researching on peatlands. Peatland is a great material, because peatland can be converted into other types of land, but it can also provide important materials. Peat is a sponge for holding very large amounts of water while at the same time it performs more functions than other type of swamp in the world. Peatland is also a most beautiful ecosystem. The beauty of the sunset in the Sabangau peat forest is much different from Europe.

The sound of birds, orang utan and thousands of insects from before noon to dark is never heard in European forests. This sound is very exotic when heard by people who has are unfamiliar with similar forest in the tropics. Peat is a natural resource which has typical characteristics.

In Java, Sumatera, Bali and Sulawesi, people have spent much money collecting water by constructing giant dams and canals ten to hundreds of kilometres long to bring water to their field crops. In Kalimantan, however, peatland with peat domes are naturally functioning catchments and reservoirs, collecting water in rainy seasons and releasing it slowly in dry seasons, without payment. In the other word, Central Kalimantan would have no meaning without peat.

Excellency Mr Governor. Is I have explained, the people attending this symposium and workshop are the international and national class of experts on peatland. Scientifics papers by them have given the scientist community's views about tropical peatland. Present here are members of the International Peat Society that has its secretariat in Finland. They want to explain to the wide world that they have negative thinking on the failure of the Mega Rice Project (MRP) based on science and not politics. They will provide the information on what we must do and how best to manage our peatland wisely. Some other experts from Finland are also attending this symposium because in that country the economy relies not only upon income generated by industries such as Nokia and Volvo but also on energy generated using peat.

We also reported that for the last ten years International Collaboration has been established between UNPAR, BPPT Technology-Jakarta, Ministry of Research and Technology Republic of Indonesia, Nottingham University, Hokkaido University and other countries. This collaboration has resulted in UNPAR having the greatest number of staff at Master and Doctoral level with background is peatland of any university in Indonesia. About twenty Master and PhD level personnel have been produced through this collaboration.

As the theme of this symposium today, peat experts will be discussing and formulating on the management of peatland with respect to fire, wise use of peatland, water management and poverty. They will be relating their experiences of these issues. I assure the Governor of Central Kalimantan, that to my knowledge, this event is the biggest meeting devoted to peatland in Indonesia in 2005. Two days before, we discussed seriously until 8 pm, although according to the schedule should be finished at 4 pm. Why, because we wanted to agree key words for the peat utilization of peat in Central Kalimantan.

We recommended that the Local Government of this province must give full attention to the peat domes as major reservoirs of water resources in Central Kalimantan. Therefore, peat damage must be restored, and attention given to the Natural Laboratory of Peat Swamp Forest and water management. The ex MRP area that has been seriously damaged must be restored also. The opening of the ex MRP was started by Presidential Decree so it is difficult to accept if restoration of the ex MRP is undertaken by a person or small group.

Mr Governor and participants,

I would like to close my address with the following keywords: "Central Kalimantan-Cooperative-Welfare in peatland". Let us contemplate comparison between Palangka Raya and Pontianak. The two cities are surrounded by peatland. But, because peatland in Pontianak has been used intensively, that city now has ten flights every day as a consequence of regional economics based on peatland. Almost all of the crop production in Pontianak is carried out on peatland. Pontianak needs for food crop is satisfied completely from peatland. Unfortunately, Palangka Raya so far has not been able to find good ways for wise use of peat, and until now still has only one return flight a day from Jakarta to Palangka Raya. This is evidence of regional economics running slowly. This symposium shows to the Central Kalimantan communities that peatland is important in the world.

Before I finished my addresses, I would like to introduce some one who has worked hard for this symposium. He has spent more than 14 years of his life for working together with Indonesian scientists for doing research. He has also developed some of the staff at UNPAR through Master and PhD courses. He has invited some donors to fund research on tropical peatland and also this symposium. He has exposed Indonesian tropical peat issues to become important issues in the world. I invite all of you to give applause to him: Prof. Dr. Jack Rieley.

Thank you.
Wassalam Wr. Wb.

BAMBANG SETIADI

INTERNATIONAL SYMPOSIUM AND WORKSHOP ON TROPICAL PEATLAND PALANGKA RAYA, 20-24 SEPTEMBER 2005

WELCOMING AND OPENING ADDRESSES

(Prof. Jack Rieley, The University of Nottingham, UK)

Excellency the Governor of Central Kalimantan Province, Rektor of the University of Palangka Raya, Deputy Minister of Research and Technology of the Government of Indonesia, Director of CIMTROP/UNPAR, distinguished guests and fellow participants, it is an honour to give this opening address on behalf of the European Union RESTORPEAT Partnership, the organisers of this international symposium and workshop.

I last stood at this rostrum in the Batang Garing Conference Centre almost exactly 10 years ago on the occasion of the International Symposium on "Biodiversity and Sustainable Management of Tropical Peatland". Several significant events have occurred since then and much research has been carried out. History appears to be repeating itself – but not quite. For example, the ill-fated Mega Rice Project has been and gone and we now have widespread peatland degradation and recurrent fire. Poverty of local people has increased and the prospect for their future livelihood is poor. On the positive side, the European Union partnership of peatland scientists, has just published a synthesis of 10 years of cutting edge research in the book "Wise Use of Tropical Peatlands: Focus on Southeast Asia" that is a guide and source book for those involved in management and restoration of tropical peatland.

During the next few days, we shall be analysing the four core problem issues for restoration of tropical peatland, namely, biodiversity, fire, poverty and water, with the assistance of the most prestigious experts in the world. In the symposium, we shall review experiences of peatland restoration from different parts of the world and extract lessons to help address the specific problems of Central Kalimantan.

In the subsequent workshop, we shall focus the brainpower and experience of more than 200 participants upon these key issues in an in-depth analysis to identify and agree action points for each. These will form the basis of an "Action Plan for Restoration and Wise Use of Tropical Peatland" that will be enshrined in our closing statement.

II wish to express the sincere appreciation and thanks of the organisers to our financial sponsors: The Embassy of Finland, Jakarta, The Embassy of The Netherlands, Jakarta, Vapo Oy, Finland and US Fish and Wildlife Department, Great Ape Conservation Fund who made the meetings possible at minimal cost to the participants.

I wish you all an enjoyable and productive time over the next few days.

INTERNATIONAL SYMPOSIUM AND WORKSHOP ON TROPICAL PEATLAND PALANGKA RAYA, 20-24 SEPTEMBER 2005

WELCOMING AND OPENING ADDRESSES

(Rector of The University of Palangka Raya)

My Honourable:

1. The chair for the House of Representative of Central Kalimantan Province
2. The Governor of Central Kalimantan
3. The Mayor of Palangka Raya City and all Regents of Regencies of Central Kalimantan
4. Head of Regional Police of Central Kalimantan
5. Head of Police Resort of Palangka Raya
6. All participants of Symposium and Workshop
7. All attendant guests

First of all I would like to express my gratitude to all the participants and welcoming to the "Earth of Tambun Bungai" and especially to the beautiful city of Palangka Raya. We should pray to the Almighty God so that the International Symposium and Workshop will run very well on God's will.

My gratitude is especially addressed to the Governor of Central Kalimantan who has been able to attend this important scientific meeting. His presence is hoped to be able to motivate and encourage all of us, scientists and researchers so this important meeting can contribute something useful for the acceleration of development in Central Kalimantan, in its relation to the management of peatland.

My special gratitude is also forwarded to all scientists of peatland from overseas coordinated by Professor Jack Rieley. I appreciate very much your participation in this International Symposium and Workshop. The same appreciation is also sent to all scientists of peatland from all over Indonesia who are members of the Indonesian Peat Association (HGI).

In addition, my special and high appreciation is also addressed to the Ambassador of Finland in Jakarta. Even though he could be with us here in this moment, he has contacted me directly by phone and apologised for his absence but he actively supported us by financial support. I also give the same respect to the US Fish and Wildlife Service, Vapo Oy, Finland and the Ambassador of The Netherlands in Jakarta.

Honourable all participants,

I think it is important to let you know that this International Symposium and Workshop is very strategic to be held in Palangka Raya Central Kalimantan because of the Memorandum of Understanding (MOU) on Peatland Research that started in 1993/1994. On September 4-8, 1995 the first International Symposium on Peatland was held in Palangka Raya by the cooperation of the Provincial Government of Central Kalimantan and the University of Palangka Raya focusing on ecological aspects of peatland.

This national and international cooperation has given positive and meaningful contribution to developing Human Resources of the University of Palangka Raya and the people of Central Kalimantan in general, through research, seminars, workshops, international symposia, short courses and short visits and comparative studies abroad. This international Symposium and Worksop also promotes the Government of Central

Kalimantan and the University of Palangka Raya to the international world, especially through the large number of lecturers who have obtained their master and doctorate (Ph.D.) degrees from abroad, especially from Nottingham University in the United Kingdom and Hokkaido University in Japan.

This International Symposium and Workshop that is being held from September 20-24 2005 on " Restoration and Wise Use of Tropical Peatland" focuses on Biodiversity, Fire, Poverty, and Water Management, , is an integral part of a multidisciplinary, international Peatland Restoration Project called RESTORPEAT sponsored by European Union focussing on techniques of fire and water management on tropical peatland areas. This is also one of the ways to solve the poverty problem of communities who really obtain their livelihood from peatland.

We have heard very often the usefulness of peatland for human livelihood, but on the other hand it often creates problems such as fire and smoke. To this special problem I have heard that the neighbouring province, West Kalimantan has been successful in overcoming peatland and forest fires. To do the same thing here in Central Kalimantan, I think we could learn from West Kalimantan.

My honourable all invited guests, The implementation of development including conservation on peatland areas is very good indeed if it is based on a good scientific research. This is based on my experience in joining the program of conservation and restoration of peatland in Central Kalimantan.

Once again I highly appreciate all ideas which are found in this scientific activity and the government of Central Kalimantan will welcome all positive and constructive ideas.

My honourable all participants,
As the Rector of the University of Palangka Raya, please let me express my thanks toall of you for your time and readiness to come to this International Symposium and Workshop and to present your papers.
Last but not least, On behalf of the University of Palangka Raya I please accept my apology for all the weakness and lack in the organisation of this Symposium and Workshop. Thank you very much and have a nice symposium and workshop.

University of
Palangka Raya Rector,

HENRY SINGARASA

INTERNATIONAL SYMPOSIUM AND WORKSHOP ON TROPICAL PEATLAND PALANGKA RAYA, 20-24 SEPTEMBER 2005

WELCOMING AND OPENING ADDRESSES

(Governor of Central Kalimantan)

Assalamu'alaikum Wr. Wb.
Prosperous regards and good morning to all of you. Honorable MUSPIDA, Head of ody/Institute/Official of Central Kalimantan, Rector of the University of Palangka Raya and other universities, invited guests and symposium participants. Firstly, we thank God who has blessed us with everything we have received until now, so that we can participate in this symposium and workshop that will be opened in a moment.

The audience whom I have the honour to address, For all invited guests and participants from outside of Central Kalimantan, especially those who come from other countries, I take this opportunity to convey to you my regards and welcome to the Tambun Bungai earth, the province reverberates the Isen Mulang enthusiasm in implementing its development. I am aware that all of you arrived in Palangka Raya yesterday or several days before and have already conducted part of your agenda. Unfortunately, I cannot say that I give you a warmest greeting, because your arrival has been spoiled by the haze and thick smoke which has come from forest and peat fires.

I also would like to thanks the organizing committee that has resolved to conduct the symposium and workshop according to the schedule decided. I believe that all of the guests and participants from outside of Indonesia are expert on the science of global warming and the greenhouse effect. Therefore in this event, it will be a good time for all of you to feel directly some of the factors that relate to global warming and the greenhouse effect, especially that coming from forest and peat fires. I expressly propose this special point to invite all of you whom I believe are scientists with specialized expert backgrounds, to support the philosophy ever since I was entrusted as a Governor, namely*, "Think Globally, Act Locally"*

Honourable guests,
Related to the last statement, I recall the interview by National Television about how do I look at my position as a Governor compared to that of Head of a Commission of Parliament of the Republic of Indonesia, when I have been entrusted to lead this Province. For me, my position as Head of a Parliamentary Commission is more prestigious, perhaps more high profile, because of the scale of authority and relationships, but my commitment is already fixed, because I am working for where I can do most and where my heart and mind are. To all of you who are not residents of Indonesia, but come from many parts of this earth, if your ideas, enthusiasm and commitment have concern for Central Kalimantan province, then you are performing the function of stakeholders in the development of Central Kalimantan, and as a friend or brother to develop this province.

As a Governor who was elected directly by the people, so the vision, mission and development program that I am implementing has a major dimension of working together for maximum effort, and mutual benefit. This involves public accountability, that can be expressed as "from promise to deliver, to deliver the promises", to the communities of Central Kalimantan. Related to this statement, the mission on management of natural resources, environmental quality and land use is described by the utilization patterns involving safety, and embraces concepts of environmental friendly and empowerment of local communities. In a special manner related to forest resources, I have decided already upon two basic policies, namely, firstly, that the forest is not the main source of income in Central Kalimantan and secondly, forest in Central Kalimantan, needs an opportunity for recovery, for breathing, for environmental preservation.

I often make a controversial statements relating to exploitation of the natural resources in Central Kalimantan aimed at increasing the prosperity of communities. During the six weeks since I was inaugurated, I have always invited people to slow down to remind themselves if their statements and wishes are supported by facts and data. Since forest exploitation commenced, the number of poor families in Central Kalimantan has reached about 35 % so one must ask what forest exploitation has really contributed to the income of local people or to the local government's ability for community empowerment? I am really surprised and touched when I learn that the exploitation of one of the major natural resources in Central Kalimantan contributed just enough value to upgrade a damaged section of road only 500 m long, while the road itself had been build by funds raised by the community. In the other hand, local communities have been mere spectators or used as low level labourers. For me, this reality has very much irony, because my vision for the next five years is to develop this region, remove its isolation and take Central Kalimantan in the direction of prosperity and with dignity.

Efforts to implement preservation and wise use of natural resources will be impossible to achieve if we are unable to provide alternative job opportunities, and are unable to solve the problem of poverty that is affecting communities. Therefore, the themes of this international symposium and workshop are exactly what are required and should be applied not only for restoration and wise use of tropical peatland, but for wise use of all natural resources in Central Kalimantan. About what had happened in the former Mega Rice Project (MRP) is a recent phenomenon that is easy to look at and learn from. This ambitious project has had direct and indirect negative impacts on more than 50% of the peat swamp forest in Central Kalimantan. It has also caused difficulties for the economies of local communities as a result of fire, drought, flood and environmental damage. But, since Presidential Decree No. 80 Tahun 1999, the theme of rehabilitation proclaimed by the President of Indonesia has not involved real action and has been lacking mechanisms for implementing solutions to these problems. Before the MRP was stopped more than US $ 250 millions were spent by the Government and more than four times the length of Java Island (> 4000 km) of canals was built that are now the source of disaster for the environment and people. Presidential Decree 80/1999, although it mentioned that the Governor of Central Kalimantan would be the coordinator for implementing development in those areas where cultivation was feasible and the Minister of Forestry would be coordinator of a prevention program in the conservation areas, no budget was allocated. Without finance for restoring and conserving the recommendations of the Ad Hoc team for the Integrated Action Plan remain as a statement for academic discussion. The peatland and forest that remain in the former MRP are not as the spine in meat, but as an ulcer or stigma, which people prefer to throw away or try to forget. Those areas, however, provide the best opportunities available for scientific reputation if they can be rehabilitated using the information available from research, technology and knowledge about wise use of peatland and forest for the benefit of community prosperity. If this point is agreed by us, I shall be pleased to invite all of you to support me to restore and rehabilitate the Ex-MRP area with an integrated plan and management strategy, and we should do this with due attention to new legislative requirements that should prevail from now on.

The audience, and especially the Symposium and Workshop participants, should understand that although the forest and peatland in Central Kalimantan has been degraded and damaged significantly, the Government and communities of this province are still responsible for its impact on the global environment. The peatland in Central

Kalimantan is the largest in Kalimantan island (more than one seventh of the total peatland in Indonesia). It covers more than one fifth of the area of this Province and one third or one million hectares must be conserved, because it supports peat thickness of more than 3 metres. Peatland in Central Kalimantan stores a very large amount of carbon equal to about 6.35 Giga tonne; a deposit is analogous to an ammunition store that has implications for environments both local and global. On the other hand, more than 64% of poor families in Central Kalimantan live and work in or near to its forests and peatland. Consequently, the amount could be described as follows “imagine 80 thousand families or about 320 thousand poor people living and staying above the tank or heap of burnt material which has been used by humans for one year”. This is one view of the peat deposit and poverty relationship, which is perhaps not exactly true, but describes and illustrates the scale of the problem and is not a deviate or modified result. This is our challenge, a global challenge that will need great support and hard work from all of us.

Participants of this international symposium and workshop:
There are several views which I have explained in my speech at the opening of this event. I hope they will help to guide you in your deliberations. Finally, I wish to express my best wishes and encouragement, to add enthusiasm and spirit for all participants to produce the best result from the meetings this week, to contribute to a solution based upon real situations that you have studied and have experience of, and especially to bring forward recommendations, which can be adopted and implemented especially for the restoration and wise use of peat swamp forest in Central Kalimantan.

In ending my speech with a blessing from the God, I declare the International Symposium and Workshop on Restoration and Wise Use of Tropical Peatland formally open. Thank you.

Wassalamu’alaikum Wr. Wb.
Governor of Central Kalimantan,

A. TERAS NARANG

INTERNATIONAL SYMPOSIUM AND WORKSHOP ON TROPICAL PEATLAND
Palangka Raya, Central Kalimantan, Indonesia
20-24 September 2005

"Restoration and Wise Use of Tropical Peatland: Problems of Biodiversity, Fire, Poverty and Water Management"

MEETINGS PROGRAMME

Wednesday 21 September 2005	INTERNATIONAL SYMPOSIUM AND WORKSHOP DAY 1	*FIELD EXCURSION*
07.00-18.00	*FIELD EXCURSION TO BLOCK C OF THE MRP (KALAMPANGAN) AND THE NATURAL LABORATORY (SEBANGAU)*	LEADER
GROUP 1	*BIODIVERSITY AND ECOLOGICAL FUNCTIONS*	Yustinus Sulistiyanto
GROUP 2	*FIRE*	Suwido H. Limin
GROUP 3	*WATER*	Adi Jaya
GROUP 4	*SUSTAINABLE LIVEL IHOODS*	Darmae Nasir
07.00	*Leave Palangka Raya*	
08.00	*Arrive Kalampangan*	
09.00	*Arrive at Kalampangan research station and peatland restoration pilot study site*	
<u>09.00</u>	<u>Refreshments</u>	
09.30 10.00-11.00	*Explanation of field research and monitoring programmes* Inspection of research and monitoring sites and dam construction *Depart from Kalampangan research site*	Jyrki Jauhiainen, Hidenori Takahashi, Suwido H. Limin
12.30	*Arrive at Kereng Bengkirai harbour, depart for Natural Laboratory*	
13.30 13.30-14.00 14.00 14.30-16.00 17.00	*Arrive at natural Laboratory Base Camp and Field Research Station* Lunch *Explanation of field research and monitoring programmes* *Inspection of research and monitoring sites and dam construction* *Depart from Natural Laboratory*	Jack Rieley, Suwido H.Limin
18.00	*Arrive in Palangka Raya*	
19.00	*Symposium/Workshop Dinner*	

Thursday 22 September 2005	***INTERNATIONAL SYMPOSIUM***	
TIME/SESSION	**PROVISIONAL PROGRAMME**	**PROVISIONAL SPEAKERS**
		Suwido H. Limin (OC) Professor Jack Rieley (SC) Rektor of UNPAR Deputy Minister of Research & Technology Governor of Kalteng
09.30-10.00	**Refreshments**	
SESSION 2: *Biodiversity and natural resource functions of tropical peatlands* (11.30-13.00)	11.30 : 4. Unlocking the natural resource functions of tropical peatlands - the key to wise use. 11.55 : 5. Water management for sustainable wise use of tropical peatland 12.20 : 6. Carbon stored in tropical peatland and losses resulting from fire and land use change 12.40 : 7 Wise use of tropical peatland – The case for The Orangutan	Dr. Susan Page, UK Ir. Adi Jaya, Indonesia and Mr. Henk Ritzema, Netherlands Dr. Harri Vasander and Dr. Jyrki Jauhiainen, Finland Simon J. Husson and Helen C. Morrogh-Bernard, UK
13.00	Questions and discussion	
13.15-14.00	Lunch	
SESSION 3: *Fire awareness, detection and control* (14.00-15.00)	14.00 : 8. Outputs from the 3 year GEF Project on peatlands 14.20 : 9. Fire occurrence in Borneo's peatlands between 1997 and 2004 and its impacts 14.40: 10. Fire management role in lowland plantation development	Mr. Faizal Parish, Malaysia. Prof. Florian Siegert, Germany Mr. Brad Sanders, USA Dr. Sarah Jewitt, UK
SESSION 4: *Poverty* (15.00-15.20)	15.00 :11. Involving local communities in the alleviation of poverty and environmental degradation: a sustainable livelihoods approach	
15.20	*Questions and discussion*	
15.40-16.10	Refreshments	
SESSION 4: *Peat land Restoration and water management* (16.10-17.45)	16.10 : 12.Review of peatland restoration globally 16.35 : 13.Water management for multiple wise use of tropical peatland 17.00 : 14.Indonesian Government approach to peatland restoration 17.25 : 15.The Key of Successful for Managing Peatland in Central Kalimantan is The Government Policy	Martin Schumann, Germany Dr. Henk Wosten, Netherlands Dr. Bambang Setiadi, Indonesia Suwido H. Limin
17.45	Questions and discussion	
18.00	Welcome Reception	

Friday 23 September 2005	**INTERNATIONAL WORKSHOP DAY 1**	**LEAD PARTICIPANTS***
BREAKOUT SESSION 1:* Biodiversity, natural resource functions and Monitoring *(08.00-09.30)	**Provisional topics** 08.00: Gibbon and orangutan food choice and its conservation implications in the Sebangau National Park 08.10: What can apes tell us about the health of their environment? 08.20: Potential effects of naturally low rates of secondary seed dispersal on forest tree species diversity in regenerating psf. 08.30: Secrets and treasures of Polyporaceae fungi in psf. 08.40: Limnology of tropical blackwater ecosystems 08.50: Preliminary study of fish biology and ecology in tropical peatland in Central Kalimantan 09.00: The relation between regeneration of plants and small mammals in peat swamp forest in Central Kalimantan. **09.10-09.30: Discussion**	Susan Cheyne Mark Harrison Laura Graham Typuk Artiningsih Sulmin Gumiri Yulintine Kyoko Hamomoto
BREAKOUT SESSION 2: *Fire-awareness, detection, control* (08.00-09.30)	**Provisional topics** 08.00: Fire behaviour at different levels of peatland decomposition 08.10: Biogeochemistry of degraded peatlands 08.20: Controlling Haze from small scale agriculture 08.30: Seasonal changes in the CO concentration in air and peat fires in Palangka Raya 08.40: Environmental field trials and GIS image analysis along the Rungan River, Tangkiling District, Kalteng 08.50: Giving Full Responsibility for Local Community As One Way of Fire Management in Central Kalimantan: TSA's Consepts **09.00-09.30: Discussion**	Bambang Hero Saharjo Ahmad Kurnain Gusti Z. Anshari Hidenori Takahashi Viktor Boehm Suwido H. Limin

BREAKOUT SESSION 3: *Wat er management and restoration techniques* **(08.00-09.30)**	**Provisional topics** 08.00: Nutrient inputs, cycling and retention in the upper Sebangau peatland 08.15: Hydrology restoration of ex-mega rice project in Central Kalimantan through canal blocking 08.30: Potential of remote sensing in monitoring hydrology of peat swamp forest 08.45: Impact of reclamation on chemical properties of ombrogenous tropical peat 08.45-09.14: other speakers **09.15-09.30: Discussion**	Yustinus Sulitiyanto Alue Dohong Martin Stahlhut Agus Supriyo
BREAKOUT SESSION 4: *Poverty and sustainable livelihoods* **(08.00-09.30)**	***Provisional topics*** 08.00: Indigenous knowledge in the use of land and water resources in Danau Sentarum National Park 08.15: Poverty among the Dayak: cultural approach 08.30: other speakers **09.15-09.30: Discussion**	Gusti Z. Anshari Kumpiady Widen
09.30-10.00	**Refreshments**	
BREAKOUT SESSIONS (10.00-11.00)	**Continue** SWOT/SMART analysis	
11.00-14.00	**BREAK FOR PRAYERS**	
12.30-14.00	**LUNCH**	
BREAKOUT SESSIONS 14.00-16.00	**ACTION PLANNING AND RECOMMENDATIONS**	
16.00-16.30	**Refreshments**	
16.30-17.30	***PLENARY SESSION AND DISCUSSION***	

Saturday 24 September 2005	INTERNATIONAL WORKSHOP DAY 3	LEAD PARTICIPANTS
STATUS REVIEW AND RECOMMENDA-TIONS 1: **Biodiversity and Monitoring *(08.00- 08.45)***	**Provisional topics** • Report from the Rapporteur • Presentation of Action Plan • Discussion	Susan E. Page
STATUS REVIEW AND RECOMMENDA-TIONS 2: ***Fire awareness, detect ion, cont rol*** **(08.45-09.30)**	**Provisional topics** • Report from the Rapporteur • Presentation of Action Plan • Discussion	Brad Sanders
09.30-10.00	**Refreshments**	
STATUS REVIEW AND RECOMMENDA-TIONS 3: ***Water*** **(10.00-10.45)**	**Provisional topics** • Report from the Rapporteur • Presentation of Action Plan • Discussion	Henk Wosten
STATUS REVIEW AND RECOMMENDA-TIONS 4: ***Poverty and su stainable livelihoods*** **(10.45-11.30)**	***Provisional topics*** • Report from the Rapporteur • Presentation of Action Plan • Discussion	Fachrurrozie Sjarkowi
EVALUATION, INTEGRATION AND STATEMENT FORMULATION 11.30-12.15	*Finalisation of action plans and merging into a unified one*	
STATEMENT PRESENTATION AND AGREEMENT 12.15-12.45	**Palangka Raya Statement on Restoration and Wise Use of Tropical Peatland** ***Participant evaluation of the symposium and workshop***	Jack Rieley
12.45	**Closing Ceremony**	UNPAR Rektor, Prof. Jack Rieley, Suwido H. Limin
13.00-14.00	**Lunch**	

PALANGKA RAYA STATEMENT ON RESTORATION AND WISE USE OF TROPICAL PEATLANDS

Problems of restoration of tropical peatland following inappropriate land use change, illegal logging and fire were addressed at the ***International Symposium and Workshop*** *on* **"Restoration and Wise Use of Tropical Peatlands: Problems of Biodiversity, Fire, Poverty and Water"** *held in* ***Palangka Raya, Central Kalimantan, Indonesia on 21-24 September 2005****. These meetings were attended by over 200 peatland scientists from Indonesia and 13 other countries, and land managers, representatives of national and local government, NGOs and community groups, and the private sector. The symposium focused on measures needed urgently for biodiversity maintenance, fire control and water management linked to sustainable livelihoods of local people in order to alleviate poverty and reduce natural resources and environmental degradation. The workshop participants assessed specific problems of peatland restoration in the former Mega Rice Project and the Sebangau catchment areas of Central Kalimantan, and incorporated the views of specialists and stakeholders into a holistic approach to identify solutions using the* **"Wise Use"** *approach. The importance of peatlands to national and regional economies and the environment was stressed in opening statements by the Governor of Central Kalimantan and the Indonesian Deputy Minister for Research and Technology. The Governor expressed his concern over the current situation and made a strong commitment to support positively, initiatives to solve the problems of fire and water management through sound science and wise use. He invited the participants to submit to him their conclusions and recommendations.*

The International Symposium and Workshop:

NOTES that there are serious problems facing the peatlands of Central Kalimantan as a result of the failed Mega Rice Project, illegal logging and fire. These are affecting negatively the livelihoods of local people and the natural resource functions of the remaining peat swamp forest;

WELCOMES the positive opening statements made by the Deputy Minister for Research and Technology who outlined the importance of tropical peatlands and peat and the Governor of Central Kalimantan who made a plea for assistance to help solve the problems of peatland restoration confronting his province;

RECOGNIZES that peatland and forest fires, promoted largely by land use change, illegal logging and peatland agriculture, are a major environmental problem in Southeast Asia that results in a noxious atmospheric haze affecting both people and the environment;

IDENTIFIES key issues affecting the biodiversity of natural peat swamp forest and recognizes the difficulties and possible methods to combat fire employing appropriate measures for awareness, control, water management, wildlife conservation and poverty alleviation;

URGES the Indonesian Government to prevent further development projects on peatland, especially on peat over three metres thick and on shallower peat where the underlying substrate is nutrient deficient or potentially toxic, and support the Government's 'Ad Hoc Team' in its efforts to find an integrated and acceptable solution to the problem in partnership with stakeholders;

WELCOMES the acceptance of Indonesian National and Provincial Governments of the need for peatland restoration, linked to fire prevention, poverty alleviation and water management, and their commitment to charting a new course for tropical peatlands through the 'Wise Use' approach.

ENCOURAGES investment by Indonesian and international governments, donor agencies and the private sector in the conservation and restoration of tropical peatland while also **PROMOTING** wise use and participatory management of this ecosystem in partnership with local communities;

EMPHASIZES the need for accountability and transparency, new partnerships, community participation, capacity building and application of appropriate technology as key elements of such investment;

RECOMMENDS that the action points identified by the workshop expert groups on biodiversity, fire, poverty and water be acted upon and implemented as matters of urgency (appended).

Endorsed by the participants at the International Symposium and Workshop on Restoration and Wise Use of Tropical Peatlands, at the Closing Plenary Session held in Palangka Raya, Central Kalimantan Indonesia on 24th September, 2005.

BIODIVERSITY

Peat swamp forests (PSF) have high natural biodiversity in unique and variable habitats. This should be conserved and enhanced. Conservation of the PSF habitat must include all fauna, flora and ecological and physical processes necessary to ensure its long-term survival. Wherever possible, and especially where fragments remain, peat swamp forest should be rehabilitated to increase the area of this ecosystem in order to provide the maximum area for its biodiversity. Conservation areas should be managed according to 'Wise Use' principles and contribute to the livelihoods of local people in a sustainable manner.

Problems

- Lack of awareness of the rules/laws governing the PSF area and lack of adequate law enforcement/resources to combat threats to PSF.
- Fires, drainage channels and illegal logging extraction canals; habitat loss and fragmentation.
- Over-exploitation of natural resources from PSF.
- Lack of knowledge and understanding locally about the importance and functions of PSF (local, regional and global) and the importance of conserving the PSF for the future.
- All forest (including PSF) in Central Kalimantan has been divided up and extraction allocated to logging companies (HPH) so that local people no longer have feelings of ownership and respect and hence have little concern for biodiversity or resource deterioration and fire susceptibility.

Priority Actions

- Map locations of all remaining peat swamp forest and assess their condition. Incorporate this information into a unified, integrated plan for conservation and enhancement of PSF biodiversity, linked to aspirations and needs of local people.
- Prevent inappropriate drainage and fires (see Fire and Water recommendations)
- Maintain and/or create adequately sized corridors between forest fragments to assist biodiversity conservation and gene flow, especially in Ex-PLG/MRP; link fragments into larger units by enrichment planting of peat swamp forest trees of local provenance.
- Establish local patrol teams (Tim Patroli CIMTROP; Rhino Patrol, Sumatera etc) to protect biodiversity and inform local people of its importance. These teams can also be used for fire awareness and control purposes.
- Local people should be made aware of rules, laws and regulations, clearly and positively; these must be enforced with severe penalties for non-compliance to act as deterrents.
- Local government must commit to conservation with vision and mission statements.
- Undertake targeted research and make results available to local people and local development professionals (i.e. translate into Indonesian).
- Promote education to explain the ecological processes of PSF to local people, local government and decision makers; enable local professional development; introduce environmental awareness into school curricula.
- Promote the 'Wise Use' use of peatland resources to avoid over-exploitation.

Constraints

- Lack of funding for targeted research and local, national and international education.
- Lack of local knowledge about the importance of the peat swamp and potential opposition to biodiversity conservation as a result.
- Lack of grass-roots capability to empower local communities to be custodians of their biodiversity.
- Short-term settlement of people from outside of the Province onto peatland areas where there is no likelihood to obtain a sustainable livelihood.

Resources needed

- Research and conservation capability and resources.
- Firm commitment from local, national and international governments, and multinationals, NGOs and the private sector to conservation and wise use of PSF.
- Alternative sources of funding to promote alternative sustainable livelihoods to over-exploitation of natural PSF resources (see Poverty recommendations).

FIRE

Forest and land fires have become an annual event that causes public health and socio-economic problems locally and nationally and unwanted trans-boundary smoke/haze across the Southeast Asian region. Fires remain the primary tool for land-clearing, although fire is not acknowledged as a major problem by the Indonesian Government at local and national levels as shown by the lack of funding and control resources allocated by them. A lead agency, staffed with experienced people, utilizing local communities, supported by proper legislation, funding, and fire mobilization capabilities, is essential to assess existing resources, determine requirements and coordinate activities on the ground within Central Kalimantan in order to prevent and combat fire.

Problems

- Forest and peatland fires have become a reegular event that causes unwanted trans-boundary smoke/haze, degrades the environment, increases poverty and harms human health.
- Over exploitation of forests, land use change and improper water management (MRP) are the main causes of these fire events.
- Fire is always caused by people and starts where they gain access to forest and peatland for human activities, e.g. roads, channels, rivers and lakes.
- Fire is the main tool for communities to establish land tenure outside of towns and villages and along roads, and land owners/licensees to achieve land-clearing objectives prior to development, and for disposal of unwanted waste.
- Current coordination of fire suppression activities has not resulted in effective actions.
- Community participation is lacking in fire management activities because most land and forest is allocated to logging companies (HPH).
- A lack of adequate firefighting equipment, operational funding, training, and fire prevention awareness contributes to the annual smoke/haze events.
- The conclusions of the April 2003 Workshop on Fire, which recommended the TSA concept be adopted, especially to empower local communities in and around the areas most susceptible to fire, were not implemented.

Priority Actions

- Establish and empower a lead coordinating agency at Provincial level that integrates activities in the regencies and villages, for example, a TSA Foundation that is supporting the local government but gives full responsibility and trust to local communities.
- Prepare an inter-agency fire management response plan.
- Ensure budgets and resources (human and operational) are available before emergency fire events.
- Ensure enforcement of existing fire laws/regulations and enact new ones if required.
- Involve stakeholders in solving fire issues and problems.
- Provide education, training and awareness for fire management.

Constraints

- Lack of coordination, funding, planning and on the ground experience and training.
- Fire is not prioritized as a main problem for which government funding is required.
- Peatlands are viewed as marginal land that does not require significant investment.
- Lack of understanding of the special characteristics of tropical peat and peatland, especially the high value of its biodiversity and carbon store and the impact of fire upon these.

Resources needed

- Skilled people, suitable quantities and types of firefighting equipment
- Sufficient funding for operational management
- International support and expertise

POVERTY

People's ability to escape from poverty is critically dependent on their access to livelihood maintaining assets. The sustainable livelihoods (SL) approach seeks to determine poor peoples' livelihood priorities and link these to different socio-economic solutions depending upon specific circumstances. By developing a detailed understanding of the factors lying behind peoples' choice of livelihood, the sustainable livelihoods approach seeks to reinforce the positive aspects and mitigate constraints and negative influences. Emphasis should be placed on reducing vulnerability and, simultaneously, promoting improvements to income availability, well-being, food security and sustainable natural resource use. The overall research emphasis of the SL approach is participatory in nature. SL options for communities living near peat swamp areas include: the potential of different land uses, integrating the conservation and development of tropical peatland, and forging partnerships between local communities, local governments, DC government agencies, NGOs and international donors and experts in order to promote the sustainable restoration and management of peat swamp forest and peatland in Central Kalimantan.

Problems

- Lack of human capital (technical support and entrepreneurial skills)
- Dispersed population with inadequate means of communication and transportation
- Poor quality produce of low value and absence of marketing network
- Lack of political representation for local communities
- Price of commodities (e.g. rattan, rubber, palm oil) depends on world market price

Priority Actions

- Focus on indigenous knowledge and employ participatory approaches that prioritize local development aspirations.
- Promote development of skills and market knowledge/information through continued technical support.
- Empower local communities to restore and manage their peatlands according to principles of 'wise use'.
- Generate alternative income earning opportunities especially for agribusiness, social forestry and ecotourism.
- Institute community-based fire control.
- Ensure cultural sensitivity towards user and ethnic groups.
- Establish marketing network with developed countries.
- Establish value adding processing industries (e.g. furniture, palm oil, rubber) within Central Kalimantan to reduce outflow of capital and profits.
- Promote alternative approaches to funding local communities to be custodians of the natural environment, e.g. through Biorights and carbon off-set mechanisms.

Constraints

- Resource degradation
- Intra and inter-community conflict
- Low soil productivity
- Changing sources of income, i.e. rice, rubber and rattan to timber, mining and oil palm
- Top-down approach in government policies
- Lack of education and technical skills

Resources needed

- Greater community representation within local government
- Land-use mapping as a guide to wise use of peat land areas
- Greater government accountability and transparency regarding infrastructure
- Emphasis on investment-based rather than project-based participatory development
- Expansion of human resources in monitoring the costs and benefits of projects implemented
- Implementation of alternative means to provide income from 'wise use' management of peat swamp forest and its natural resources (e.g. develop Biorights and carbon trading mechanisms)
- Institute agribusiness schemes for farmers in areas surrounding peat swamp forest funded by small loans from a local development or land bank with low rates of interest.

PEATLAND RESTORATION AND WATER MANAGEMENT

Peat Swamp Forests (PSF) are unique ecosystems with many complex interrelations. Until recently they were regarded as waste land that had to be put into use for humankind. Recent fire, erosion and flood events show the need for restoration of degraded PSF. Restoration is the process of bringing something back that has been degraded or lost. That means it is initiating or accelerating the recovery of the ecological functions of peatland ecosystems, as far as possible, for a variety of uses including forestry, agriculture, agro forestry, wildlife conservation and nature conservation. Because peat occurs, and is maintained, only under water saturated conditions, water management is the basis of peatland restoration. Very little of the knowledge that is available concerning peatland restoration can be used in the tropics because tropical peatlands differ in many of their characteristics from peatlands in the boreal and temperate zones.

Problems

- Degraded tropical peatlands are changing from carbon sinks to carbon sources, emitting large amounts of carbon dioxide.
- Downstream water quality has deteriorated, leading to reduction in fish populations, increasing poverty and damaging human health.
- Dry and open peatlands face a high risk of fire.
- Numerous drainage channels and the extermination of the forest lead to an immense water runoff far too rapid to maintain a sustainable water balance, i.e. flooding in the rainy season and drought in the dry season.
- A complex, dome-shaped ecosystem that requires appropriate and specific restoration techniques.

Priority Actions

- Limit further degradation by regulation of the water level because prevention is much cheaper than restoration (highest principle); keep the optimum amount of water in natural peat swamp forest.
- Prevent fire (see Fire recommendations); stop illegal logging.
- Prepare an integrated multiple land use plan that identifies areas with different restoration objectives and potential.
- Attract private and governmental investors to support an integrated research program that can lead to successful restoration activities.
- Implement an approach that integrates biodiversity maintenance and enhancement, fire control, poverty alleviation and water management (including supply of potable water to local communities) (see biodiversity, fire and poverty recommendations).
- Reforest deep peat areas using natural tree species of local provenance (not seed) as a means to raise and stabilize the water table.

Constraints

- An indeterminate number of channels that prevent water saturation has been established by illegal loggers in remaining peat swamp forest.
- Public awareness and acceptance is inadequate and must be increased, otherwise local people will not support restoration measures.
- Insufficient knowledge of the functioning of tropical PSF.
- Lack of coordinated action and appropriate land use planning to resolve social conflicts and solve technical problems.
- Lack of funding.

Resources needed

- Exchange platform of knowledge and data (such as DEM, GIS, climate, hydrology…)
- Funds are needed to implement measures
- Government agencies and NGOs must agree and implement a common approach to peatland restoration and water management.

RESTORATION AND WISE USE OF TROPICAL PEATLAND IN CENTRAL KALIMANTAN: A NEW APPROACH TO OLD PROBLEMS

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SUMMARY

Development of peatland in tropical countries has been promoted mostly without adequate knowledge of the ecological and natural resource functions of the peat swamp ecosystem or an understanding of its environmental and socio-economic importance. This has led to conflict with its global and regional environmental roles in carbon and water cycles and wildlife conservation importance. As a result of inappropriate developments and mismanagement many peatland areas in the tropics are experiencing severe degradation and peatland landscape restoration and natural resource rehabilitation needs to be implemented as a matter of urgency. Virtually nothing is known about restoration of impacted, damaged or utilized tropical peatland. Once a large area of tropical peatland has been damaged severely it is impossible to return it back exactly to its former condition, at least within human time scales. The long term value of tropical peatlands should be optimised through sustainable wise use that involves an assessment of the economic and social as well as ecological and natural resource function values, together with a cost-benefit analysis of alternative development options.

Keywords: **peat swamp forest, restoration, wise use, conservation, natural resource functions**

INTRODUCTION

In Indonesia, peatland development started in the 1970s because of the need to increase domestic food production to feed arising population. In the 1990s, most of the remaining natural peatlands in Southeast Asia, especially in Indonesia and Malaysia, were targeted for development. The approach in Indonesia was to undertake large land development projects involved aquaculture, agriculture and plantation crops. In both countries, these projects were initiated without carrying out research on the very specific physical, chemical and biological attributes and properties of this ecosystem and the role that it plays in landscape and global environmental functions and control systems.

It is evident that traditional approaches to development when applied to tropical peatlands, are inappropriate and that many projects have failed to achieve their objectives of increasing food supply and alleviating poverty (Diemont et al., 2001). Much money has been wasted and large areas of peatland (and its forest cover and natural resources) have been destroyed. As a consequence, in Indonesia, peatland landscapes have been degraded, poverty of people living in their surroundings has increased as investment remained low and racial tension has intensified. In addition, there has been an increased risk of fire that has brought problems affecting human health and the global environment. Forest and peatland fires have been increasing in frequency, duration and severity in Southeast Asia since the early 1980s. They are related to land clearance activities using fire that is difficult to control and, in the protracted dry seasons of El Niño years, these spread to adjacent areas of degraded and natural peat swamp (Page et al., 2002).

Strategic planning has not been based upon sound knowledge of the peatland landscapes or the properties of peat, and most developments have commenced without independent, reliable environmental impact assessments. The involvement of all stakeholders, including local communities, in a wise use approach linked to restoration of peatland functions, is essential in order to achieve a consensus for implementing the most appropriate management of tropical peatland that will be truly sustainable (Rieley & Page, 2005).

WISE USE OF TROPICAL PEATLAND

Why do we need wise use?

Peatlands in Southeast Asia have been affected adversely by development policies that have relied strongly on single sector interests and lack of integration and an almost complete disregard of environmental consequences. There have been initial windfall benefits for a few developers from tree felling and timber removal, and infrastructure construction operations, while problems have been created long into the future for local populations and governments without the finance to provide mitigation or rehabilitation.

Concerted and coordinated action to stop or minimise the loss and degradation of tropical peatlands through inappropriate and non-sustainable land conversion is now a major priority whilst there is an urgent need to restore peatland landscapes that are already damaged and non-functional. This can be achieved only through planned programmes of peatland restoration and wise use based upon scientific and technical knowledge obtained through field experimentation and observation. The involvement of all stakeholders, including local communities, is essential in order to prevent further fires that will render any attempts at tropical peatland rehabilitation futile.

Wise use of tropical peatlands is essential to ensure that sufficient area of this resource remains to carry out vital natural resource functions while satisfying essential requirements of people now and in the future (Rieley & Page, 2005). This involves evaluation of their functions and uses, impacts caused by, and constraints to development so that, by assessment and reasoning, it will be possible to highlight priorities for their management and wise use, including mitigation of past and future damage.

Joosten & Clarke (2002) defined 'wise use of peatlands' as 'the uses of peatlands for which reasonable people now and in the future will not attribute blame' and outlined a context for, and parameters within which, wise use decisions could be taken in relation to peatlands. They provided a framework, based upon values of peatlands, and including a decision tree, through which wise use of peatlands can be achieved assuming that conflicts arising could be resolved.

Wise use involves the acquisition and application of knowledge to some beneficial purpose through a process of evaluation and decision making that will achieve the widest possible acceptance amongst 'stakeholders'. When linked to 'sustainability', 'wise use' adopts the mantle of continuity and permanence.

Wise use of tropical peatlands necessitates integrated planning and management and the challenge is to develop mechanisms that can balance the conflicting demands on the tropical peatland heritage to ensure its continued survival to meet future needs of humankind.

Constraints to wise use of tropical peatland

Illegal logging

Four decades of timber extraction in Indonesia through the Government-promoted concession' system (HPH) has not improved the livelihoods of local communities surrounding peat swamp forest (Limin, 2000).

Inappropriate development

There are numerous examples of poorly planned, badly implemented and mismanaged development projects on tropical peatland but the most disastrous is the Mega Rice Project carried out in Central Kalimantan from 1996 to 1998 (Muhamad & Rieley, 2002).

In 1995 more than a million hectares of wetland, mostly peatland, in Central Kalimantan were allocated by the Indonesian Government for a huge project to establish the biggest rice producing area in Indonesia. This project was known popularly as the "Mega Rice Project" (Proyek Pengembangan Lahan Gambut*).*

Land conversion by draining peat for human settlement and irrigating for rice cultivation made the area unusually dry since excavation of deep ditches led to water flowing out of this area and did not provide the water reservoirs necessary for irrigation. As a result, widespread fires in 1997 devastated most of the area bringing the project to a stop. Although the project was not closed down officially until 1999, this fire disaster prevented further transfer of migrants into the project area.

Fi re

Forest and peatland fires have been a recurring problem in Indonesia since the early 1980s when conversion of peat swamp forest to agricultural use increased in scale, promoted by the Indonesian Government's transmigration programme.

Balancing conservation and development of tropical peatland

Development of peatland in tropical countries has been promoted mostly without adequate knowledge of the ecological and natural resource functions of the peat swamp ecosystems or an understanding of their environmental and socio-economic importance.

Implementing wise use of tropical peatland

Drainage of tropical peatland and its utilization for market orientated purposes has been unsuccessful because this peat presents problems that are not encountered in the land use conversion of dry land ecosystems. As a result of inappropriate developments and mismanagement many peatland areas in the tropics are experiencing severe degradation that now requires peatland landscape restoration1 and natural resources rehabilitation. Virtually nothing is known about restoration of impacted, damaged or utilized tropical peatland. The principle ecological requirements for restoration of lowland tropical peatlands are availability of an adequate supply of rainfall of appropriate quality and its retention at the peat surface in order to provide effective rewetting, availability of suitable colonising plant species to consolidate rehabilitation and bring about [2]renaturation" and a realistic and scientifically sound management plan based upon research and local experience.

There are several reasons why these conditions cannot always (perhaps never) be met in the tropics even when a large reservoir of peat remains. Firstly, the peat surface may not retain precipitation in the dry season because runoff is too rapid as a result of drainage and it may flood quicker and more severely in the rainy season owing to subsidence following land use change and/or fire. Consequently, the capacity of degraded peatland landscapes for hydrological self-regulation has been lost Secondly, deep land drainage on the periphery and around the peatland may affect its water balance, while groundwater abstraction from a permeable substratum beneath or adjacent to the peatland can affect the water balance substantially. Thirdly, peatland plants may not be able to rehabilitate themselves owing to mineralization of the peat surface following degradation, although a vegetation cover may regenerate eventually as a result of longer term successional processes; destruction of the seed bank and tree bases as a result of fire and peat subsidence remove the potential for vegetative reproduction.

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[2] *Restoration implies an attempt to return a degraded landscape to its former condition as far as possible and is a rather strict definition; rehabilitation implies a less specific re-creation of natural resource functions and wildlife interest*

GUIDELINES FOR IMPLEMENTING RESTORATION AND WISE USE OF TROPICAL PEATLAND

The following guidelines should be observed in tropical peatland restoration and rehabilitation projects:

1. assess changes in ecosystem functioning and estimate economic and social costs and benefits;
2. maintain a flexible approach and avoid specificity of the ultimate goal;
3. optimise ecosystem value and accelerate rehabilitation by using fast-growing nurse plant species;
4. maximise ecosystem complexity in order to optimise availability and flexibility of site resources;
5. protect against, or control, damaging influences such as fire;
6. conserve peat soil;
7. re-establish plant (especially tree) cover and hydrological integrity, e.g. to reduce acidity and prevent further acidification and peat oxidation;
8. where replanting is needed, choose seed and other propagules from local sources using species adapted to the peat swamp forest habitat; and
9. involve stakeholders and provide alternative sources of income to local communities to reduce their dependence on peatland natural resources.

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PEATLAND RESTORATION: LESSONS FROM THE BOREAL ZONE

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SUMMARY

Research in peatland restoration began around 1992 in Canada through a partnership of scientific researchers from different universities (Peatland Ecology Research Group), the Canadian peat moss industry and governmental agencies. The common objective is the sustainable management of Canadian peatlands. More than ten years later, research in peatland restoration has progressed immensely. The vision of the peat industry has also evolved and regulations on peat mining are being developed. Many tools are used to transfer and communicate scientific results to land users. Scientific workshops are organised annually to present the latest scientific results. Newsletters (*Echo tourbières*) are distributed to inform industrial partners and other collaborators of current research activities. Annual technological transfer workshops allow scientists to teach in the field on restoration methods to peat industry employees, who in turn bring their practical expertise for improving large scale restoration methods. Working in collaboration with many competing peat companies has represented a major challenge for the scientists but the opportunity to join various forces and expertises allows us to make more progress in resolving problems in the field and applying results of scientific projects.

***Keywords:* partnership; communication; restoration goals; restoration research approach; restoration practices.**

INTRODUCTION

Setting goals for any restoration project is not an easy task. Several big restoration projects in North America such as restoring sectors within Jasper National Parks or the Kissimee River in the Everglades have stirred away from restoring the land back to a former state in historical time (Higgs, 2003). Most often, a process-oriented approach is favoured which calls for a return of dominant processes to the landscape. The Society for Ecological Restoration International Science & Policy Working Group (2004) defines the ecological restoration of a habitat as the process of assisting the recovery of an ecosystem that has been damaged, degraded or destroyed. The concepts are not new since, in 1987, A.D. Bradshaw was discussing restoration in those terms:

> *"The essential quality of restoration is … that it is an attempt to overcome artificially the factors that we consider will restrict ecosystem development. The actual restoration operations will often be dominated by engineering or financial considerations, but their underlying logic must be ecological"* (Bradshaw, 1987).

It is along the same lines of thinking that the goals for peatland restoration in Canada have been developing. Because restoration of complex wetland ecosystems to their former patterns is impossible, the existing wetlands or peatlands should be improved and restored as far as is possible to former wetlands within socio-economical and environmental limiting conditions (Anonymous, 1995; Wheeler, 1995; Charman, 2002). In the process, all stakeholders should be involved including ecologists, industrials, social scientists, historians and policy makers. There is considerable variation in restoration costs and in the duration of the recovery process, variation that is strongly related to the scale and length of time of the changes made in the landscapes.

In view of these constraints, we define the general goal of peatland restoration in Canada as the return of degraded or destroyed peatland sites to wetland ecosystems. Over time and through plant succession, these wetlands should regain their peat accumulating function. The notions discussed here in peatland ecological restoration apply mostly to the boreal biome of the northern hemisphere but maybe some approaches can be transferred to the particular case of restoring Central Kalimantan peatlands.

GOALS OF PEATLAND RESTORATION

The restoration of peatlands will seek to re-establish a plant cover dominated by Sphagnum or brown mosses depending on the substrate minerotrophy, as well as a hydrological regime typical of peatlands (Rochefort, 2000). In the boreal biome, the latter two groups of mosses forms the bulk of the peat deposit, in tropical peatlands restoration will focus on assisting the returns of the main vascular plants contributing to peat accumulation. Nonetheless, the restoration process should ensure the return of functions of the ecosystem necessary to its self-perpetuity (Lode, 2001). Among these functions is adequate productivity permitting the accumulation of carbon, cycling of nutrients, recovery of the vegetation structure that will favour animal and plant biodiversity, and characteristics that permit the ecosystem to resist biological invasions and fire destruction.

The concept of peatland restoration retained in the northern Hemisphere subscribes to the notion of 'Sustainable Use' of peatlands. This means that after any type of disturbance, the peatland ecosystem and its main functions are restored back within a human lifetime, so that future generations can appreciate the presence of this special habitat, often little known by the general public. Thus, the general goal of restoration is not to renew peat as a natural resource, but rather to manage the ecosystem as to impede its loss in certain regions or localities and maintain the structure and functions of these types of habitat.

Briefly the factors influencing plant establishment on degraded peatlands are presented and the last section gives an overview of restoration practices in Canada. More details about the Canadians approach to peatland restoration can be found at 1) the Peatland Ecology Research Group (PERG) - http://www.gret-perg.ulaval.ca/, 2) within a book chapter within the Peatlands of the boreal biome edited by Wieder and Vitt (2006) and 3) the Peatland Restoration Guide edited by François Quinty and Line Rochefort available in a PDF format from http://www.peatmoss.com/pm-restguide.php . The following sections are a summary of these documents.

WHERE TO START ON DEGRADED PEATLANDS

First the factors impeding the recolonisation of a degraded peatland have to be identified along with knowledge of which plants can act potentially as eco-engineers for the peat building function (Campbell *et al.,* 2003; Campbell & Rochefort, 2003). In the Northern Hemisphere, for example Canada, *Sphagnum*-dominated peatlands (bogs and poor fens) are characterized by a strong relationship between vegetation and hydrology (Ingram, 1983). *Sphagnum* mosses are abundant and dominant in these ecosystems and they are able to modify their physico-chemical environment to the point of impeding the processes of decomposition (Clymo, 1987). With time, peat accumulates, which slowly raises the peat layers above surface runoff causing an impoverishment in mineral input as the peatland becomes fed only by atmospheric precipitation (Glaser & Janssens, 1986). The highly fibric and porous structure of the *Sphagnum* carpet can store atmospheric water and limits considerably water table fluctuations (Ingram, 1983; Wheeler, 1999). In natural bogs, the *Sphagnum* mosses maintain the eco-hydrologic self-regulating systems favourable to their own growth (van Breemen, 1995) and are the reason why so much attention has been given to the long term re-establishment success of *Sphagnum* mosses during the development of restoration techniques (Money, 1995; Rochefort, 2000; Tuittila *et al.,* 2003). An analogous group of plants acting as eco-engineers have to be identified for Central Kalimantan.

General Approach

Sphagnum mosses possess a high potential for regeneration from vegetative fragments but factors allowing this expression under field conditions have only begun to be understood. Numerous field observations show that spontaneous re-colonization of peatland ecosystems by Sphagnum mosses is not a common phenomenon on milled peatlands (presently the most common type of abandoned peat fields). Indeed, very few post-milled peatlands that have been abandoned over the last 15 to 25 years have been re-colonized readily by Sphagnum plants over extensive bare peat areas (for example less than 1% in Canada; Rochefort, 2001; Poulin et al., 2005). Some old traditional methods of harvesting peat appears to be more conducive to spontaneous regeneration and these are being studied to understand the factors that favoured this natural regeneration. Bare peat surface field conditions in Central Kalimantan appear to be similar to an abandoned extracted peatland in Canada. Field reconnaissance in the degraded peatlands of Central Kalimantan to find sectors (even if small in extent) where spontaneous regeneration is occurring will be well worthwhile to study. Ecotones between natural and degraded peatlands can be a good place also to examine for natural recolonisation and understand processes which allow regeneration to be successful.

The first years of trials to reintroduce Sphagna on bare peat were unsuccessful (at the end of 1980's and beginning of 1990's). All moss reintroductions carried out by spreading fragments on bare peat; by either reintroducing whole Sphagnum individuals in wet hollows and water-filled ditches or by the transplantation of entire Sphagnum cores ("plugs") resulted in dead plant material after one or two field seasons or at most they just barely survived (the large "plugs") without any spatial extension after 10 years of monitoring. Sphagnum moss establishment became successful only once it was realized the importance of providing a favourable humid microclimate at the interface of air-peat surface and protecting the vegetative moss fragments against desiccation. Then it became possible to develop efficient restoration techniques on a large scale. It is easy to conclude that the road to the success of restoring the peatlands in Central Kalimantan will be quite different as mosses are not an important part of the peat-forming ecosystem but that trees and their relation to long periods of inundation will need to be studied in detail.

Ten years of restoration practices in North America have now shown that there are three management interventions (ellipses in Figure 1) that are paramount to the success of Sphagnum establishment on bare peat surfaces when working from a paludification approach: i) the active reintroduction of plant diaspores1[3], ii) the application of a protective mulch cover, and iii) the rewetting of the site by a combination of blocking drainage and field surface preparation. For sites prone to frost heaving (Groeneveld & Rochefort, 2002), phosphorus fertilization is also essential.

OVERVIEW OF RESTORATION PRACTICES

Practical considerations for implementing restoration projects on a large scale are well described in detail in the following books:

- Restoration of damaged peatlands (Wheeler & Shaw, 1995);
- Conserving bogs. The management hand book (Brooks & Stoneman, 1997);
- La gestion conservatoire des tourbières de France (Dupieux, 1998);
- Guidelines for wetland restoration of peat cutting areas - Results of the BRIDGE-Project (Blankenburg & Tonnis, 2004);

[3] *Any part of a plant capable to grow as a new plant. This includes seeds and spores, but also rhizomes, stems, leaves, branches, etc.*

- Conservation and Restoration of raised bogs. Geological, hydrological and ecological studies (Schouten, 2002);
- Peatland restoration guide, 2nd edition (Quinty& Rochefort, 2003).

Thus, for this section, only general guidelines that can be applied to any peatland restoration project in countries where Sphagnum-dominated peatlands occur will be discussed. But still several concepts can apply to the restoration of Central Kalimantan peatlands. The main mechanical steps used in the Canadian peatland restoration approach are illustrated in Figure 2 and explained in further details below.

Planning

A good restoration plan should have two different components:

1. Site conditions, goals, and objectives
2. Planning restoration operations

Identification of conditions of the site is a necessary step because site characteristics dictate the correct goal to achieve: restoration or reclamation. Likewise an overall plan for the restoration of the Mega Rice project should be designed with the involvement of main stakeholders. The second step consists of defining the operations that need to be carried out, planning resources and time required, setting up a schedule, and evaluating costs. This information should include the following elements:

- Site characteristics prior to peat extraction
- Hydrologic environment
- Topography
- Peat characteristics
- Chemical aspects
- Existing vegetation of the restoration site
- Surrounding landscape
- Setting the right goal
- Setting the right objectives
- Identification of a donor site (source of plant material to reintroduce)
- Identification of one or more reference sites
- Identification of a non-restored section as control site (optional)
- Monitoring protocols

The overall water budget should be evaluated to see if primary positive moisture conditions still exist, mostly for the case of *Sphagnum* peatland development. A hydrological approach as used by van Seters and Price (2001, 2002) should provide useful clues on restoration potential, mostly when peatlands are at the limits of their normal climatic distribution. If not, reclamation may be a more appropriate goal, and this should be known from the beginning.

To prepare functional restoration goals, a reference ecosystem should be described as the model for planning the project, and later serve in the evaluation of the project. Typically, the reference represents a point of advanced development that lies somewhere along the intended trajectory of the restoration (Society for Ecological Restoration International Science & Policy

Working Group, 2004). In other words, the restored ecosystem is eventually expected to emulate the attributes of the reference, and project goals and strategies are developed in light of that expectation. The reference can consist of one or several specified locations that contain model ecosystems, written descriptions, or a combination of both. The value of the reference increases with the amount of information it contains, but every inventory is compromised by limitations of time and funding. Minimally, a baseline ecological inventory describes the salient attributes of the abiotic environment and important aspects of biodiversity such as species composition and community structure. In addition, it identifies the normal periodic stress events that maintain ecosystem integrity (Society for Ecological Restoration International Science & Policy Working Group, 2004). With peatland ecosystems, paleoecology can also be a useful tool to define the reference ecosystem (Lavoie *et al.*, 2001; Gorham & Rochefort, 2003).

A good quality preparatory plan should include both desk and laboratory work (literature search, climatic and hydrological data compilations, chemical analyses, computer mapping) and field work. Once ecological information is gathered and more insight is gained into what is possible in term of biological restoration, meetings with all stakeholders involved including local communities should be organised to agree on end-goals. These are principles that directly apply as well to the restoration of the Mega Rice project. Once the plans are made, restoration work can begin.

Surface Preparation

Water availability is paramount in peatland restoration as it will be in Central Kalimantan although not to the same extent. As peat extracted peatlands of Canada have lost their natural ability to store water and regulate water table fluctuation, management procedures must be undertaken to reduce water losses and to provide a water supply to Sphagnum and other introduced plants. To achieve these goals, two types of action can be undertaken: 1) redesign the surface topography (Figure 2a) and 2) blockage of the former drainage system. Blocking the former drainage system is a necessary action (Money, 1995; Rochefort, 2001) as illustrated in Figure 1 by the ellipse but should be done only at the end of all the restoration actions to make sure that the site can support the repeated passage of machinery until the end of the restoration works. Serious thought should be given in the sequence of rewetting of the Mega Rice Project as it can impede other interventions later on, but definitively some entire sections well connected with a natural tropical peatland should be made in order to study the natural recolonisation process when drainage is stopped.

Plant Material Choice and Spreading

Active introduction of plants is done when one wants to accelerate the formation of a new plant cover. The most important feature of this plant carpet is the presence of *Sphagnum* mosses, which are largely responsible for the unique characteristics of peat bogs and for the accumulation of peat in the Northern Hemisphere. Thus, the plant material that is introduced must contain a major proportion of *Sphagnum*. The presence of other mosses, for example *Polytrichum*, can contribute substantially to the success of restoration because *Sphagnum* mosses are poor primary colonizers. The quality of the recolonising material in terms of peat-forming plant species is a major factor responsible for the success of restoration. A site dominated by Sphagna, for example, is the best source for acquiring reintroduction material while a site lacking *Sphagnum* should not be considered. The most practical and abundant source of peat bog plant diaspores is a bog itself, but current research is taking place on *Sphagnum* "farms" to produce *Sphagnum* diaspores for restoration that would be very useful for countries where mires are not abundant (Joosten 1998; Campeau & Rochefort 2002; Gaudig & Joosten 2002). Ideally, plant material is collected near to the site to be restored in order to minimize transportation and differences in population genetics from out of region donor sites.

Collection of plants involves shredding the surface vegetation and picking it up. This material will be spread over the restoration site to form a carpet. Collection of plants, when carried out properly allows rapid recovery of donor sites and does not result in permanent damage

(Rochefort & Campeau, 2002). The choice of donor sites should always minimize impacts to pristine sites. Once the plants have been shredded with the help of a rotovator (Figure 2b), picked up, and transported to the restoration site, moss fragments are spread using a standard box manure spreader (Figure 2c).

Diaspore Protection

Because mosses are being used, plant fragments are exposed to the sun and wind and they dry rapidly (Sagot & Rochefort, 1996), hence, it is essential to protect the newly reintroduced diaspores as soon as possible. For peatland restoration on sites where peat instability does not appear to be a problem, the use of straw mulch alone should be sufficient (Figure 2d). However, on those sites where instability is a severe problem, straw alone is not the best option. Its effect is short term, as it decomposes rapidly, seriously decreasing in efficiency after one year of application and being close to nil after two years. In these cases, the use of a pioneer plant such as Polytrichum strictum with better stabilizing capacities, may assist in achieving restoration success (Groeneveld & Rochefort, 2005).

Fertilization

Fertilization aims at assisting plant establishment. In restoration experiments, it was shown that phosphorus fertilization increases the development and spread of *Polytrichum strictum* (Sottocornola *et al.*, 2002), which in turn provides conditions suitable for the establishment and growth of *Sphagnum* fragments. Application of phosphorus also appears to promote germination and establishment of several vascular plant species typical of peatlands (Figure 2e) (Sottocornola *et al.*, 2002).

Blocking Drainage and Rewetting

The objective of blocking drainage is essentially to keep water within the restoration site and improve its distribution. This action should be carried out last, once all other restoration steps have been completed, in order to facilitate the movement of machinery over the site during the restoration process (Figure 2f). Until re-wetting has been carried out, however, *Sphagnum* will not establish (Figure 1). The use of wet humified peat makes the most efficient and impervious dams when there the gradient is low. Different experiments done within Peatland Ecology Research Group (PERG - http://www.gret-perg.ulaval.ca) have shown repetitively the synergic effect of mulching and blocking drainage.

Besides blocking the drainage, many other treatments aiming at supplying water to the *Sphagnum* fragments and impeding desiccation have been tested, including sprinkler irrigation, pumping water into irrigation ditches, windbreaks to retain snow on the restoration site, and surface inundation distributed via perforated PVC pipes. All of these management practices proved to be equal to mulching or did not significantly improve *Sphagnum* establishment rate if applied in combination with mulching (Rochefort, 2001). As alternatives are costly to implement, mulching and blocking drainage remain the best options.

Time to "Recovery"

Monitoring is essential to evaluate the restoration success. It is possible to revegetate a cutover peatland with peatland plants and stabilize the surface peat substrate within three to five years. Taking as an example a restoration project done in eastern Canada (Bois-des-Bel), it was found that

after five years of restoration, total plant cover by peatland plants was already 90% and a moss carpet composed of *Polytrichum* and *Sphagnum* species covered 70% of the ground. Figure 3 illustrates the changes observed through the years. In this case, success is evaluated only in terms of vegetation cover, excluding non-peatland or wetland species. It is only with a long-term monitoring program that it will be able to assess if the different ecological functions have been restored in the peatland (Waddington *et al.*, 2003; Tuittila *et al.*, 2004).

Evaluation of post-restoration projects will reveal successes but also failures. All progress made should be shared with stakeholders and failures discussed in order to find solutions. A great part of the success of restoration project is to have within the research team a good communication program that includes a monthly bulletin on what is being done in research, a web site, an education program for schools, scientific conferences and technological transfer workshops. A scientific committee and advisory board (mostly representing the funding agencies) should be organised and meet at least once a year to reflect on progress in relation to the initial goals.

Improving the large scale management of the restoration approach

Throughout the vast country of Canada, there is a diversity of approaches and machinery that can be used to implement a restoration project. Different machinery, or timing of work in a season, can have an effect on the restoration success. As we begin to have more large scale restoration projects, analysis of the management factors should be carried out to pin point less efficient practices (e.g. a machine that would mechanically shred too much of the moss material and decrease its regeneration potential during the collection or the spreading steps) and facilitate overall restoration success. This work is on-going at the moment.

LESSONS LEARNED!

From start, it is important to agree on explicit restoration goals: all stakeholders should be involved. The restoration work should have an ecological basis, especially a good understanding of the main processes to be restored to make sure that the main goods and services expected to return will be able to do so.

Before any large scale undertaking, it is necessary to have achieved success in a number of small projects undertaken from an array of different starting conditions. Finally, it must be planned to allocate a good portion of the budget to communication, workshops, bulletins, education, exchange of ideas and scientific meetings. I am looking forward to read about progress in the near future on the restoration of Central Kalimantan degraded peatlands.

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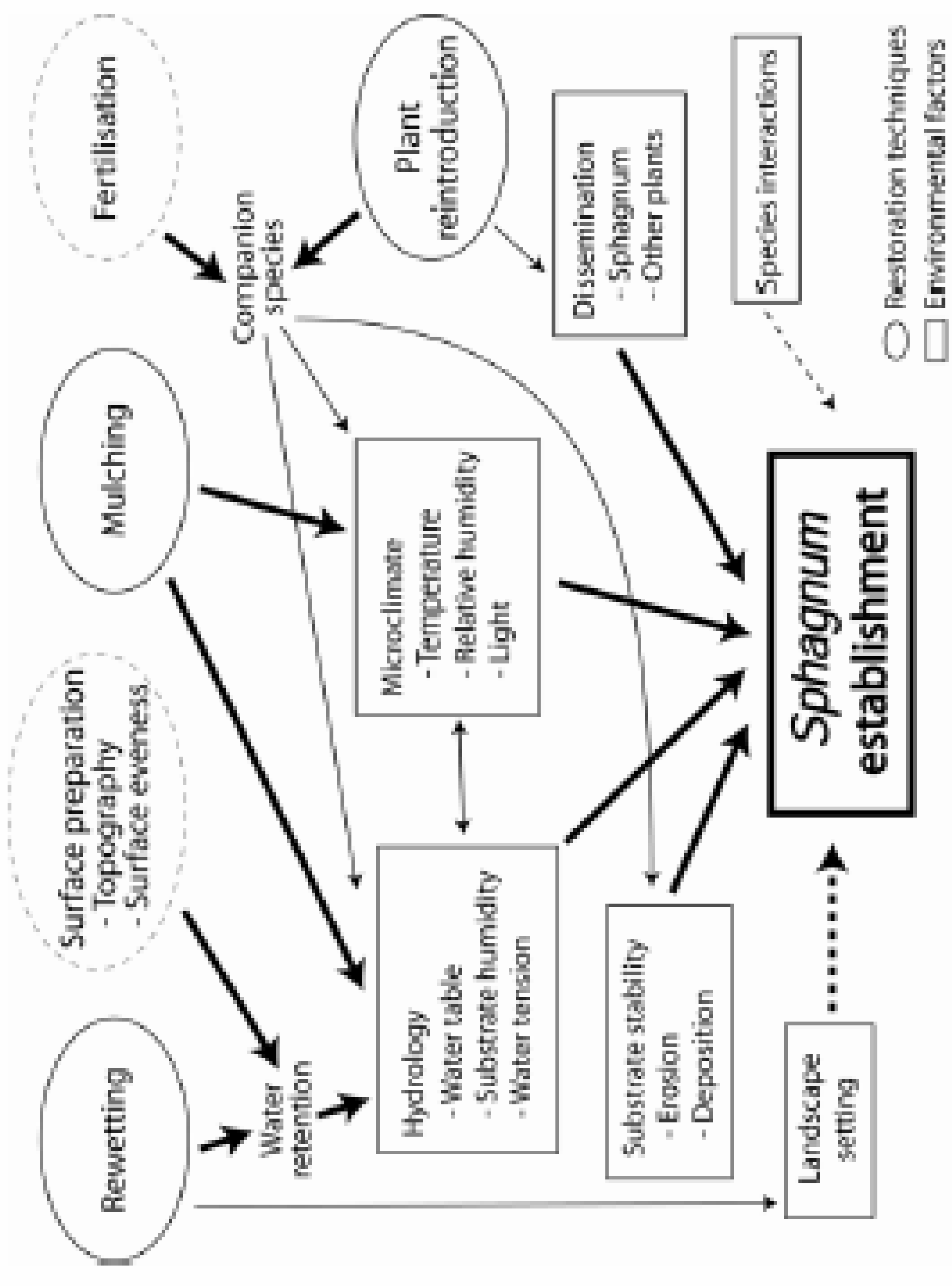
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Microclimate
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- Relative humidity
- Light
Dissemination
- Sphagnum
- Other plants
Substrate stability
- Erosion
- Deposition
Landscape setting
Species interactions
Sphagnum establishment
Restoration techniques
Environmental factors

Figure 1

Figure 2

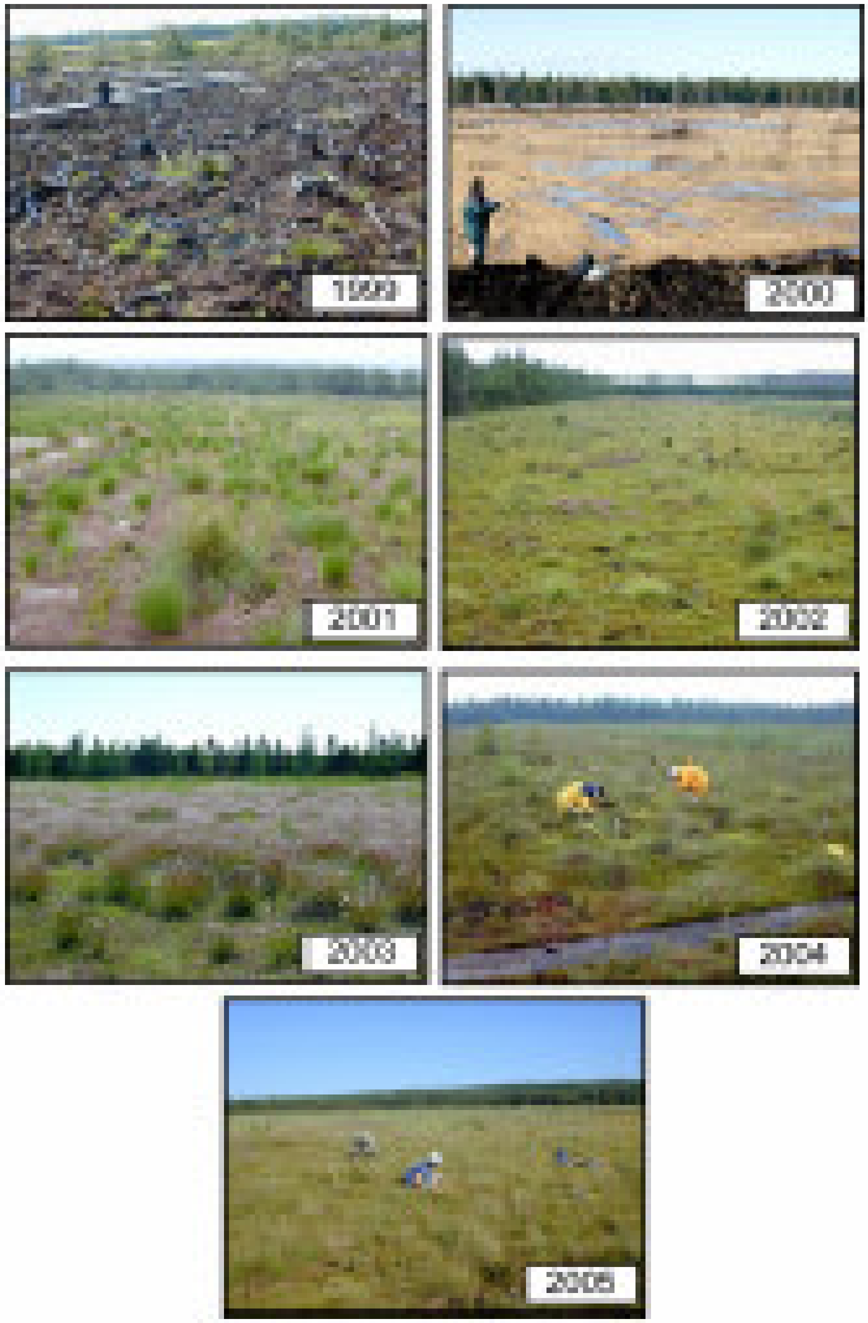

Figure 3

FIGURE LEGENDS:

Fig. 1. Factors affecting the success of *Sphagnum* establishment on bare peat substrates. Rectangles represent the factors directly responsible for the success of moss establishment. Management practices (actions) – absolutely necessary to re-establish a moss cover when degradation is extreme such as in a cut-over peatland – are represented in ellipses. The ellipses with dash line represent optional management practices, specific of each case study, or factors suspected to be compulsory (fertilization) but still under study. The full line arrows point to relationships that have often been demonstrated through several field trials; the dashed line arrows are relationship still under study. Adapted from Rochefort (2000).

Fig. 2. The six main mechanical steps proposed for successful restoration of milled harvested peatlands. Description in the text. Photos taken by PERG.

Fig. 3. Plant revegetation sequence of the whole ecosystem experiment at Bois-des-Bel peatland showing relatively bare peat substrate prior to restoration in 1999, the year of restoration in 2000 and five years of recovery. In 1999, prior to restoration, bare peat still covered 71% of the ground after 20 years of abandonment. Dead wood that frost heaved to the surface with time is also abundant. The picture of 2000 is a general view of the restored site covered with straw mulch on top of the *Sphagnum* inoculum. By two years after restoration (2001), the moss carpet covered 62% of which 22% was composed of *Sphagnum* species; part of it is seen coming through the straw mulch. In 2002, most of the ground vegetation was dominated by cotton-grass (*Eriophorum spissum*) and *Polytrichum strictum*. Four years after restoration (2003), a moss carpet dominated more and more by Sphagna had developed (35%). The undergoing survey of 2005 points to an increase to 65% *Sphagnum* cover and 80% total moss cover that remains below 0.2% in the non-restored comparison site. Photos taken by PERG.

IS POVERTY ERADICATION POSSIBLE IN THE PEATLAND AREAS OF CENTRAL KALIMANTAN, INDONESIA

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SUMMARY

Official statistics published in 2004 showed that the poverty level in Central Kalimantan was serious, namely around 20% to 40% of the population in some districts, especially those in which peatland was a major agricultural resource base. Socio-economic improvement and poverty eradication cannot be successful unless three fundamental strategies of economic development are implemented. Urban biased development programmes must be avoided, a systematic approach to agribusiness development should be implemented and Social Forestry Management Unit-based industrial forest plantations promoted to enable faster participation of local, national, and foreign investors. For all of these purposes, some conceptual inputs and policy recommendations were formulated, based on the ecological, technical, and socio-economic research findings of several EU-funded projects that have operated since 1998. In terms of improving traditional sources of income for people that are generally used to depending much on a logging economy, the task is very complex and difficult. Damaged forest ecosystems and the need to feed and prosper the growing number of people should necessarily change the current agricultural development and forestry management policies of the province of Central Kalimantan. These should be replaced with a different approach in which consistent community development will enhance productive capacity as well as marketing accessibility of the rural population. Meanwhile, ecosystem improvement to minimize drought and flooding incidents that hamper agribusiness development should be undertaken by promoting social forestry development to the people and associated potential investors in order to provide better economic prospects for those participating in the programmes.

***Keywords:** poverty, peatland, Central Kalimantan, social forestry, ecological restoration, peat swamp forest*

INTRODUCTION

When a proposal to establish a new province of Kalimantan Tengah (Central Kalimantan) was prepared in the early 1950's, inspired by KKSD (the Dayak-Peoples' Awareness Committee) and submitted by Mahir Mahar and Cilik Riwut as head of delegation to the Central Government (Anon, 1992; Riwut & Mantiki, 2003), no one in the region felt suspicious that later on the newly born province would not be able to grow economically strong and prosper socio-economically as expected. Even though cultural heritage and natural resource potential in the early years of the province were so convincingly abundant, however, after one third of a century since its establishment (in accordance with Emergency Act No.10/1957 and Act No.21/1958, (which designated Palangka Raya as the capital of the province) the province of Kalimantan Tengah has so far achieved insignificant economic progress.

The socio-economic importance of the peat swamp forest ecosystem is unquestionable, because various tradable goods are harvestable from it. People have traded them extensively from peatland in Kalimantan (Indonesian Borneo), a business that has amounted to about US$1.5 billion annually during the last 15 years, mostly from logs and processed timber. Poverty has increased, however, as peat swamp forests have become degraded and their resources dwindled, a process that has been intensified as a result of fire and illegal logging following the demise of the unsuccessful 1997-MRP (mega-rice project). Ironically, daily socio-economic life has become much harder when later both legal and illegal logging were strongly restricted and seriously controlled. The policy turns out to have significantly decreased the magnitude of business transactions in many parts of the province, and so the slowing down economy eventually has brought with it more poverty. Official statistics published in 2004 showed that the poverty level in this province was alarming, namely around 20% to 40% of the population of some districts (Tables 1 & 2). The problem is especially severe in districts with peatland based agriculture.

PEATLAND ECONOMY: THREE CAUSES OF POVERTY

Tropical peat swamp forests have been used by local people for millennia for a large variety of life support products and services without destroying them. They provide an important component of livelihood subsistence and also cash income for local and indigenous people who live near and around these areas. The poverty problem relates basically to the forest indulging life style, which is widespread in Central Kalimantan where it is practiced by native people (the Dayaks) and immigrants (Banjarese from Southern Kalimantan and Javanese, Madurese and settlers from other parts of Indonesia) all of whom have benefited economically from the abundant natural resources.

First Cause

This is concerned with traditional, but environmentally unsound, resource based economy being performed by many people living in the surroundings of peat swamp forest. The importance of the peatland ecosystem in supporting local livelihoods is clearly seen from the marketable logs of various classes or species derived from it. Other peat swamp forest products traded frequently by local people include rattan stems, jelutong latex, gemur bark, medicinal plants, charcoal and fire-wood, honey, various inland water fish, frogs and crabs (not to mention some wild species of endangered animals). The natural resource harvest has been conducted mostly as a primitive means of providing livelihood for local inhabitants as well as early migrants arriving into the area from elsewhere in Indonesia. The traditional and non-traditional style of livelihood in peatland area may be categorized as follows (Sjarkowi, 2002):

Extractive: this is typified by tapping exhaustible resources, for example, gold mining, from a river bed, clay-brick making and stone breaking by wood fire. These activities are usually complemented by exploiting trees from nearby forest to be used as a source of firewood energy, and therefore doubling the environmental impact of this particular business effort. The work is conducted mostly by transmigrant labourers (Javanese) in conjunction with Dayak or Buginese owners.

Exploitative: this type of business activity depends on the ability to exploit the abundant, but somewhat fixed availability, of biological resources within the peatland ecosystem. Tree cutting and jelutung latex tapping and gemur bark stripping are examples although, of course, forest logging is obviously the most popular. The masterminds of this earning activity are Banjarese people in cooperation with some Dayaks, whilst transmigrants act as labourers.

Explorative: this effort is about harvesting fish or prawns, medicinal herbs or roots, rattan and swamp turtle, which are available in abundance in remote parts of the peat swamp forest ecosystem. These activities impose minor negative impacts on the ecosystem and have good economic prospects given the fact that modern society has been attracted back to nature for its pharmaceutical and luxury needs. Many potential resources are still unknown within the peat swamp jungle and there is therefore a potential for future development. Indigenous local people together with well-educated Dayaks are certainly very talented in undertaking this kind of business.

Conservative: this is typified by win-win efforts by local people in utilizing the peat swamp forest in environmentally friendly ways. Examples include bee-keeping within a forest site and Toman (Ophiocephalus micropeltes) fish fattening. The latter is conducted by families taking advantage of kitchen (organic) solid wastes to feed small wild fish that are caught easily in square nets placed underneath their houses and, in which snake-head fish young are fattened for 10 months until they are large enough for sale.

Intensive: this is a sedentary agribusiness practiced mostly by well-settled transmigrant farmers, although some Dayak and Banjarese families are also involved. The intensive pattern is technologically oriented and difficult to develop in peatland areas. The actual performance is unfortunately impaired by pests and diseases because appropriate technology for peatland agriculture (including aquaculture and animal husbandry) has not been developed so far by the local communities. This is the real challenge to be answered by scientists that really care about the optimal and wise utilization of the tropical peat swamp forest ecosystem.

What is wrong with all these "business" efforts? Why do they contribute to poverty? Technically speaking there is nothing wrong with any of them as they are acceptable when only a few people are involved in them and only 'low-technology' tools being used. That is necessarily so, particularly when the associated MLR (man-land ratio) is still relatively very low, both in terms of either man against land area or agricultural land. Agricultural involution (typified by insignificant welfare impact out of minor progress in agriculture) is a consequence of it because only minimal negative ecological impact is associated with each practice and therefore only minor price fluctuations result from fluctuations in supply and demand for each product, resulting in low quantity. This situation changes when capital intensive agribusiness investment promotes massive forest land area conversion into another spatial use in order to support agricultural development, which brings about sudden (or non gradual) changes ecologically and socio-economically. In this situation, the ecological impact of the peatland ecosystem changes can be negatively pervasive, while product price fluctuation becomes very significant and unpredictable. Consequently, economic development of peatland areas in Central Kalimantan has not been able to make a steady progress and, consequently, has led to income inequality and increasing poverty, while the widening social gap has resulted in social unrest.

Second Cause

This concerns the capital transformation process. It has been acknowledged only recently by decision makers that peat swamp forest ecosystems do not only have direct use values as reflected by marketable products that can be harvested or mined from them, but they also have many other values (i.e. indirect use, option, bequest, and existence values). Peat swamp forest conversion projects must take these values into consideration and accept their importance. Any magnitude of forest conversion must mean total capital transformation, namely, from all sorts of natural capital into financial capital in a sustainable way. Of course, in a forest indulging economy as described above, such a business attitude is presumably forgotten some, if not most, of the time. Waste in a resource based economy becomes inevitable, and the capital transformation can only generate insignificant economic progress or minor social welfare improvement. This is really unfortunate. As discussed below, the potential loss or gain cannot be underscored.

Indirect use values of Peatland Forest in support of peoples' quality of life

Traditional wisdom among indigenous people of Kalimantan clearly recognizes peatland forests as natural stores for various daily living needs. There are seven common major characteristics of Dayak civilization: (1) long house, (2) mandau and sampit hunting and defence instruments; (3) plaiting and weaving with rattan and tree bark materials; (4) pottery utensils; (5) swidden agriculture; (6) paternal (both patrilineal and matrilineal) hood, and; (7) ritual traditional dances. Characteristically (1) and (4) require landscape sites with a mineral soil base, while the rest (1, 2, 3 and 5) may be supported by peatland forests. Therefore pristine peatland ecosystems are not only indirectly valuable in terms of their (bio-geophysical) ecological functions that support socio-ecological harmony but they also imbue socio-economic and socio-cultural strength to the native people. Failure to direct environmentally sound and sustainable development could clearly bring the region to ecological and social disaster. Considering that those natural (peatland ecosystems) and socio-anthropological entities have been in dynamic evolution for thousands of years, it is predictable and calculable how much of the indirect value would be lost consequently and wasted if peatland forest degradation should become out of control.

Option values that support peoples' desire to improve their future economic welfare

The peatland ecosystem has the potential to be developed economically for ecotourism, carbon trading, home of important medicinal plants and animals, and a future source of renewable energy for the benefit of the economy of Kalimantan and its inhabitants. A better understanding of social behaviour of the natives and migrants is needed urgently in order to guide various interests of communities and local, provincial and central governments to harvest particular peatland forest resources. It is important that these option values are not wasted before a sustainable model for best practice and wise use of forest resources is formulated.

Bequest values in support of peoples' faith and cultural traditions

Social attitudes and local traditions surrounding a peatland ecosystem are believed to have long been influenced and structured by the bounty of peatland bio-geophysical resources. A pristine tropical peatland ecosystem is rich in biodiversity. Various tree species suitable for building traditional houses and equipment can easily be harvested in a sustainable manner from the jungle by the native people. The peatland ecosystem and the 'adat' values and traditional leadership are necessarily composed of some important values and sustainable norms for peatland forest development. Traditional rules should neither be dismissed nor undervalued, and could become the key whenever a social change needs to be introduced in the course of a sustainable management program.

Existence values that support peoples' right to secure the welfare of future generations

Wherever a primary peatland ecosystem still exists, it is very likely to be because of the thickness of peat that makes it unsuitable for agricultural use. It is understandable that peat thickness must be more or less heterogeneous throughout a peatland landscape. Areas of shallow peat will occur, where the associated fauna and flora would necessarily be relatively different in terms of population density and size. Such a phenomenon in the eyes of the native tribes of animism must have been recognized as holy spots to be respected and revered. Anthropologically speaking a peatland ecosystem has been influenced to some extent by the socio-ecological values, socio-economic attitudes, and socio-cultural behaviour of the surrounding tribes and people. Socio-economically speaking, however, those sacred spots and sites should necessarily determine the 'existing values' of a peatland ecosystem. It presents a bargaining position that may only be exchanged by the native people for an extremely high monetary value.

When all sorts of potential values other than direct use values are not taken into consideration by way of proper resource use planning, prepared by government and business decision makers, then ignorant actions by resource harvesters will surely unleash an ecological boomerang that can impair economic achievement. Even if large-scale forest logging is taking place and causing an economic boom, in terms of employment and various business transactions, such a development process is more accurately described as a 'pseudo capital transformation', because:

(1) Much capital transformation may be taking place in the local economy, but local people are competing mostly between themselves for only a small share of the economic wealth while most of the capital gain being obtained by large companies is flowing out of the province.

(2) Socio-economic transformation may have occurred promoting undesirable social behaviour of laziness or unproductive habits and a consumptive society without sufficient and sustainable sources of income owing to an unsustainable natural resource base.

(3) Socio-cultural transformation may evolve with loosening of traditional adat community values that become more materialistic and vulnerable to influences from outsiders and that may lead to business instability and social unrest.

It is easy to understand that 'pseudo capital transformation' as such does not help much to prosper the people in a peatland region. Existing poverty may be alleviated temporarily, but the vicious circle of poverty remains stubbornly. That is why a city port like Pulang Pisau (in the southern part of Central Kalimantan), which once was very busy with forestry based business transactions, became a 'dead city' once the forest resource base was exhausted.

Third Cause

This concerns market failure to provide perishable and bulky agricultural products with favourable prices. The 'price taking' market transaction for these agricultural products is weakened further by inadequate physical infrastructure. A kind of urban biased development is highlighted vividly in Central Kalimantan by the fact that only the road facilities in the capital city of Palangka Raya can be considered to be regularly in good condition. Elsewhere in the province, some 80% of roads in the rural hinterland are in a bad condition (see Table 3), and this is certainly a major constraint to economic progress, making it impossible to improve social welfare.

One way of understanding the effect of bad transportation is by taking a close look at spending and income patterns of either transmigrant or local (Dayaks) villagers (Tables 4 & 5). The empirical findings show that sedentary agriculture, which produces miscellaneous vegetables, was conducted on only about 0.48Ha of land. In other words the activity takes place in the home yard, which is exactly 0.5 ha, although each transmigrant family receives an additional 2 ha of main plot land from the Government. From this small farmed area each transmigrant family obtains only about 30% (slightly less than Rp 4million on average) of their total yearly income (around Rp12million). It is little wonder that temptation to become involved in illegal logging or illegal mining or other labouring activities for wages becomes so attractive in the eyes of the farmers. This further implies that:

(1) The farmers are really aware of the unexpected risk associated with drought and flooding, and so the best way to run the locally oriented 'agribusiness' in peatland areas is by way of limiting the farming size but varying the crops rationally.

(2) The farmers are actually able to extend their sedentary farm land in order to cover sufficient family spending, but the expected profitability of 'agribusiness' that faces a limited market demand is not too promising.

(3) The farmers are technically capable of fulfilling far-distant market demand for miscellaneous horticultural and other perishable products, but such an economic endeavour is constrained by bad transportation infrastructure.

Clearly, the bad condition of roads to and from rural areas is contributing greatly to the persistent poverty problem in peatland areas of Central Kalimantan (Soeparmanto, 1991). Peoples' own initiative and their farming experience cannot be utilized optimally to combat effectively the poverty problem that they are faced with. Only population growth can locally increase the size of an isolated market so as to increase to some extent non-forestry business transactions. Otherwise, there must be a serious effort to loosen the physical isolation of each productive peatland zone. Such an effort very much depends upon the political will of executive and legislative bureaucracies at the district and provincial levels.

PEATLAND MANAGEMENT: THREE ESSENTIAL INGREDIENTS

The empirical findings discussed above identify three important lessons on how to deal with poverty strategically.

First lesson

While population size continues to grow, forestry resources will soon be depleted and economic competition among ethnic populations will increase with the result that poverty will remain and its reduction will become more difficult. Extensive CD-program and systemic market engineering (ME-program) are necessary to enable people enhancing productivity and uplifting more added values so as to increase economic prosperity.

Second lesson

Since peatland ecosystems are becoming more and more threatened by the alarming rate of forest conversion, it is essential that peat swamp forest restoration must be constantly carried out without hesitation. A more cohesive role of investors and local communities as well as local government is very important in the efforts to implement social forestry to achieve effective sustainable forestry.

Third lesson

While appropriate transportation infrastructure is capital intensive to establish, commitment and consistency to restore the infrastructure is even more important. In order to build up the commitment, it is very important for the local government to conceptualize systemic scenarios of integrated agribusiness development before getting sufficient and consistent budget support from the legislative bureaucracy.

The above three important lessons lead to three essential ingredients to combat comprehensively poverty in the peatland areas of Central Kalimantan. The community development and market engineering (CD & ME) programs are essential for improving traditional ways of income earning among people, and implementing them may enhance productive capacity and economic creativity of rural populations. In support of these programs, the provincial government must take concrete steps to encourage and initiate inter provincial (inter-island) trading. Peat swamp forest restoration is essential in order to minimize drought and flooding incidents that hamper agribusiness development; then a social forestry approach to be called SFMU (social forestry management unit; or SUPK = satuan usaha perhutanan kerakyatan) is considered to be most appropriate. As a business entity, SFMU is supposed to be conducted by tripartite partners, namely, wise investor, local people and local government. It is obligatory for an SFMU to grow cash crops (e.g. Kumis-Kucing

(*Orthosiphon aristatus*)) and catch crops (e.g. vegetables whenever appropriate to catch profit opportunity) that will encourage people to grow tree crops. SFMU-based industrial forest plantations should be promoted as business entities that can participate directly in a regional forest rehabilitation program (instead of 'project' as usual). The establishment of good and sufficient rural-urban road infrastructure is also essential, but to get this requirement fulfilled it is important to have a blue print of a strategic plan for integrated agribusiness development programs for each district. Only by doing will the legislative institutions be likely to guarantee special budget support with strong commitment.

However, it must be emphasized that when the recommendation about SFMU is to be implemented, because a concept of social forestry can be misunderstood, it is not simply another example of the old fashioned approaches already well known in the world of forestry in Indonesia. What is actually meant by SFMU here is basically an integrated agribusiness strategy, which may be considered as phase-4 of social forestry evolution to be called here as 'Business Clustering Phase of Community-Based Forestry' which has been badly needed since the early 2000[4]'s.1 This strategy must pay much attention to 3 elements, namely: (1) Urgency for conservation and management of remaining protected forest (but an opportunity should still be given to the surrounding community to take economic advantage out of a manageable forest) since almost all production forest areas are degraded; (2) Emphasis on restoration of all heavily degraded forest as well as unproductive 'fallow' land by using a systematic business-unit approach (that encompasses social engineering, tree-crop farming and forestry business clustering); (3) Equitable task and responsibility sharing among agents of the 'industrial forestry triangle' (i.e. investor-community-government) to be followed with equitable sharing of the benefits eventually accrued.

Fortunately, scientific inputs are already available from various ecological, technical, and socio-economic research findings of several European Union funded projects, namely, EUTROP (1997-2001), STRAPEAT (2001-2004) and RESTORPEAT (2004-2007) that have been coordinated locally by CIMTROP (Centre for International Cooperation in Management of Tropical Peatland) at the University of Palangka Raya, Central Kalimantan. Indeed, the challenge to speed up economic development and poverty eradication has to be faced seriously within Central Kalimantan (Sjarkowi, 2005), but the application of that concept to peatland areas is certainly not easy for the 3 following reasons.

Firstly: an SFMU will likely be opposed strongly by systemic actors of illegal logging. Indeed, life is really beautiful when things are being felt abundant and so some people become somewhat dispassionate having been indulged by the richness of Mother Nature, whilst others are in a rush to extract natural endowments before potential competitors have awakened. This is what actually happened with regard to the hundreds of metric tons of timber products being harvested each month during wet season out of the Sg. Sebangau catchment. While the indigenous Dayaks remained mostly calm with their daily non-timber earning sources, around 200 people were involved in logging operations from week to week, deep within the 'jungle' where they rotated in groups. Each group of loggers was commanded by a local boss stationed permanently or temporarily in the nearby village, and the group activity usually ended with an income accounting after every month or 3 week period of

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[4] [1]According to Wiersum (1994) until mid nineties the concept of social forestry had evolved through 3 phases of empirical development. *(1)* ***Experimental phase (late 1970's to mid 1980's);*** *Emphasis on village woodlots and individual tree growing based on scaling-down of conventional forestry practices as means to address fuel wood and desertification problems. (2)* ***Consolidation phase (2nd part 1980's);*** *Increased understanding about the role of trees in livelihood strategies of villagers. Less emphasis on firewood, more on multi-product system and integration of tree growing with agriculture. Increased recognition of significance of indigenous agro-forestry practices. Less emphasis on community forestry approaches. (3)* ***Diversification phase (early 1990's);*** *Increased emphasis on conservation and management of existing forests, including controlled utilization of non-wood forest products. New understanding about the role of common property and joint forest management. Recognition of the need to conserve the cultural integrity of tribal forest dwellers. Increased attention to integrate forestry activities in local-level land use planning*

operation (Figure 1 describes the hierarchy of logging actors). The amount of timber extraction was obtained based on some interviews in August 2000 with a few actual doers and group leaders of timber cutting. It was calculated that since 1998 (the height of the economic crisis in Indonesia) timber extraction in the Sg. Sebangau catchment increased at a rate of more than 15,000 hectares, of forest logged annually. Since the forest had already been selective logging by forest concession companies, the productivity of the illegal extractive efforts is believed to have been very low. The estimated figure is about 120,000 tree stands amounting to some 40,000 cubic metres of wood being harvested annually. Only about 15% of the harvest consisted of Ramin (*Gonystylus bancanus*), whilst the rest was a mixture of poor quality woods. The illegal and semi illegal logging activities were then responsible for some Rp15 billion (=US$ 0.25 million) timber-based business annually in the rural region of the Sebangau catchment alone. Unfortunately, empirical information revealed that only a small portion of the business cash flow really went into the pocket of the field laborers. The actual doers in the 'jungle' only received about Rp1-1.5 million (US$220 at that time) per individual for a 3-weeks up to one month of working. That is an amount just slightly above the minimum requirement for someone to live normally for a month by Indonesian standards. This necessarily implies two things, namely: (1) most of the money from forest logging went to the 'local boss' and even further away to the 'faceless boss'; (2) the persons involved in the field simply couldn't utilize their earning to transform partially the usual economic activity into other activities of higher capacity that would generate added value in a sustainable way. Therefore, a large portion of distributable economic rent normally considered as a source of royalty that a local authority is supposed to be collecting was removed (enjoyably) by the bosses (or *cukong* in Bahasa Indonesia). Such a phenomenon is not good for the district and provincial economy as a whole. It goes without saying that in such an economy, ecosystem degradation, followed by environmental pollution and increased risk of natural hazards (e.g. fire) would consequently be taking place unchecked over time. Eventually, it could stop the economy from either self-transforming or growing. Such gloomy information reveals that the remaining tree stands in the Sebangau catchment (a peatland ecosystem of about 600,000 ha originally designated as limited production forest) will be cleared out completely within the next 20 to 25 years[22]This is likely to be followed by various kinds of ecological disaster and social economic problems, which therefore have to be properly anticipated, monitored and prevented. The degraded peatland forest already clear cut over the last decade could be restored and its large trees could recover and be ready to harvest again after at least 35 years. With such a scenario, it is perceivable that in the future there could be a period of 5 to 10 years when the timber based economy in Sebangau would simply be stagnant before the time comes for economic actors to conduct the next round of forest harvesting. Unfortunately, therefore, if ecologically sound business alternatives are not introduced very soon, social conflicts will intensify and serious social upsurge could potentially occur to destroy the existing social structure and economic infrastructure.

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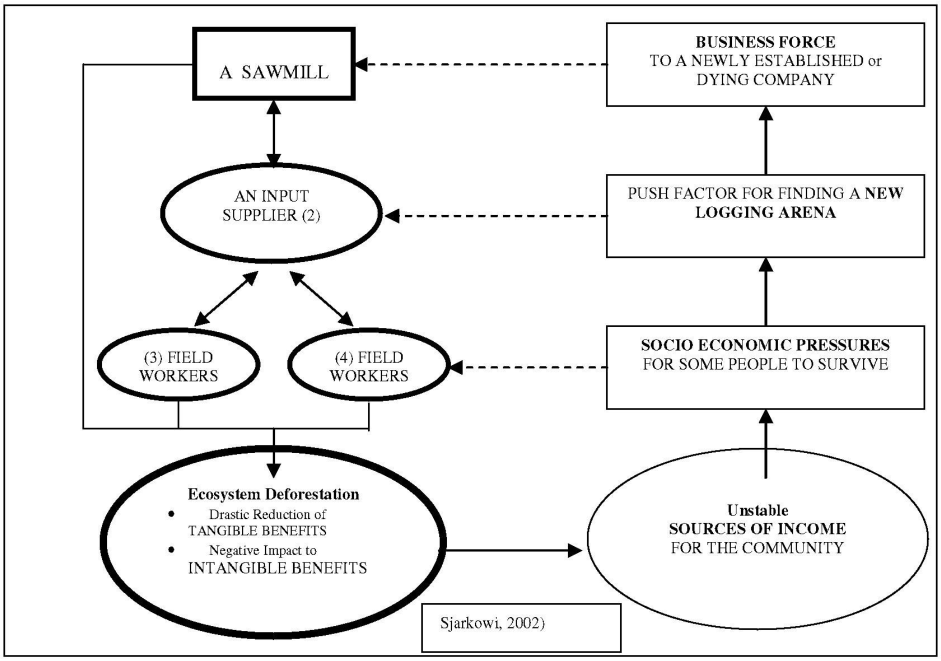
[2] *Most of this area was gazetted as a new National Park by the President of the Republic of Indonesia in 2006. In the light of the information presented in this paper it will be virtually impossible to maintain the condition of this vast peatland area in a way that will enable the natural peat swamp forest ecosystem to return to its original sustainable condition. This large store of carbon and reservoir of diversity, which have global implications, are under great threat of further degradation and may disappear quite soon with the result that problems of environmental degradation, fire and poverty will increase (Editor's note).*

Figure 1: ***Socio-Economic Chain of Logging Activity in Central Kalimantan***



Notes*; 3 > Javanese spontaneous & newly migrants usually labouring to dig out the swampy ground for log channelling ("tatah");* 4 > *Javanese transmigration settlers and some Banjarese and a few Dayaks individuals for the work of tree felling ("pembalakan")*

Secondly: an SFMU is surely unattractive if its tree cropping has to stand alone without cash crops and catch crops to be grown as complementary farming. However, it was understood from the STRAPEAT Study (2001-2004) that daily climate fluctuation (very hot or very heavy rain) over time could really make it difficult to grow cash crops or catch crops at too far a distance from one's house because of the need for watering when the climate happened to be so hot. In relation to this issue, some problems would become serious for transmigrants that are likely not used to undertake tree cropping which tends to be away from their home yards; and with the local people that are not really familiar with cash and catch crops farming while their focus would be more on tree cropping (such as rubber plantation) at a plot rather far away from their house. The issue is not merely about what extension service materials to attach onto related CD and ME programs, but rather, it is more about how to condition institutional development that can constantly guide social commitment to bring the mixed farming business into sustainable success. A non government (or community based) but more like non traditional (modern or business oriented) local institution is preferably suitable, since intensive cooperation and collaboration have to be promoted whilst extensive commercial transaction (e.g. bio-rights) needs to be dealt with (Absor in Sjarkowi, 2002). The question here is, of course, when and from where to start the institutional building process. Although sometimes that is more like a question of 'which comes first, egg or chicken?', but the importance of finding the most capable leadership team for an institutional organization must go through a buying time. Leadership set up can, therefore, be determined after the agronomy process and the associated CD program within an SFMU community have gone through for quite sometime. For this matter there will be no exact timing formula considerably appropriate. Either for transmigrants or for the local (Dayaks) community a case by case observational recommendation has to be decisively determined.

Thirdly: there is no guarantee that an SFMU will get political support from local government (both executive and legislative bureaucracy) as strong as from every other stakeholder for its comprehensive implementation. Local government is entitled to collect tax and retribution from the growing agribusiness, but the very low salary of Indonesian civil servants does not encourage their maximum dedication to push a project or a program towards success. A mechanism has to be established in order to position PT Perhutani (the state enterprise mandated particularly to manage state-owned forestry business) to be part of the total system of SFMU programme development. By doing so a portion of the agribusiness revenue that may accrue later on can partially go into the State pocket, which is accessible in accordance with the district government share and receivable for its own use and for the additional welfare of its officials in particular. At the primary agribusiness level Perhutani may be activated as supplier of best tree-crop (*Hevea braziliensis* or *Acacia* spp) seedlings. At the agro-industry level it may have a substantial share in a chip production business by allowing the company to harvest the existing Acacia trees which have grown large after being planted under a re-greening program in the late 1990s in many parts of the peatland area in the C-Block of the ex-MRP (mega rice project). In conclusion, it may be conceivable to say that the SFMU establishment programme could get not only strong policy support, but also should obtain a stronger push from local government (district and provincial) with sufficient infrastructural facilities being specially established in particular peatland areas.

CONCLUSION

Degrading peat swamp forest and rural poverty are twin problems that may be seen especially in Central Kalimantan. In order to restore peatland ecosystems and eradicate rural poverty, the peatland economy has to be developed accordingly. There are three main causes of rural poverty in peatland areas, and three essential ingredients to attack poverty are highly recommended. The future of peatland ecosystems will remain questionable if the local government does not take such a recommendations seriously into consideration. The peatland ecosystems and all biological as well as exhaustible resources inside them are too expensive to fade away with a careless attitude of the 'civilized' but poor inhabitants.

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Table 1: Poverty Status in Central Kalimantan

Kabupaten/Kota ***Regency/ Municapility***	Peduduk ***Population*** **(000)**	Pddk Miskin ***The Poor ****	Garis Kemiskinan ***Line of Poverty*** **(Rp/capita/month)**
(1)	**(2)**	**(3)**	**(4)**
Kotawaringin Barat	198,4	**25,18**	128.841,00
Kotawaringin Timur	288,3	**46,31**	146.075,00
Kapuas	328,5	**45,41**	125.695,00
Barito Selatan	121,3	**25,96**	120.257,00
Barito Utara	110,1	**20,02**	141.579,00
Sukamara	35,4	**13,92**	92.706,00
Lamandau	53,9	**13,83**	118.580,00
Seruyan	103,3	**14,55**	148.731,00

Table 1: (continued)

Kabupaten /Kota ***Agency / Municapility***	Peduduk ***Population*** **(000)**	Pddk Miskin ***Poor&Poorest people***	Garis Kemiskinan ***Line of Poverty*** **(Rp/Kapita/Bulan)**
(5)	**(6)**	**(7)**	**(8)**
Katingan	126,3	**16,74**	117.859,00
Pulau Pisau*	114,2	**21,54**	95.134,00
Gunung Mas	82,5	**18,67**	133.754,00
Barito Timur	81,3	**23,24**	135.895,00
Murung Raya	87,1	**17,07**	133,754,00
Palangkaraya	182,3	**17,45**	106.728,00
Jumlah/*Total*	**1.912,7**	**205,54**	**134.374,00**

Table 2: Rate of Economic Growth, Kalimantan Tengah 1999-2004

Year	*At Current Price (Rp)*	*Percentage of Growth*	*At 1993 Constant Price (Rp)*	*Percentage of Growth*
(1)	(2)	(3)	(4)	(5)
1999	**4.258.398,39**	**8,79**	**1.779.576,24**	**-1,57**
2000	**4.650.803,02**	**9,21**	**1.725.532,89**	**-3,04**
2001	**5.146.481,14**	**10.66**	**1.739.919,28**	**0.83**
2002	**5.687.034,87**	**10.50**	**1.771.295,29**	**1.80**
2003	**6.386.932,09**	**12,31**	**1.819.485,04**	**2,72**
2004	**7.176.364,46**	**12,36**	**1.862.281,49**	**2,35**

Table 3: Length of Roads at Regency/Municipality by Type of Surface, Condition and Class of Roads (Km; condition in 2003)

Uraian *Description*	**Kabupaten/Kota** *Regency/Manicipality*					
	Kobar	**Kotim**	**Kapuas**	**Barsel**	**Barut**	**Sukamara**
(1)	(2)	(3)	(4)	(5)	(6)	(7)
▪ Kondisi jalan/ Road Condition	1.273,00 324,90	1.509,28 146,14	1.480,41 -	374,50 76,50	2.295,91 400,42	- -
▪ Baik/Good	541,85	115,72	-	125,00	1.448,05	-
▪ Sedang/Fair	178,85	331,28	-	95,00	314,82	-
▪ Rusak/Damaged	227,40	915,30	-	78,00	132,62	-
▪ Kelas Jalan / Class Of Roods	1.273,00	1.509,28	1.480,41	374,50	2.295,91	-
▪ Kelas I+II	-	-	-	-	-	-
▪ Kelas III + IIIA	-	-	-	-	-	-
▪ Kelas IIIB	459,23	-	-	374,50	-	-
▪ Kelas IIIC	813,77	1.509,28	1.480,41	-	2.295,91	
Jumlah/*Total* 2003	**1.273,00**	**1.509,28**	**1.480,91**	**374.50**	**2.295,91**	-

NB: ***Notice that about 80% of the roads throughout CK districts are in bad condition***

Table 4: Average Annual Spending as Proxy to Total Family Income; Kalimantan Tengah 2005

No.	*Spending Item*	*Average Family Spending, 1 year periode*	
		Trans-Family (n=40)	Native Family (n=30)
1	Consumption	5.156.223	6.488.183
2	Ritual ceremony	1.331.817	415.783
3	Educational cost	814.075	683.633
4	Health spending	368.150	429.133
5	House maintenant	862.667	1.094.333
6	House equipment	64.467	45.696
7	Family recreation	170.333	208.667
8	Farm necessity	516.993	820.540
9	Transport cost	959.833	642.758
10	Debt repayment	628.767	1.444.700
11	Saving	629.033	186.667
12	Tax	152.328	191.987
	J u m l a h	11.548.819	12.606.384
	Average F-size	***5.45***	***5.21***
	Average per-month	Rp 176.587	Rp 201.838
	***Poverty line** (2005 est'd)*	**Rp 150.499**	**Rp 150.499**

Sample villages include Kelampangan, Gandang and Kantan Muara

Table 5: Family Income from Sedentary Agriculture in Kelampangan

No	Crop	Hectares	Revenue	Crop	Net Revenue
1	Jagung	0.236	968.300	43.000	572.775
2	Sawi manis	0.069	812.800	367.355	445.445
3	Tomat	0.029	230.000	24.090	205.909
4	Kacang panjang	0.027	242.750	145.792	96.958
5	Mentimun	0.067	43.000	67.200	- 24.200
Total		0.428	2.296.850	999.962	1.296.888
Total income out of 3 production cycles					**3.890.664**
Total spending 1-y					11.548.819
Estimated total extra income from non-sedentary agricultural activities					**7.658.155**

UNLOCKING THE NATURAL RESOURCE FUNCTIONS OF TROPICAL PEATLANDS: UNDERSTANDING THE NATURE AND DIVERSITY OF PEAT SWAMP FOREST VEGETATION AS A FOUNDATION FOR VEGETATION RESTORATION STUDIES

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SUMMARY

The rapid loss of biological diversity that is occurring as a result of species loss owing to habitat destruction and fragmentation is considered one of the world's most pressing environmental problems. Whilst the diversity associated with lowland tropical peatlands is usually lower than adjacent terrestrial rain forest ecosystems, many peatland species are specialists, which are not found in other habitats. The inaccessibility of peatlands has also drawn in species that, although not confined to this habitat, are dependent upon the shelter and food that peat swamp forests provide, compared to the intensively logged forests on mineral soils. As more information on the biodiversity of tropical peat swamp forests accumulate it is clear that this ecosystem has been undervalued as a habitat for rare and threatened species, for example, orang utan.

Keywords: peat swamp forest, biodiversity, restoration, natural resource functions, wise use

INTRODUCTION

Lowland tropical peatlands provide a range of valuable ecological functions and environmental services (Maltby *et al,* 1996; Page & Rieley, 1998). For example, they support a large diversity of plant and animal species, some of which are endemic or endangered (Page *et al,* 1997). These vast wetlands are also important catchment and control systems that provide water for drinking and irrigation and, in coastal areas, they are buffers between salt and freshwater hydrological systems. During the last 15 years, there has been increasing interest in the important role played by tropical peatlands in the global carbon cycle; they are recognized as storing globally significant amounts of carbon and are also repositories of important geochemical and palaeoenvironmental information (Sorensen, 1993; Neuzil, 1997; Page *et al,* 2004; Weiss *et al,* 2002; Wiist & Bustin, 2004). In addition, lowland tropical peatlands have contributed to the way of life and economy of indigenous people for centuries through the provision of plant and animal resources for food, shelter, medicine and cultural well-being.

In recent decades, tropical peatlands have come under increasing pressure from human-mediated disturbances, in particular logging, drainage and conversion to agriculture or plantation forestry. The associated changes in forest and land management practices have impaired the natural resource functions of the peatland ecosystem, greatly reducing the area of undisturbed forest and increasing its susceptibility to degradation and fire (Page *et al.,* 2002). The challenge facing those involved in the management of tropical peatlands in the 21^{st} century is to develop integrated planning and management mechanisms that balance the conflicting demands on the tropical peatland resource to ensure its continued survival. This strategy of 'wise use' involves evaluation of natural resource functions and uses, the impacts caused by development, and the priorities for future sustainable management and use, including mitigation of damage. These mitigation measures may, where appropriate, include efforts to promote restoration of the original forest cover, but restoration efforts will only be effective if they are based upon sound understanding of natural ecosystem processes.

This paper provides a brief overview of the current state of knowledge of the vegetation of lowland peat swamp forests in Southeast Asia and the key ecological features that need to be considered before embarking on restoration initiatives.

PEAT SWAMP FOREST VEGETATION

Lowland tropical peat swamps are almost exclusively ombrogenous systems (i.e. the peat surface only receives water from precipitation), whilst geogenous peatlands, that are fed additionally by water that has been in contact with the mineral bedrock and soils, are of more limited distribution, being confined to the edges of coastal lagoons, the banks and flood zones of rivers, and the margins of lakes. Undisturbed, lowland ombrogenous peatlands support peat swamp forest, whilst geogenous wetlands support freshwater swamp forest. The ombrogenous swamps provide a unique tropical forest environment: the peat substrate, which may exceed 10 m in thickness, affords an extremely unstable, acidic, nutrient-poor, and almost continually waterlogged rooting environment. Many of the forest trees have buttress or stilt roots that provide improved stability on the waterlogged peat soils and also breathing roots (pneumatophores) that protrude above the peat surface, enabling respiratory gas exchange to occur under anaerobic conditions.

The global centre of tropical peat swamp forest distribution lies in the Indo-Malayan realm, in Malaysia, Indonesia, Vietnam, Thailand and the Philippines. In most of these countries the area of peat swamp forest has been reduced to a small fraction of its former extent, with the largest remnants found in Malaysia and Indonesia. Approximately 800 tree species have been recorded from the peat swamp forests of western Malesia (i.e. excluding the peat swamps of Papua New Guinea), comprising 71 families and 237 genera. The principal tree families represented in the peat swamps are Euphorbiaceae, Myrtaceae, Lauraceae, Clusiaceae, Rubiaceae and Dipterocarpaceae. Members of the Pandanaceae often form a dense ground cover; pteridophytes and insectivorous pitcher plants (Nepenthaceae) also occur. In marked contrast to boreal and temperate peatlands, the principal peat-forming plants are the trees, whilst bryophytes, grasses, sedges and herbaceous species play a very minor role in both the vegetation and peat formation.

Table 1: Comparison of tree species diversity between five forest types on the island of Borneo.

Forest type	No. tree species / hectare	Reference source
Lowland dipterocarp forest	270-393	Davies & Becker 1996; Suzuki *et al.* 1999.
Heath forest	70-171	Davies & Becker 1996; Suzuki *et al.* 1999.
Peat swamp forest	75-120	Anderson 1963; Siregar & Sambas 2000; Waldes unpublished.
Sub-montane forest	115	Simbolon & Mirmanto 2000
Montane forest	48	Simbolon & Mirmanto 2000

The tree species diversity associated with peat swamp forests is usually lower than that of adjacent forest ecosystems on mineral soils (Table 1), but several tropical peatland trees are specialists and restricted to this habitat. Studies of the peat swamp forests of western Malesia have revealed that *Archidendron clypearia, Dactylocladus stenostachys, Gonystylus bancanus, Horsfieldia crassifolia, Shorea belangeran* and *S. teysmanniana* are confined almost exclusively to this habitat and three of these species, *G. bancanus, H. crassifolia* and *S. belangeran*, are included on the IUCN (www.iucn.org) red list of globally endangered plants. Phytogeographic studies have also indicated considerable regional variation in the peat swamp flora, with only five tree species (from the total of 800) displaying a widespread distribution across west Malesia, namely *Baccaurea bracteata, Campnosperma coriaceum, Ilex cymosa, Madhuca motleyana* and *Stemonurus secundiflorus*. Across the peat swamp forests of the island of Borneo there are only three widespread tree species (*Dactylocladus stenostachys, Cratoxylum arborescens* and *Koompassia malaccensis*) and there are striking sub-regional differences in floristics between the peat swamps of northern Borneo (Brunei and Sarawak), west, central and east Kalimantan. Thus at both regional and sub-regional scales, tropical peat swamp forest vegetation displays considerable heterogeneity.

Differences in hydrology and nutrient availability exert strong influences on the composition and structure of the forest vegetation, with most large tropical peatland domes exhibiting a concentric zonation of forest sub-types, ranging from tall, floristically-diverse and structurally-complex forest over shallow peat at the margins to less diverse, low-canopy pole (small diameter) forest over thicker peat towards the centre, although some exceptions to this general pattern have been described (Page *et al.,* 1999). Six phasic communities have been described for the peatlands of Sarawak (Anderson, 1963, 1964), ranging from a structurally complex, species-rich community around the edges of large peat domes, to stunted, dense low pole and *padang* (open) communities on deep peat which coincide with zones of hydrological and nutrient stress (as a result of waterlogging and low nutrient availability); intermediate communities are dominated by the dipterocarp tree *Shorea albida*. In the peat swamps of Central Kalimantan, five phasic communities have been identified (Table 2) (Page *et al.,* 1999). These differ in several respects from those described from Sarawak, principally the absence of *S. albida*, and the presence of a tall forest community dominated by *Palaquium leiocarpum* on the central part of the peatland dome. By contrast, the peatlands of the Malay Peninsula and Sumatra appear to support only two main forest types, a tall, marginal mixed swamp forest and a lower, pole forest on the thicker peat, although it should be noted that there are only a few accounts of the vegetation of Sumatran peat swamps. The high levels of vegetation heterogeneity associated with peat swamp forests may, at the regional and sub-regional scale, reflect long-term biogeographical events (i.e. changes in geological configuration, climate, sea-level changes and land-sea distributions) (Metcalfe, 2002), or ecological events that operate over shorter time scales, including variability in succession trajectories and differences in disturbance regimes. Whatever the underlying cause or causes, this information highlights the individualistic nature of both regional and local community dynamics within tropical peat swamp forest.

Table 2: Principal tree species occurring in three peat swamp forest communities on peat of increasing depth across a peatland dome in the Sebangau catchment, Central Kalimantan.

Principal tree species	Mixed swamp forest at the edge of the peat dome on peat up to 6m thickness	Low pole forest nearer to the centre of the peat dome on peat from 6 to 10 m thickness	Tall interior forest on the central peatland dome on peat from 10 to 13 m thickness
Palaquium ridleyi	x		
Calophyllum hosei	x		
Mesua sp.	x		
Mezzettia parviflora	x		
Combretocarpus rotundatus	x	x	
Sizygium		x	
Tristaniopsis obovata		x	
Shorea teysmanniana		x	x
Palaquium leiocarpum			x
Stemonurus secundiflorus			x
Mezzettia parviflora			x
Neoscortechinia kingii	x		x
Palaquium cochlearifolium	x		x

In general terms, the taller peat swamp forest sub-types (e.g. marginal mixed swamp forest) which have the greatest tree species diversity and canopy stratification, also support the greatest floral and faunal diversity (Page *et al.,* 1997). Lower canopy forest sub-types (e.g. low pole and padang forest) are less species diverse. These forests are not without interest, however, and several noteworthy species of plant, mammal and bird have been recorded in low pole forest (Page *et al.,* 1997), whilst the many water-filled hollows on the forest floor support unusual species of blackwater fish (Ng *et al.,* 1994).

Where tropical peat swamps have been degraded by human activities, various secondary forest and non-forest plant communities replace the original vegetation, ranging from open canopy forest with invasive tree species (e.g. *Macaranga* spp.) at sites that have been logged-over, through to seriously degraded sites which have been logged, drained and/or burnt on at least one occasion. At these latter sites there will, at best, be a fragmentary forest canopy and ground vegetation dominated by ferns (including *Stenochlaena palustris*, *Lygodium* and *Pteris* spp.), grasses (e.g. *Imperata cylindrica*), sedges (*Scleria* and *Cyperus* spp.), shrubs (e.g. *Melastoma malabathricum*) and other fast-growing species. In Central Kalimantan, studies are currently underway to determine the pathways of secondary vegetation succession following various types of peatland degradation, including successive fire events. This will provide useful information on the processes of spontaneous vegetation recovery. In conjunction with planting trials of native peat swamp forest tree species, this work will provide initial data on the site treatments that may be required to enhance restoration success, e.g. manipulation of hydrology and nutrient conditions or the removal of barriers to tree regeneration, such as the lack of bird perches at deforested sites.

KEY BIOPHYSICAL FUNCTIONS

In any ombrotrophic peatland there is an intimate relationship between the hydrological and nutrient-supply conditions and the associated features of the vegetation. The fluctuation of the water table within tropical peatlands depends mainly on rainfall because evaporation and outflow are fairly constant. During the wet season, rainfall always exceeds the combination of evaporation and surface run-off. In this period, the water table increases and may come to or rise above the surface, creating several months of anaerobic rooting conditions. By contrast, during the drier months of the year when the rain-free period may last for several weeks, the water level drops below the soil surface often to depths of 0.2 to 0.6 m, and peat swamp forest vegetation may be faced with a physiological water deficit. Water table fluctuations vary across an intact peat dome by up to 0.60 m near the edge and 0.45 m near the centre. (Ong & Yogeswaran, 1992; Yonetani & Takahashi, 1997; Page *et al.,* 1999; Takahashi *et al.,* 2002). These differences in hydrology play a fundamental role in determining the fine-scale spatial vegetation patterns observed across intact peatland domes, with the low pole and padang forests normally occupying the wettest central parts of the dome where water levels are highest, and the taller forest types occupying locations where there is a greater hydraulic gradient and thus reduced levels of waterlogging. By contrast, in degraded and drained peatlands, low rainfall during the dry season may enable groundwater levels to drop to 1 m or even 1.5 m below the soil surface. Under these conditions, not only may the low water table limit the range of plant species able to establish and survive, but susceptibility to fire will also be greatly increased. During the wet season, areas that have subsided as a result of peat degradation or fire may experience extensive flooding with groundwater levels of more than 1 m above the soil surface for a prolonged period of time. Studies in the peatlands of Jambi province, Sumatra have shown that this creates shallow lakes where plant species cannot re-establish (Wösten *et al.,* 2006). The restoration of near-normal seasonal water levels is, therefore, likely to be crucial to the successful re-establishment of a closed forest cover, although it is too early to speculate to what extent the fine-scale differences in hydrology and hence vegetation can be replicated in restoration schemes.

Plant nutrients are in limited supply in ombrotrophic peatlands and subtle differences in nutrient cycling may have significant impacts upon the growth and performance of peatland plants. In tropical peat swamps, vegetation growth is dependent upon both the supply of nutrients from the atmosphere and efficient recycling of the existing nutrient pool within the ecosystem (Page *et al.,* 1999). In a study of the nutrient dynamics of a peat swamp forest ecosystem in Central Kalimantan (Sulistiyanto, 2004) it was demonstrated that internal nutrient transfers were related to forest tree biomass through gravitational influence (throughflow, stemflow and litterfall) and recycling (organic matter decomposition and uptake by the trees), and to storage in and release from the surface peat (accumulation or degradation) (Weiss *et al.,* 2002). Nutrient inputs (in precipitation and dry fall) were higher than nutrient losses (in runoff from the peat dome). The overall nutrient budget indicated that chemical elements were being retained within the forest vegetation, with any surplus being stored in currently accumulating peat. In contrast, studies on non-peat forming tropical forests have shown mostly annual net losses of most plant nutrient elements (Lewis, 1986; Bruijnzeel, 1991). Intact peat swamp forest vegetation clearly operates under limiting but efficient conditions of nutrient supply and cycling; studies of nutrient cycling in secondary peatland plant communities could play an important role in highlighting the extent to which nutrient pathways have been disrupted and their likely impact upon vegetation performance.

LESSONS FOR WISE USE AND VEGETATION RESTORATION

Wise use strategies for tropical peatlands need to acknowledge the global importance of the tropical peat swamp forest ecosystem, which supports a high diversity of tree species, including some species which are both habitat endemics and globally endangered. These strategies also need to recognise the high levels of vegetation heterogeneity that tropical peatlands display at a range of scales. There is clearly a lot more work that needs to be done to provide a comprehensive description of peat swamp forest plant communities; there is also some urgency given the current high rates of land conversion of tropical peatlands. These data are important in their own right as they enable comparisons between different locations, which may be important in terms of setting regional conservation priorities, but they are also an important guide for restoration initiatives since they enable local restoration targets to be set which can be used to determine the eventual success or failure of restoration measures. Restoration studies in tropical peat swamp forest are in their infancy but owing to the nature of the system and the range of disturbances it is clear that defining the success of the restoration cannot be standardized easily across sites. Understanding the cause or causes of forest damage will be important if the restoration is to succeed; equally, preventing further disturbance, in particular that caused by fire, will be absolutely vital. Establishing the right environmental biophysical conditions will also be an important prerequisite of success. The hydraulic conductivity, water level, acidity and nutrient content of the peat substrate will determine which tree species can establish, but these parameters may have been altered as a result of drainage or fire. Research needs to be carried out on the tolerance of individual tree species to these altered conditions. Other questions that need to be answered include (1) should the forest be left to re-grow naturally, perhaps with some mitigation measures in place, or (2) should trees be reintroduced artificially, by planting out from nursery stock? Future areas of research should also include long-term vegetation monitoring of restoration sites, accompanied by analysis of hydrological conditions and biogeochemical pathways that occur as the system is restored, and which can be useful in relating the restored forest to the reference system. Time in post-fire vegetation development is extremely important and should be considered as an, if not the, over-riding dimension that shapes all vegetation formation factors (Mueller-Dombois, 2001). It is unlikely that the success of tropical peatland restoration schemes will be measured in decades or perhaps even centuries.

The advantages of restoring peat swamp forest vegetation are numerous and should be pursued in a range of locations across Southeast Asia, but particularly in those areas where the peat thickness is so great that it is likely to prohibit any other form of sustainable land use. Restoration of the forest cover will contribute to improvements in water quality and water supply, maintenance of the peatland carbon store, and provide the people living in or adjacent to peatland landscapes with an improved quality of life.

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WATER MANAGEMENT FOR SUSTAINABLE WISE USE OF TROPICAL PEATLANDS

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SUMMARY

The lowland peat swamps of Borneo are purely rain-fed. They have their origins in the topographic conditions that lead to semi-permanent waterlogging. Under natural conditions, they are formed by the accumulation of vegetation, which is deposited on the waterlogged soils faster than it can decay. Hydrology is an important (if not the most important) factor in the formation and functioning of peat swamp ecosystems. The hydrology of a peat swamp depends on the climate, topographic conditions, natural subsoil, and drainage base. Water management, especially drainage, is needed to make these peatlands suitable for agriculture or other land use. Any changes in the hydrology, especially those from the introduction of drainage, will have often-irreversible effects on the functioning of these fragile ecosystems. Only a sound understanding of the hydrology of peat swamps will make it possible to develop and manage them in a more sustainable way. In this paper, water management challenges for the wise use of these peat lands are discussed. The challenge hereby is to strive for a balance between water levels allowing optimal land use and water levels minimizing peat subsidence. It should be remembered, however, that subsidence cannot be completely arrested; it is the price one has to pay for utilising lowland peat swamps.

Keywords: **peat land, hydrology, water management, land use, fire, subsidence**

INTRODUCTION

About one quarter of the world's tropical peatlands (11 million hectares) occur in Borneo. In their natural conditions, peatlands are waterlogged most times of the year. Poor drainage, permanent waterlogging, high rainfall, and substrate acidification are conditions in which plant residues accumulate faster than they decay. In the tropics, the rate of peat accumulation is about 2 to 5 mm/year (Charman, 2002). Drainage is needed to make these waterlogged lands suitable for agriculture or other land use. The leading principle of the traditional water management practice was based on fulfilling the drainage requirements: avoiding flooding by evacuating excess rainfall within a certain period of time (Lim, 2003, DID, 1973). Furthermore, it was assumed that this excess rainfall is mainly removed by surface runoff. The design principles for peatlands were thus similar to those for mineral soils, although their soil and hydrological characteristics differ greatly. Compared to mineral soils, peat has a much higher infiltration capacity, drainable pore space and hydraulic conductivity, but a lower capillary rise, bulk density and plant-available water (Ong & Yogeswaran, 1991). Another major difference is the subsidence behaviour of peat: it is never-ending and partly caused by oxidation. In tropical peat, subsidence rates vary between 20-50 mm/year of which 60% is attributable to oxidation and 40% to shrinkage. This oxidation leads to CO2 emissions, which under Borneo conditions is estimated to be in the order of 26 tonnes per hectare per year (DID, 2001). Besides the loss of peat by oxidation, the excessive subsidence rates result in a pronounced drop in the elevation of the land, reducing the efficiency of the drainage system (Figure 1). To avoid flooding and waterlogging problems during the monsoon season, frequent deepening of the system is required. The resulting lower water levels trigger off increased subsidence and so on. In Western Johore, Peninsular Malaysia, for example, it is estimated that the low water levels in the drainage system, caused by uncontrolled drainage, increase the overall subsidence by approximately 30 per cent (DID & LAWOO, 1996).

Many development projects on tropical peatlands fail through a lack of understanding of the natural functions of the peatland ecosystem (Rieley *et al.,* 2002). In Central Kalimantan, Indonesia, in the area planned for the former mega-rice project, the hydrology of peat domes has been altered by the construction of thousands of kilometres of drainage canals. The canals cut through the dome-shape of the peat swamps and greatly increased their runoff. More than 4600 km of drainage/irrigation canals have been constructed across peat domes up to 12 m thick. The main and secondary drains vary in size with widths varying between 10 to 40 m and depths between 2 to 6 m. In additional, numerous small canals have been dug to transport illegally logged timber from the peatland forest. Although these canals are small, varying in width between 1 and 3 m and relatively shallow (depth < 1 – 1.5 m), they can be up to 10 km long. To sustain the use of lowland peat a new approach in water management, based on controlled drainage, is nowadays advocated (Ritzema *et al.,* 2003). The strategy for this new water management approach is based on the principle that peat is a precious resource that should be handled with care to prolong its life. This can only be achieved if there is a shift from the concept of unrestricted removal of excess water to controlled drainage. This integrated water management principle combines drainage, irrigation and water conservation, all three aiming to enhance sustainable agricultural land use. Drainage is needed during the monsoon to control the water table and to remove excess surface and subsurface water from the land. Irrigation, which in this case is called sub-irrigation or inverse drainage, is needed to supply water through capillary flow during dry spells and water conservation is needed to control the water table at a higher level throughout the year to sustain the peat. Thus a water management system in peatlands has to be multipurpose, i.e. it should (i) remove excess surface and subsurface water; (ii) control the water table, and; (iii) conserve the water. Water management is also required in degraded peatlands to restore the hydrology and for fire prevention. In this paper, the three main challenges to apply this new water management approach are discussed.

CHALLENGE 1: EACH TYPE OF LAND USE REQUIRES ITS OWN SPECIFIC WATER MANAGEMENT SYSTEM

Each type of land use requires its specific depth of the water table. Water table control is not only needed for agriculture (Table 1) but also to restore the hydrology in degraded peatlands and for fire prevention. If the water table in a peat swamp forest falls to about 0.40 m below the ground level the fire risk increases significantly (Takahashi et al., 2002) (Figure 2). Subsidence, however, is dependant upon the depth of the water table: the deeper the water table the higher the rate of subsidence. For the conditions in Borneo, the relation between subsidence and depth of the water table is estimated to be (Wösten et al., 2003):

Subsidence rate (cm per year) = 0.1 * depth of the water table (cm)

Thus, if in a peat area, two different types of land use, e.g. an oil palm plantation next to a vegetable growing area, are practiced, the elevation of the ground will be different: in the oil palm area with its lower water table the subsidence will be higher and thus the elevation lower (Figure 3). This in turn will influence the depth of the water table as the permeability (i.e. hydraulic conductivity) of tropical peat soils is very high. In the vegetable plot adjacent to the oil palm area the water table will be too low owing to seepage while, in the oil palm area, the water table will be too high, creating waterlogged conditions. These differences in subsidence rates have also repercussions for the operation and maintenance of the water management system: the deeper the water table the higher the subsidence, thus the shorter the time period after which the drainage canals have to be deepened to avoid waterlogging. For oil palm plantation in Sarawak, it is estimated that the drainage canals have to be deepened every 5 years (Veltman, 2006). The same conditions will prevail when agriculture or other land use types that require drainage are introduced next to an undisturbed peat swamp forest: the peat forest will be drained from its edges and in the course of time it will disappear completely. How long this will take depends on the thickness of the peat: for shallow peat (peat depth < 1.50m) this can happened in a couple of years, for deep peat (> 3.00m) it can take centuries but in the end the peat will vanish. Thus combining different types of land use in one peat catchment or combining land use and nature conservation are unsustainable options.

Table 1: The various crops that are often considered for cultivation on the peat soils of Sarawak, their water management requirements and the main constraints to their yields (DID, 2001)

Crop	Water Management Requirements			Main constraints to yields or productivity[a]
	Optimum range of the water table (m)		Maximum period of flooding (days)	
	Minimum	Maximum		
Oil palm	0.6	0.75	3	▪ low fertility ▪ susceptible to termites ▪ poor anchorage ▪ drought stress
Cssava/ Tapioca	0.3	0.6	nil[b]	▪ mechanisation
Sago	0.2	0.4		
Horticultural crop	0.3	0.6	nil	▪ mechanisation
Aquaculture				▪ water quality ▪ construction of ponds ▪ water control in ponds
Paddy	- 0.1	0.0		▪ water control in individual plots ▪ plant nutritional problems ▪ mechanisation
Pineapple	0.75	0.9	1	▪ mechanisation
Rubber	0.75	1.0		▪ poor anchorage
Acacia crassicarpa	0.70	0.8		▪ poor anchorage

a Constraints to transportation (e.g. good access) that apply for all crops are not mentioned in this list.
B Very low tolerance, not to be planted in flood-prone areas

CHALLENGE 2: WATER STORAGE AND WATER LEVEL CONTROL

Depending on the season, the water management system has to perform different functions: during the rainy season removal of excess water is required but during the dry system water conservation is needed. Furthermore, water table control is needed to maintain favourable growing conditions for the crops or to avoid excessively dry conditions (fire prevention). Water table control is, however, difficult, because as already discussed the water management requirements change from season to season, thus adjustable control structures are needed. The challenges to make such structures are discussed in the next section. Furthermore, all peat domes are convex-shaped and their only source of water is rainfall. Especially in the dry season, when evaporation exceeds rainfall, the water tables will fall and this deficit cannot be supplemented by irrigation as this would require pumping. There is, however, a possibility to use the internal storage capacity of the peat-dome itself. If the central part of the peat dome is left untouched, it can be used as a water storage area. By surrounding the area with a low internal bund, the original high water tables can be maintained and waterlogged conditions during the rainy season can even be increased. The slow release of water during dry periods can be used to maintain a high water table in the lower parts of the dome.

CHALLENGE 3: STRUCTURES

As discussed in the previous section, water table control is needed either to create good conditions for agriculture or to restore degraded peat domes. To control water tables, structures are required in the canal system. To construct these structures a number of constraints have to be overcome, i.e.:

- Peat has a very low load-bearing capacity, thus structures either have to been piled or floated. Pile structures have the disadvantage that after a few of years the surrounding area will have subsided and the structures end up "*hanging*" in the air and no longer suitable for water table control. "*Floating*" structures have unit weight more or less the same as that of the surrounding peat: these structures will thus subside at the same rate as the surrounding peat area. These "*floating*" structures can be made from dried and compressed peat or e.g. polystyrene, which is lightweight (from 15-35 kg/m^3), insensitive to water and insects and has favourable compressive and tensile properties (DID, 2001).
- Peat has a high permeability thus the structures cannot achieve much head difference (= difference between upstream and downstream water level) and thus cannot store much water. They will mainly act as an extra barrier to flow (= increase flow resistance).
- Discharge requirements fluctuate greatly over the year as rainfall varies considerably. In the rainy season, flow can be especially high and these extreme discharges should not result in overtopping the banks and the water control structure as this will result in severe erosion. The structures should therefore be designed as weirs.
- Canals are also used for navigation/transport, thus either alternative transport facilities are required or the local people have to accept that structures act as barriers to their freedom of movement.

Keeping these constraints in mind, the following options are proposed:

- Instead of making large structures at long distances apart, a cascade of weirs with small head differences should be constructed (Ritzema et al., 1998). Simulations using a one-dimensional, non-steady state, model for water movement and water quality indicate that from the prevailing slopes of the peat-domes in Borneo, structures should not be spaced more than 200 m apart (Bleeker, 2005).

- To avoid too much discharge, the construction should start at the upstream end of the canal.
- To avoid too much load/weight, indigenous materials should be used: timber, (compressed) peat etc. This will also reduce cost.

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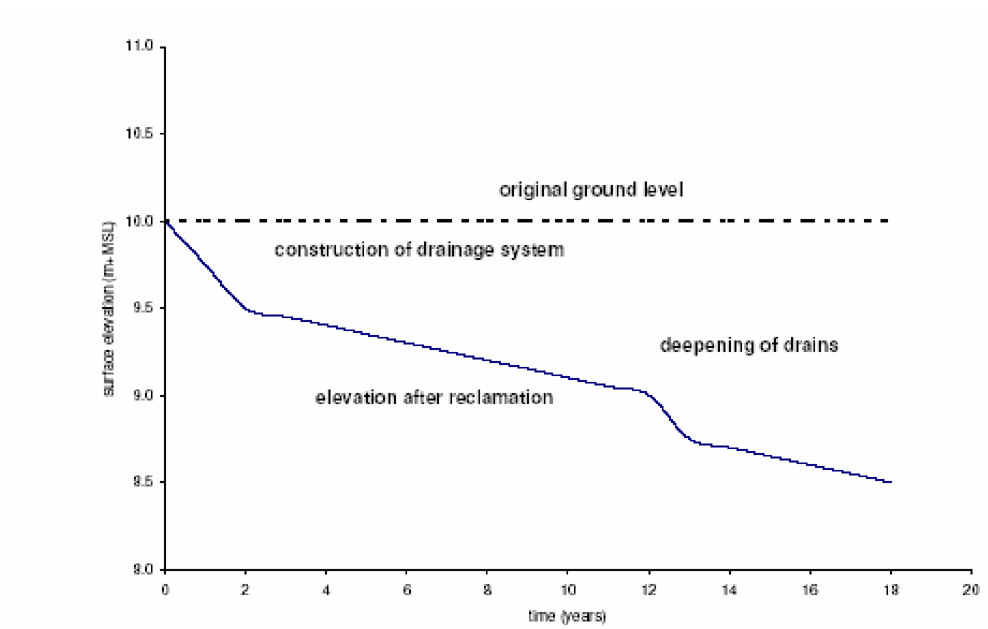

Figure 1 The everlasting subsidence results in a continuously lowering of the elevation of the land surface (After Eggelsman 1982).

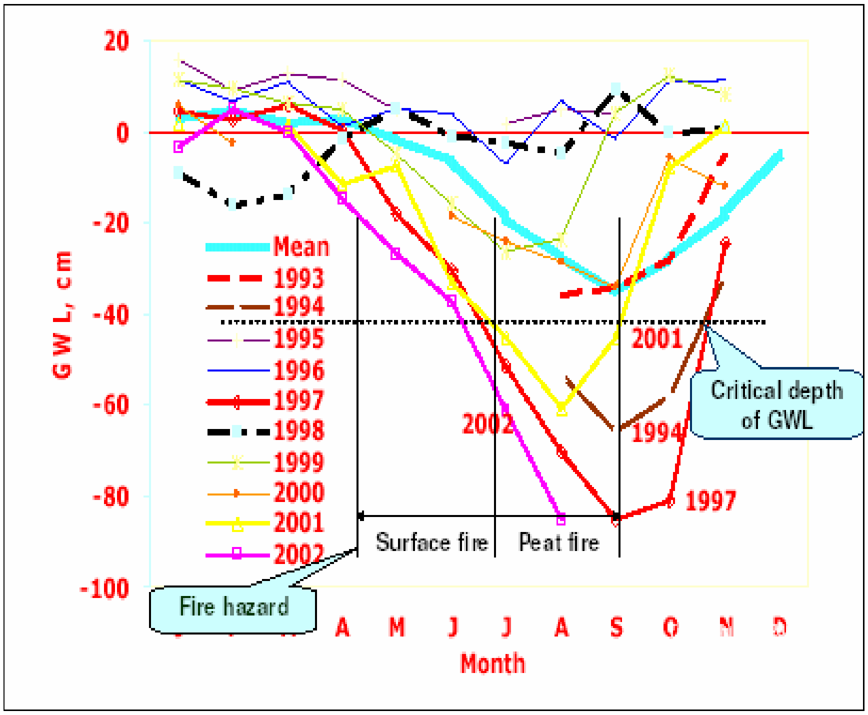

Figure 2 Relation between the depth of the water table in a peatswamp and the occurrence of peat fires (after Usup, 2004)

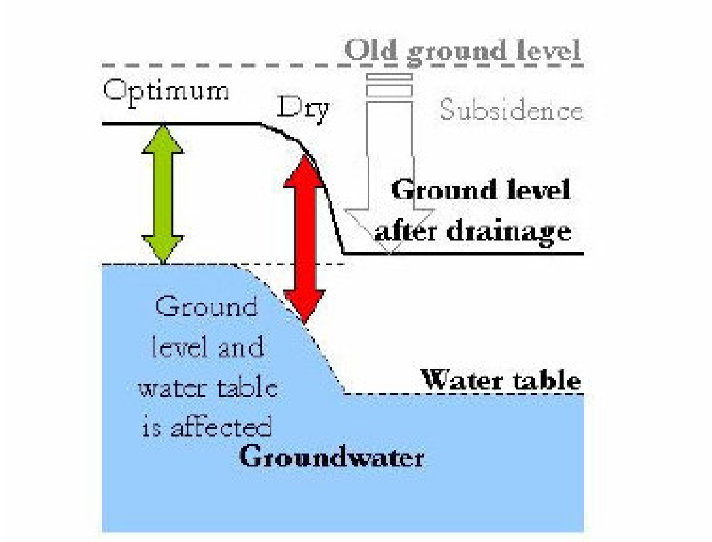

Figure 3 Two different types of land use adjacent to each other results in different subsidence rates (Veltman, 2006)

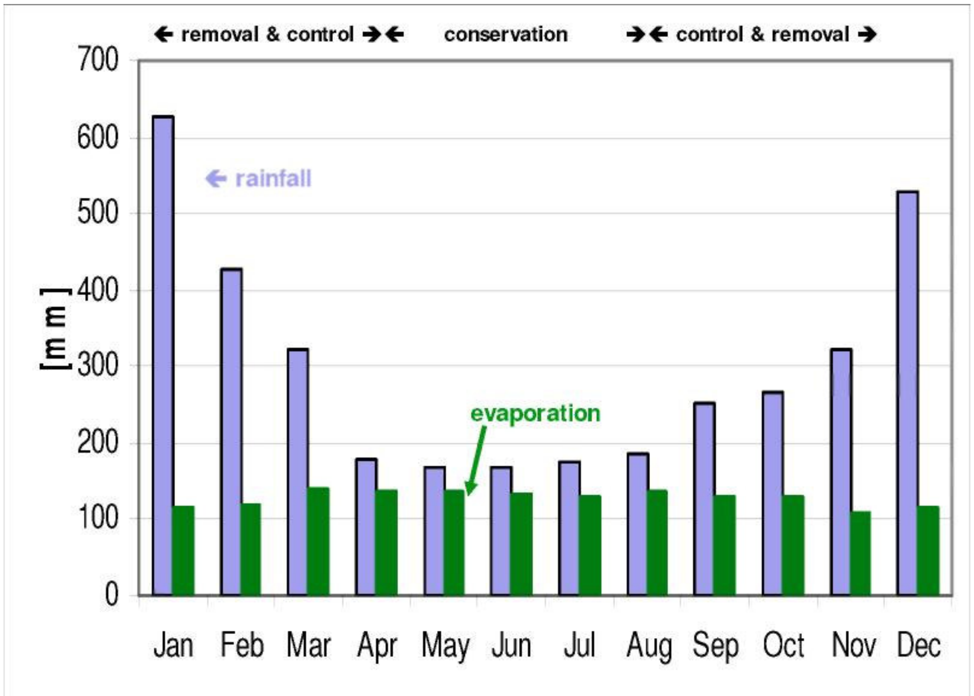

Figure 4: Depending on the season the water management system has to perform different functions: during the rainy season removal of excess water is required but during the dry system conservation is needed.

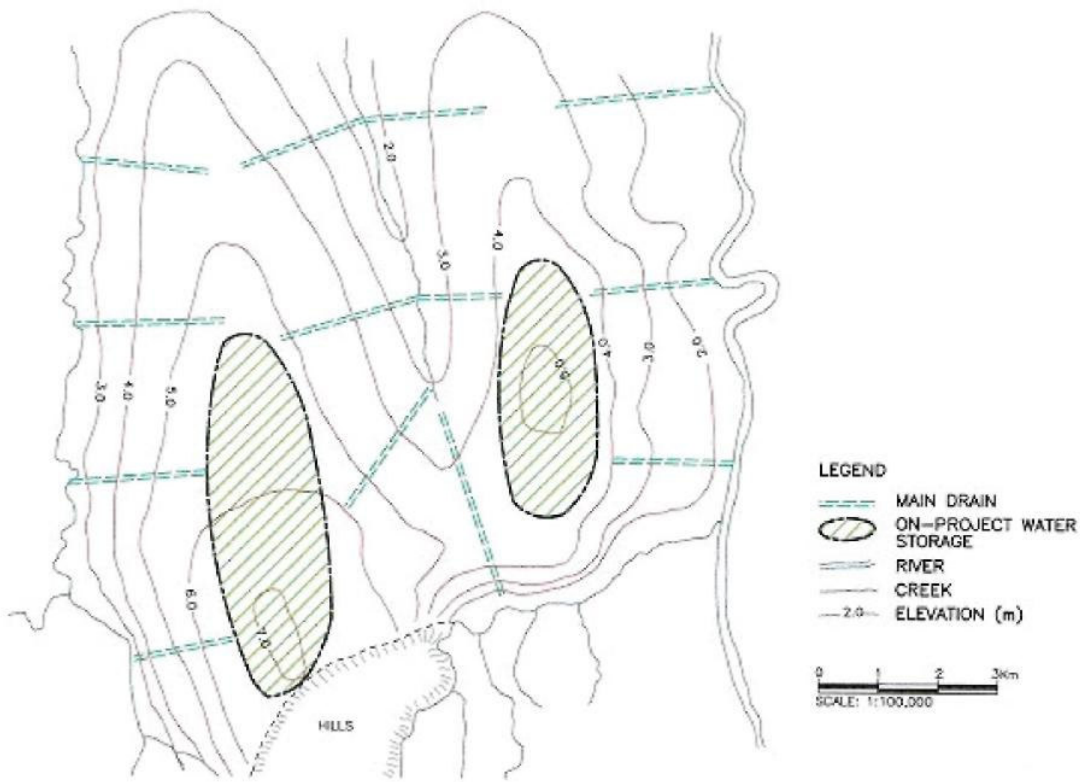

Figure 5 Water-storage at the top of the peat-dome is an option to keep water table high (DID 2001)45454545

CARBON STORED IN TROPICAL PEATLAND AND LOSSES RESULTING FROM FIRE AND LAND USE CHANGE

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SUMMARY

Tropical peat swamp forests own the most excellent qualifications for being one of the most efficient carbon traders on the earth, both in the dynamic atmosphere-biomass carbon exchange processes and through their carbon storing capacity. Some of the world's most outstanding peatlands, *e.g.* tropical peat swamp forests underlain by massive peat deposits are in large extent located in Indonesia. One of the consequences of the expected reinforcing climate change could be large-scale elimination of existing wetlands, thus enhancing the climate change processes by releasing the biomass and peat allocated carbon back to the atmosphere. Man made forest clearance and drainage are speeding up this process because the carbon allocating vegetation is decreased and agricultural use of peat requires low water table that leads to peat substrate oxidation. Wise management of natural forest areas and drained peat has potential to significantly reduce carbon losses and extend the existence of the peat resource.

Keywords: **Carbon loss, carbon dioxide, climate change, gas emission, land use, methane, peatland restoration, Southeast Asia, tropical peatland**

INTRODUCTION

Terrestrial ecosystems have an important role in the global carbon cycle. The global forest resource accounts for some 80% of this dynamic exchange (FAO, 2000). About 1.2% of the global atmospheric carbon dioxide (CO_2) may be converted into tropical seasonal forests and rainforests annually (Williams *et al.,* 2001). On the other hand, wetlands form the largest component of the terrestrial biosphere carbon pool (Dixon & Krankina, 1995). Wetlands with a thick surficial layer of peat, *i.e.* peatlands, are recognized as one of the largest global labile carbon (C) stores with about 24% deposits of the total soil allocated carbon (Maltby & Immirzi, 1993).

During the past 100 years, the global mean temperature of the earth's surface is estimated to have increased by 0.3-0.6°C (IPCC, 2000). Combustion of fossil-fuels and deforestation have increased the concentration of atmospheric CO2 by 30%, and more than doubled the atmospheric CH4 concentration from the pre-industrial levels.

One of the consequences of climate warming with 3-4°C could be elimination of 85% of all existing wetlands (WCMC, 2003). Some of the world's most outstanding peatlands, e.g. tropical peat swamp forests, are in large extent located on the Indonesian territory. The tropical peat reservoirs may represent 15% to over 30% of the world total peat C-pool (Maltby & Immirzi, 1993; Jaya et al., 2000). Tropical peat swamp forests seem to own the most excellent qualifications to be one of the most efficient carbon traders on the earth, especially through their carbon storing capacity.

This paper summarizes the hazards that are rapidly degrading tropical peat carbon stores, suggests some ways to reduce impact on this ecosystem and proposes matters that should be taken into consideration when the ecological functions on badly mismanaged peatland areas are attempted to be restored.

CARBON CYCLE IN TROPICAL PEAT

In wetlands, annual primary production exceeds annual mineralization of dead organic matter and part of the excess material becomes stored in the system as semi-decomposed substrate known as peat. Low external nutrient availability, waterlogged conditions and anoxicity, and low pH in peat substrate induce peat formation. Tropical peatlands can be found near the Equator in places where substantial rainfall and only moderately sloping topography provide appropriate conditions of poor drainage, permanent water logging and substrate acidification.

Carbon dioxide is fixed from the atmosphere in photosynthesis, and it is released back to the atmosphere in plant and animal respiration and, in oxic conditions, by microorganisms in aerobic decomposition of organic matter. Anaerobic decomposition in waterlogged peat requires a consortium of microorganisms to break down plant polymers to provide substrates for methanogenic bacteria (CH4 production). Part of the CH4 produced usually escapes to the atmosphere, but some may be trapped by methanotrophic bacteria consuming CH4 as an energy source, and is released as CO2. Factors controlling CO2 and CH4 production in peat include water table, temperature, pH, substrate availability and degradability, competitive electron acceptors and methanogenic populations (Valentine et al., 1994; Lovley et al., 1996; Miyajima et al., 1997). The greatest influence on gas formation in tropical peat may be set on substrate quality and hydrological conditions. In tropical climates daily and annual variations in the amount of rainfall can be marked (Takahashi &Yonetani, 1997), and long periods of extremely low precipitation can lead to temporary drought. Most organic soils shrink when dried but swell again when re-wetted, unless they are dried to a threshold value beyond which irreversible drying occurs (Andriesse, 1988).

Peat swamp forest reclamation necessitates extensive drainage and forest clear-felling followed by burning, and many of these actions aim to improve peat bearing capacity, site accessibility, and improve oxic conditions for plant roots and nutrient circulation. Net ecosystem C-storage is immediately reduced by removal of aboveground biomass. Plantation grown timber possesses high biomass C-density, but the total effect on carbon storing depends on the length of time the cut timber is protected from oxidation (Van Noordwijk et al., 1997). In selectively logged forests harvesting leads to a decline in organic matter deposition onto soil (Brady, 1997). In agricultural cropping the C-cycle is even more rapid. Owing to the smaller supply of easily degradable organic debris, decomposition rate in peat can be expected to slow down but still continue from oxidizing peat. Sound water table regulation can maintain favorable peat physical properties for crops and slow down peat and carbon loss (Radjagukguk, 1997; Ambak & Melling, 2000).

CARBON EMISSIONS FROM TROPICAL PEAT

Estimates of long term C-accumulation rates in natural tropical peatlands peat vary between 61 – 225 g C m-2 y-1 (Maltby & Immirzi, 1993; Neuzil, 1997). This is high in comparison to long term C-accumulation rate (20 g C m-2 y-1) in bogs and fens of boreal and northern subarctic regions (Clymo et al., 1998; Turunen, 2003). The present global C-deposition to peatlands is estimated to be 0.1 – 0.2 Gt y-1 (Buringh, 1984; Armentano & Verhoeven, 1988), and the share of tropical peatland in this is about 0.06 – 0.093 Gt C y-1 (Immirzi et al., 1992; Franzen, 1994). High uncertainty prevails in the given estimates for the present peat accumulation rate especially in tropical peatlands.

Observed CO2 emissions in natural forest peat have ranged between 236 – 1955 mg m-2 h-1 (Jauhiainen et al., 2005; Melling et al., 2005a). Annual CO2 originated C emission estimate in forested peat surfaces vary between 884 – 985 g CO2-C m-2 y-1 (Ishida et al., 2001; 2005). Globally, natural wetlands are currently a major source of atmospheric methane, emitting about 15-20% of the global budget (Matthews & Fung, 1987; Aselman & Crutzen, 1989). If the peat swamp forest CH4 emissions in general remain only about 1 g m-2 y-1 level (Jauhiainen et al., 2005), the relatively small area of peat swamp forests (10% area of the peatlands) would have a minor role in the global CH4 emissions budget. CH4 emissions from tropical peat soils is estimated to be 2.43 Gt y-1 (Inubushi et al., 1998), thus contributing only 2.1% of methane emissions from global natural wetlands and 0.45% of global methane emissions.

Pristine tropical peat swamp forests are regarded to function as a carbon sink and store, but drainage and forest clearance can rapidly convert them to a C-source. Peat subsidence, as a consequence of selective logging and artificial drainage, may be as fast as 35 – 60 mm y-1 (Brady, 1997; Wösten & Ritzema, 2002). Peat subsidence has been estimated to result in 2,000 g m-2 y-1 CO2-C losses in developed peat (Wösten et al., 1997). The mean CO2 flux rate of 300 mg m-2 h-1 for fallow peat results in about the same annual C-emission (Jauhiainen et al., 2002). However, cropping from arable tropical peat is found to cause in some cases CO2 loss of up to 11.6 kg C m-2 y-1 (Immirzi et al., 1992). Methane emission rates from developed peat swamp peat have been low (Jauhiainen et al., 2002; 2005). Even if the water table is near to the peat surface in fallow peat, it seems to have no marked effect on CH4 emissions (Jauhiainen et al., 2002). This may be owing to the lack of fresh and easily decomposing substrate. Furthermore, in order to initiate substantial methanogenesis, a long period of water saturated conditions is required (Hadi & Inubushi, 2000). Drained fallow peat seems to be inactive in CH4 production and it can form even a small CH4 sink (Jauhiainen et al., 2002; Melling et al., 2005b).

FIRE AND C-EMISSIONS

During the 1990s, large-scale fires occurred in Brazilian Amazon, Mexico, and Indonesia (FAO, 2001; Nepstad et al,, 1999; Siegert et al., 2001). If fire management is poor, fires ignited on agricultural land can spread to logged forests, damage vegetation (Uhl & Kauffman, 1990; Verissimo et al., 1995) and increase vulnerability of the forests to subsequent fires (Nepstad et al., 1995; Page et al., 2002). Net annual C-emissions from tropical wildfires range from 750–7,000 g m-2 depending largely on preceding fire and land-use history (Cochrane et al., 1999)). Emissions from peat fires have released 5,000 – 10,000 g C m-2 (Page et al., 2000; Siegert et al., 2002) up to 30,000 g C m-2 (Page et al., 2002). Based on estimates of the total area of fire-stricken peatlands, it has been concluded that the fires of 1997/98 released between 0.8 and 3.7 Gt C to the atmosphere as a result of burning peat and vegetation in Indonesia (Langenfelds et al., 2002; Page et al., 2002). Estimate of the amount of carbon released in ENSOE years 1994/95 fires was 0.6 – 3.5 Gt C (Langenfelds et al., 2002). This C-burst to the atmosphere is equivalent up to 59% of the current global annual C-emissions from the burning of fossil fuels or up to 200% of the emissions due to land use change (Pearce, 1997).

CLIMATE SCENARIOS AND TROPICAL PEAT SWAMP FORESTS

Long-lasting regional smoke-haze and fire episodes during the extreme droughts associated with ENSOE have occurred repeatedly in Southeast Asia (Maltby, 1986; Page et al., 2000). The current precipitation extremes associated with the ENSOE are likely to become more intense in the tropical Indian Ocean region in the future (Meehl & Washington, 1996). In Southeast Asia, the present rainfall scenarios suggest 2.4% increase by 2020 to a total of 8% increase by 2080 (Whetton & Rutherford, 1994). Annual surface temperature is predicted to rise by up to 3.3°C in tropical Asia by the year 2080 (Lal et al., 2002). In these scenarios, the predicted lower precipitation during the dry season and the higher average annual temperature will lead to drier conditions in tropical peatlands, and labile forest net C-balance is likely to be negative (Suzuki et al., 1999).

The danger of major fires is increased in years with a prolonged dry season, and climate change is suggested to increase the number of days with increased risk of fire in tropical areas (Goldammer & Price, 1998; Stocks et al., 1998). The ENSOE phenomenon is also a major cause of year-to-year variability in the number of cyclones in the Asia Pacific region (Lander 1994). Some studies suggest an increase in tropical storm intensities with CO2-induced warming (Henderson-Sellers et al., 1998; Royer et al., 1998). Increase in storm abundance is likely to increase the abundance and size of gaps in fragmented canopy closure forests in disturbed sites and areas with long fragmented edges. Logging reduces leaf canopy coverage, and leads to increased amounts of flammable undergrowth (Verissimo et al., 1995; Holdsworth & Uhl, 1997; Siegert et al., 2001).

CARBON SPARING USE OF PEATLANDS

In order to preserve tropical forested peatland allocated carbon, strategies designed for other forest types can be applied. Firstly, management can increase C-sequestration into forest biomass and peat by improving conditions for forest regeneration and production in existing forests, as well as enhancing C-sequestration into degraded and mismanaged lands through restoration and agroforestry practices (Houghton, 1990). The C-sequestration potential of tropical agroforestry systems is estimated to be between 12 and 228 t ha-1 (median 95 t ha-1) in the humid tropics of Southeast Asia (Albrecht & Kandji, 2003).

Secondly, existing C-stock losses can be more efficiently minimized. Decrease in the rate of deforestation could have a more immediate positive effect on preserving C-stores, as indicated from afforestation and reforestation practices (FAO, 2000). Skilful logging practices lead to lower damage caused to the residual stand and during transportation of logs out from the forest (Barreto et al,. 1998; Sist et al., 1998). Reduced impact of logging also leads to a smaller decrease in the forest C-stocks and to faster forest regeneration (Putz & Pinard 1993). It is possible to combine fire prevention and firefighting with land use policy.

Peat and the forest standing on the top of it can well be identified as a source of energy. Sustainable production of wood for fuel does not cause net C-emissions, if the released carbon in burning is replaced by regrowing biomass. The positive effect of using wood fuels is gained only if it keeps energetically equivalent part of the fossil fuel reserves unexploited in deep soil layers (van Noordwijk et al., 1997). Peat deposits are C-stores and cannot be regarded as a renewable energy source or biofuel because the subsidence rate in drained peat is about 15–30 times that of the growth rate in undrained peat (Andriesse, 1988). Using wood in long-lasting products and substituting for more C-releasing materials are other ways to preserve carbon.

Peatland reclamation amplifies changes in the C-flux rate between the peat and the atmosphere, and replacement ecosystems (for example agriculture, agroforestry and plantations) are in general unable to match the long-term capacity of peatlands to store carbon (van Noordwijk et al., 1997). Carbon storage in plant biomass is only feasible in long rotation perennial agroforestry systems that i.) enable full tree growth and where the woody component represents an important part of the total biomass, and ii.) all harvested timber is processed in any form of long-lasting products or used as an energy source substitute for fossil fuel burning (Albrecht & Kandji, 2003).

RESTORATION OF PEATLANDS

One of the largest single development projects in Southeast Asia has been the well known One Million Hectare Peat Soil Development Project, which was an ambitious attempt to convert a massive tropical peatland area in Central Kalimantan, Indonesia into a crop production area. At present, the ex-MRP affected area covering about 1.5 Mha is an almost treeless injury in a vast peat-covered landscape; a legacy handing out mostly non-productive land, an over 4,600 km long network of malfunctioning irrigation canals, oxidizing peat, and a terrain susceptible to frequent large-scale fires (Muhamad & Rieley, 2002).

For securing carbon in tropical peat, restoration of mismanaged peat should consider at least two primary factors, namely, peat hydrology and vegetation cover. Restoration of peat hydrological conditions is needed in order to i.) reduce further carbon losses from peat, ii.) generate favourable environmental conditions for C-allocating vegetation for improved microclimate and more stabile hydrology, and iii.) minimize carbon losses caused by fires. In topographically relatively even areas, hydrology restoration i.e. slower water movement inside and out from the area can possibly be carried out by blocking the structures originally built for drainage. Carbon allocation and vegetation succession can be restarted by establishment of pioneer vegetation nuclei at potentially best locations. Existing woody vegetation regrowth can be encouraged from remaining root stocks and by enrichment planting. Areas that have lost all woody vegetation are likely to present harder challenges for appropriate vegetation establishment.

Although one major target of restoration can be improved, i.e. C-sequestration, ecosystem rehabilitation should bring increased value also through increased biodiversity and other natural resource functions. Considering the future of the restoration areas, it should be remembered that for ensuring the resource existence and avoiding further destruction, local communities must get added value from the site survival through improved economic prospects.

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WISE USE OF TROPICAL PEATLAND – RECONCILING ORANGUTAN CONSERVATION AND ECONOMIC DEVELOPMENT?

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SUMMARY

Orangutans are endangered and their numbers continue to drop annually. Successful conservation initiatives are desperately needed, particularly in peat swamp forest which is their most important habitat. Successful conservation depends on local support and involvement, but this is unlikely to be forthcoming as long as there is a perception that orangutan conservation is in direct conflict with economic development of a region. The potential benefits of conservation for local communities are discussed here and Indonesian scientists and conservation managers are encouraged to pursue these opportunities.

Keywords: **Orangutan, Peat Swamp Forest, Community development, Ecotourism**

INTRODUCTION

Orangutan Conservation

The orangutan, *Pongo spp.*, is believed to number around 60,000 wild individuals (Singleton *et al.*, 2004), but this number is falling rapidly as problems of illegal logging, fire, forest conversions to oil palm and hunting are being controlled inadequately. The global population is estimated to have halved in the last ten years (Singleton *et al.*, 2004) and many scientists predict that no viable populations will be left in the world by the end of this century unless urgent action is taken to protect this species (Rijksen & Meijaard, 1999). Great apes are mankind's closest living relatives, sharing up to 98.5 % of human DNA, and together with humans are unique in the animal world: both make and use tools; employ plants for self-medication; experience a range of emotions and demonstrate moral decision-making.

Orangutans are important for Indonesia, which is famous for its orangutans, on international television and print media, and to the tourists who visit Kalimantan and Sumatra. Eighty percent of the world's orangutans are found in Indonesia, which is committed to protecting this species, both through its internal laws and by signing the international GRASP treaty. GRASP, the Great Apes Survival Project, is a unique alliance of all 23 great ape range countries, donor countries, UNEP and UNESCO, NGO's, academia and the private sector (Conrad et al., 2005). The treaty, signed at the Intergovernmental Meeting on Great Apes held in Kinshasa, Democratic Republic of the Congo from 5-9 September 2005, pledges to support and implement effective measures to counter the threats facing the great apes. The treaty encouraged the provision of long-term ecologically sustainable economic benefits to local communities; and invited international institutions and agencies to prioritise policies promoting ecologically sustainable livelihoods for local and indigenous communities which prevent activities detrimental to the survival of the great apes. GRASP aims to use funds provided by the UN, European Commission and individual donor countries to support areas and regions that are currently neglected and under funded.

Orangutans are distributed throughout most of Borneo and in the north of Sumatra (Figure 1). They inhabit tropical rainforest, including dry dipterocarp-dominated forest, freshwater swamp, limestone karst and submontane habitats. The most important habitat, however, is peat swamp forest. The highest recorded orangutan densities are in this habitat type, at Suaq Balimbing (Sumatra) and Gunung Palung (Kalimantan), and mean peat swamp forest density (2.94 individuals per square kilometre, n=25) is significantly higher (independent samples t-test, p=0.015) than density in dry lowland forest (1.96 ind km–2, n=50) (Husson et al., 2006). Peat swamp forest supports a high density because there is a stable, year-round supply of food, whereas freshwater swamp and dipterocarp forests more typically provide huge amounts of fruit for part of the year with long periods of fruit shortage in between. Thirty-five per cent of all orangutans occur in peat swamp forest, and the largest remaining populations are found in this habitat (Singleton et al., 2004). Protecting and restoring the most important areas of peat swamp forest is crucial therefore to protect the orangutan from extinction.

IMPORTANCE OF ORANGUTAN TO LOCAL COMMUNITIES

Indigenous people, in those communities surrounding orangutan habitat areas, do not prioritise orangutan conservation. In a study of local attitudes towards this species, carried out in villages along the Sebangau and Katingan rivers, Smith (2002) found that 50% of local villagers thought that the orangutan's future prospects were bad, but that there was a general lack of concern for the species. Economic development of the area is the main concern, with 70% of respondents considering the future prospects of their community to be poor. Whilst many people regard orangutans as an asset to the area, it is considered that protection of the species would bring no benefits.

Therefore we conclude that there is no perceived benefit to local communities from the protection of orangutan. Nevertheless there are potential benefits, some direct, some more abstract (Table 1). Although communities do not view protection of wildlife as a priority, they do recognise other benefits of conserving and rehabilitating forest habitat. These include maintaining a continuous income through the constant availability of forest resources (i.e. they recognise the virtue of sustainable harvesting); providing protection against floods and improving air quality (protection against fire and smoke pollution) (Smith, 2002). It is also the case that peat swamp forest is not a suitable habitat for many alternative uses, such as oil palm plantations and rice padi. Foreign governments traditionally encourage conservation and habitat restoration activities through the provision of loans to developing countries and trade agreements. These economic benefits theoretically support all citizens of a country. Increasingly, foreign governments and international NGO's are providing funding for *in-situ* habitat conservation activities, to directly mitigate the problems highlighted by local communities (above), or helping to introduce and develop environmentally-sustainable livelihoods and economic development. Many of these grants are focused specifically on orangutans, i.e. organisations will provide grants if there is a demonstrated benefit for orangutan conservation. The Great Ape Conservation Fund has been established by the government of the United States of America for this purpose - 1.5 million dollars is set aside each year for projects that aid great ape conservation. In the field this has meant funding for environmental education, habitat restoration and rehabilitation, scientific research and illegal logging patrols amongst a wide range of projects. International NGO's such as The Nature Conservancy, The World Wide Fund for Nature and Conservation International promote endangered species, including the orangutan, for their fund-raising, with campaigns such as ‘sponsor an orangutan’ raising millions of pounds in western countries.

Funds and campaigns are targeted at the orangutan because of its status as a ‘flagship’ species, charismatic and well-known, and a symbol of endangered species world-wide. Flagship species, such as the tiger, gorilla, whale and panda, raise passions amongst people who consider that the world would be a poorer place without them and want to help save them from extinction. Although this may be a moralistic, idealistic view of the world, often out-of-touch with the economic realities of the regions where these species are found, their donations may be used to improve the economic condition of these regions and peoples and, if targeted correctly, benefit both the endangered species and habitats and the local communities.

Ecotourism, defined as ‘tourism activities in areas of natural habitat that have no negative impact on the environment’ or, in conservation terms, ‘tourism activities that provide positive benefit for the conservation of a natural resource, species or ecosystem is of great potential economic benefit. In nearly all cases, such positive benefit is the injection of funds into an area, through employment and into a trust fund to be used for infrastructure development (schools, clinics); development of naturally-sustainable livelihoods and habitat protection activities. Positive benefits can also accrue from related education and research activities, changing local perceptions of the resource or by fostering willingness to protect an area by the local and national authorities. This model is already in place elsewhere in the world. Thousands of tourists go on trips every year to see rare and charismatic animals in their natural habitat. Major tourism ventures are centred on viewing wild tigers in India, mountain gorillas in Uganda and Rwanda, great white sharks off the coast of South Africa, polar bears in Canada and many species of whale world-wide. Many of these operations provide valuable income for conservation. The potential is clearly there for a similar operation with orangutans.

Orangutan ecotourism is still undeveloped. 3000 tourists a year visit Tanjung Puting National Park to see rehabilitated orangutans, more visited Bukit Lawang in North Sumatra before the flash-floods of last year, and 10,000 tourists a year visit the Kinabatangan River in Sabah to view orangutans from boats. Revenues from these operations are small and mainly benefit tour operators. They are focused predominantly on rehabilitation centres, which do not provide the ‘wilderness experience’ desired by many visitors. There are no opportunities to join a tour to see wild orangutans on foot. Compare that to the situation in Africa where 10 years ago, before the civil war in the Democratic Republic of Congo broke out, Virunga National Park, home of the famous mountain gorillas, was generating $10 million a year from ecotourism.

The Ugandan government sells chimpanzee tracking permits for $220 and twenty-four $360 gorilla-watching permits a day and are sold out two years in advance (Ugandan Wildlife Authority, 2006). Hence over 3 million dollars a year is raised by the government of Uganda from the mountain gorillas alone, of which a substantial proportion supports development and welfare of communities surrounding the ape habitat. As a result, Uganda currently has one of the best primate conservation records in the developing world. The potential is there for a similar enterprise in Indonesia – if the infrastructure, marketing, a profit-sharing mechanism and – importantly – a system of regulation and proper management are put in place

CONCLUSIONS

Orangutan conservation depends on protection and restoration of peat swamp forest habitat. Protecting peat swamp forest habitat depends on the support of local government, institutions and communities. Hence, orangutan conservation is not possible without the support of local people. As described here, this can be difficult to achieve as local communities, quite rightly, place their economic livelihoods as most important, and the general perception is that conservation is in direct conflict with maintaining and improving their standard of life. Conservation and development can be mutually reinforcing if the potential economic benefits of orangutan conservation are understood and taken up. Many grant-giving bodies are eager to support orangutan conservation projects, particularly in important but under funded regions and over long time periods. We encourage Indonesian scientists, conservation managers and government institutions to pursue these opportunities in order to successfully protect their peat swamp forests, and educate local residents of the positive benefits of conservation.

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Figure 1 Current orangutan distribution, identifying locations of peat swamp forest habitat. Base map from Caldecott & Miles (2005)

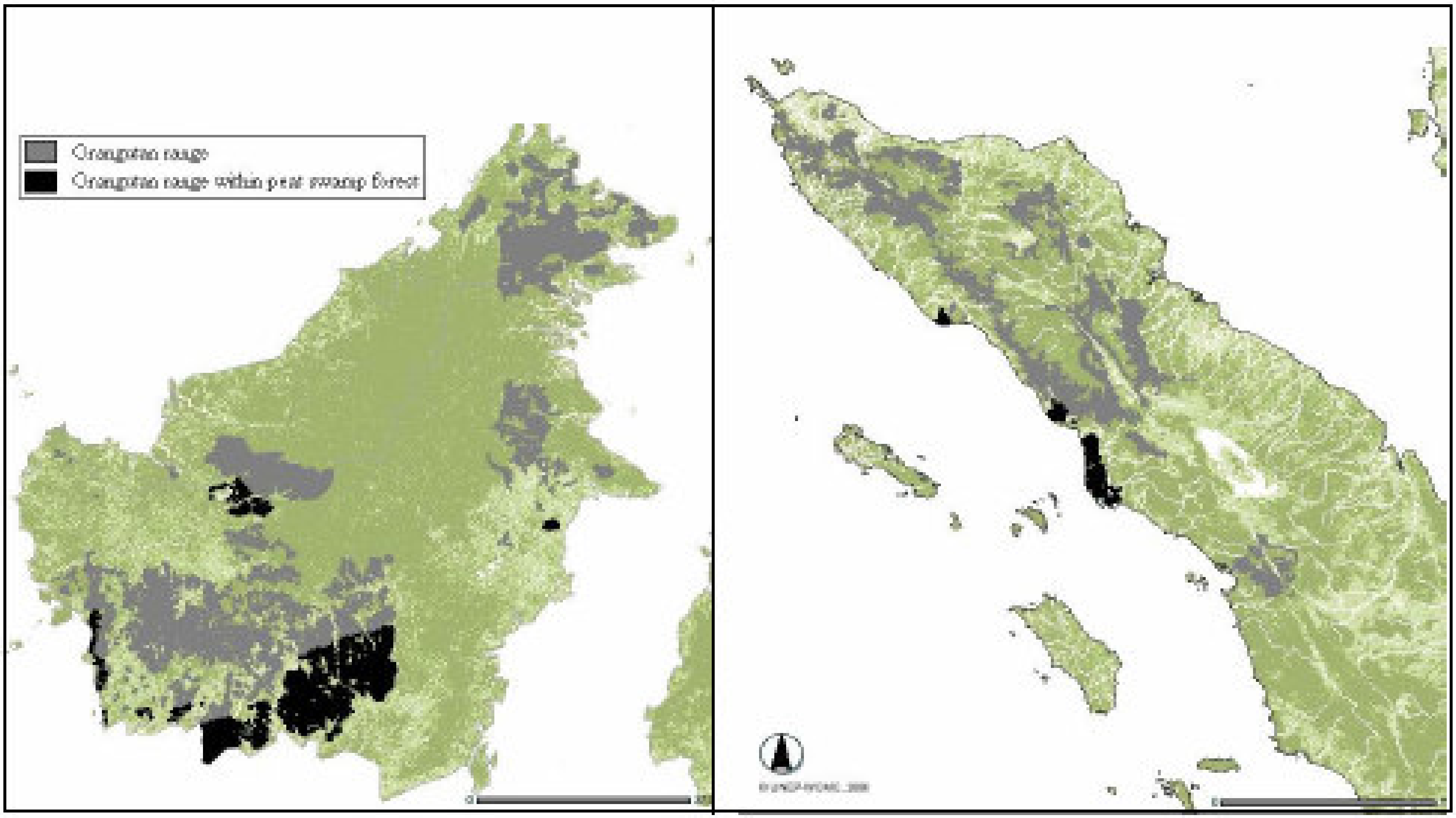

Table 1: Potential benefits to local communities from conservation projects and funding sources.

Type	Benefit to conservation	Benefit to communities
Research projects	Discovery; Monitoring; Capacity building	Employment; Support industries (e.g. transport, food)
Grants for habitat restoration	Improve degraded habitat; Protect against catastrophic events (e.g. fire)	Employment; Protect against floods; Improve air quality; Conserve natural forest products
Grants for habitat protection	Reduce uncontrolled exploitation of habitat and illegal activities	Employment; Prevent 'outsiders' depleting resource
Grants for developing alternative livelihoods	Reduce uncontrolled exploitation of habitat; Provide alternative income to local communities	Economic development; Sustainable livelihoods
Grants for environmental education	Increase understanding of conservation and negative impacts of habitat degradation	Employment; Increase understanding of the benefits of conservation; Develop pride in habitat and species
Educational links and training	Capacity building; Knowledge base for future	Presence of local, trustworthy experts
Inter-governmental loans, trade agreements and carbon-trading	Increase government willingness to protect habitat	Economic development theoretically benefits all citizens
Ecotourism	Reduce uncontrolled exploitation of habitat; Provide alternative income to local communities	Employment; Support industries; Economic development; Profit-sharing; Infrastructure development; Develop pride in habitat and species

TOWARDS A GLOBAL EXCHANGE OF PEATLAND RESTORATION INFORMATION WITH SPECIAL ATTENTION TO THE RUOERGAI PLATEAU (CHINA)

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SUMMARY

A science based and practical guide to peatland restoration is being prepared within the framework of the UNEP-GEF project "Integrated Management of Peatlands for Biodiversity and Climate Change" of which some general principles are presented. Restoration entails a clear formulation of aims, i.e. of the peatland function(s) to be restored. The restoration perspectives strongly depend on the actual condition of the peatland in question, because different degradation stages imply different potentials and demand different restoration techniques. A case study from the Ruoergai Plateau (China) illustrates how the root causes of present-day degradation go back to soil hydraulic changes caused by thousands of years of traditional grazing. The consequent increased vulnerability to degradation and desertification only became apparent through overgrazing and drainage as a consequence of socio-economic changes in the last decennia. The scale and complexity of the problems require international cooperation to understand and solve them.

Keywords: **peatland, management, guidelines, restoration, China**

INTRODUCTION

The UNEP-GEF project "Integrated management of peatlands for biodiversity and climate change" (2003 – 2006) aims to assess the impacts of management practices on peatland carbon stores and biodiversity and determine appropriate mitigation or restoration measures. One of the key outputs of the project will be a Global Handbook on Peatland Restoration. The Handbook will summarize the options, aims, and techniques of peatland restoration. A great variety of links to and information on projects from all over the world, but with special attention to the pilot regions of the UNEP-GEF-project (Indonesia, China, West-Siberia and Europe), will promote international exchange of experience and knowledge.

This paper presents some central aspects of peatland restoration planning and exemplarily discusses peatland degradation processes and restoration options for the Ruoergai mountain peatlands (China).

PEATLAND RESTORATION

Restoration is the activity of trying to bring something back that has been lost. Ecosystem restoration aims at initiating or accelerating processes that return a degraded ecosystem to a state that is more like a former state. The term "restoration" can only be used sensibly when simultaneously the aim of the restoration project is explicitly and clearly set. Basically there are three questions that should be answered before starting a restoration project:

- What would you like to have back?
- Is it possible to get it back?
- What do you have to do to get it back?

A full regeneration to its original, natural state can only be achieved in the earliest stages of peatland degradation, because initial degradation leads rapidly, through positive feed-back, to more and irreversible degradation. Therefore the first goal of every restoration practise should be to limit further degradation.

PEATLAND FUNCTIONS

The products and services ("functions") that mires and peatlands may provide are manifold (for an overview, see Joosten & Clarke 2002). Some of these functions can be performed only by pristine mires; others can also or even be executed better by peatlands that have been modified by human action. Some functions are sustainable, i.e. they can be exploited infinitely; others destroy their own peatland resource base and can only be provided for a limited period. It is important to formulate the aims of a restoration project (which peatland functions have to be restored?) clearly, in priority order, and concretely. This is necessary to

- identify adequate methods (different aims require different methods).
- prioritize between conflicting aims (too often mutually incompatible aims are formulated).
- enable effective evaluation (unspecific aims, e.g. restoration to a "functioning wetland", cannot be evaluated).

Stratigraphical and palaeoecological studies and comparison with less disturbed reference sites may give insight into the original functioning and functions of the peatland before degradation.

DEGRADATION STAGES AND RESTORATION OPTIONS

Specific peatland functions require specific conditions. Peat accumulation and associated carbon sequestration, for example, take place only when both a suitable hydrology and the appropriate vegetation prevail. To assess the restoration potential of a degraded peatland it is necessary to analyse its current vegetation, the properties of its peats, and the hydrology of both the peatland and its water catchment area.

The degradation stages (see Table 1) differ fundamentally from each other. Stronger degradation not only implies a more intense modification of the same component, but also a quality leap to other and ecologically more important peatland components. Therefore more severely degraded peatlands are increasingly difficult to restore and require explicit attention to components that have not been directly impacted. In general, peatland restoration should start with restoring the components with the most functional impact (the ones further to the right in Table 1) because these determine the condition of the weaker components (those further to the left in Table 1). It makes, for example, little sense trying to restore the vegetation by planting or seeding peatland/wetland plants, when the hydrology has not yet been repaired.

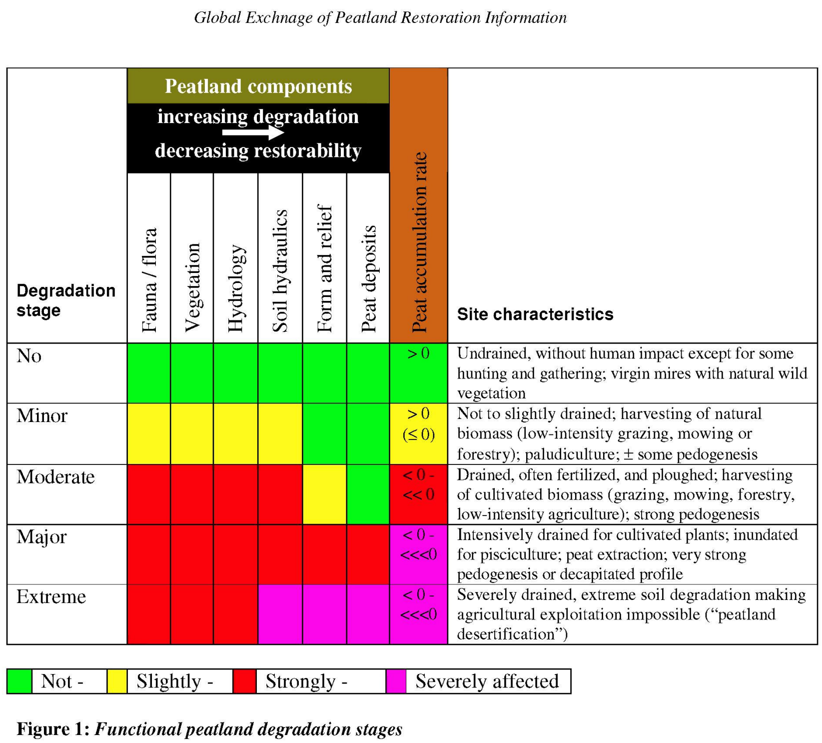


Figure 1: ***Functional peatland degradation stages***

RESTORATION TECHNIQUES

Key principles with respect to peatland restoration not only comprise ecological engineering techniques (that should be adaptable to individual needs and possibilities), but also include objective setting, cost benefit analysis, environmental impact assessment, legal concerns, stakeholder consultation, contract management, monitoring strategies, and long-term catchment and site management plans.

A special case is nature conservation, as restoration opposes the essence of nature: spontaneity. In nature conservation the "means" are an implicit part of the "ends". Every deliberate act increases the artificiality and decreases the naturalness of the resulting patterns and processes. You cannot make an ecosystem more natural; it can only become more natural. Restoration for nature conservation should therefore restrict the intensity and frequency of the techniques employed to the minimum (Joosten, 1996).

PEATLANDS ON THE RUOERGAI PLATEAU

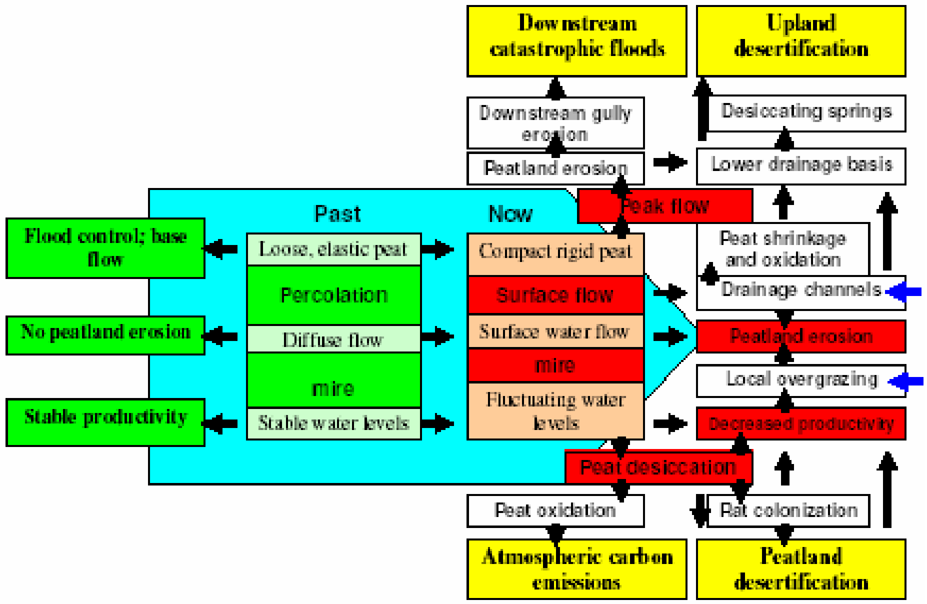
The Ruoergai marshes (490,000 ha) in the northeast of the Qinghai-Tibetan Plateau (alt. 3400 to 3900 m) constitute one of the world's largest expanses of high-altitude peatland. As the headwater of the Huang (Yellow) and Yangtze Rivers, they have high importance for regulating water storage and supply. They are of global significance for biodiversity conservation and carbon storage.

The Ruoergai peatlands are subject to immense losses of grazing land by erosion and desertification. To counteract the rapid devastation of wetlands (incl. peatlands) the Chinese Wetland Action Plan and China's Agenda 21 propose to introduce sustainable management practices. This requires, as a first step, an analysis of the root causes of the degradation. Preliminary studies (Thelaus, 1992, Frenzel et al., 1995 and own field research indicate that since the start of grazing on the Ruoergai Plateau the rangeland ecosystems, both on mineral and organic soils, have changed substantially.

Before the establishment of human settlements percolation mires dominated most of the peatlands on the plateau. Their vegetation was dominated by Carex spp. and Kobresia spp. that formed a homogenous, hardly decomposed peat with poor mineral content (Thelaus, 1992 and Björk, 1993). Its large pore-volume and high water-conductivity allowed the water to flow diffusely (percolate) through the peat mass. The capacity to shrink and swell enabled the peat to respond to the changing water supply (oscillation) and maintain a stable base flow. The peat was spongy enough to keep the surface permanently water saturated. These conditions caused a high rate of peat accumulation (Thelaus, 1992) through high vegetation productivity and reduced peat mineralization.


Figure 2: ***Pristine and degraded peatland in Ruoergai and Hongyuan County (China)***

Since the start of grazing on the Ruoergai Plateau, 5000 years ago (Wu, 2000 and Wiener et al., 2003), the ecosystems on mineral and organic soils have changed substantially (see Fig. 3).



Grazing and deforestation of the higher mineral ground led to erosion and deposition of clastic sediments in and over the peatlands. Together with the increase in trampling through long-term grazing, this caused compaction of the existing peat, more rapid decomposition of new peat, a substantial decrease in peat accumulation rate and major changes in peatland hydrology (Figure 3). The more strongly decomposed, compact, and less elastic peat forced the water to flow over the peatland surface, leading to the surface-flow mires that currently dominate the area. This major change in hydrology has changed the functioning of the peatlands of the Ruoergai Plateau fundamentally and probably irreversibly with major effects upon the peatlands themselves and their mineral surroundings, both up and downstream.

In contrast to the former percolation mires, the current surface flow mires show peak discharge consequent on precipitation and little base flow during drier periods. The increased peak interflow from the less vegetated uplands has to be transported over the peatland surface, which leads to the development of preferential flow paths and an increased incidence of surface erosion, certainly after damage of vegetation and surface peat through intensive grazing. The increased peak flow leads to gully erosion that extends into the underlying mineral substrate and to an increase in catastrophic flood occurrences downstream.

Shrinkage of the peat through drainage, the origin of erosion gullies, peat oxidation, and the digging of drainage ditches have lowered the drainage base in the peatland basins, causing a lowering of the groundwater head in the adjacent uplands, with consequent drying out of hill slope springs, drought stress on the upland vegetation, increased desertification and, again, increased erosion and deposition of clastic sediments over the peatlands.

The strongly decreased storage coefficients of the compacted peat lead furthermore to much lower peatland water levels in dry periods, to drought stress of the vegetation in the peatlands, and to colonization of the dried out peatlands by rats. All of these processes decrease vegetation productivity and increase wind and water erosion and mineralization/oxidation of the dry peat (Figure 3).

C ONC LUS IONS

The example of the Tibetan Plateau shows how thousands of years of yak grazing (cf. Wiener et al ., 2003) has led to a change in soil hydraulic conditions, which made the peatlands vulnerable to overgrazing and degradation. Efforts in the last 30 to 40 years to drain the peatlands in order to increase vegetation productivity and livestock carrying capacity have lead to the opposite, namely, degradation, desertification, decreased productivity and associated negative impacts. Considering the huge areas of degraded peatlands, the complexity of the problems, and the lack of local peatland knowledge, international cooperation is needed to understand and solve the problems.

The substantial changes in peat-hydraulic conditions must be kept in mind when planning restoration measures. It will not to be possible to restore the peatlands to their original state as percolation mires, as peat compaction and decomposition are largely irreversible. The management of drainage systems and of grazing intensities (marked with blue arrows in Figure 3) seem to be the only possibilities to manipulate this complex system.

Although currently the overwhelming majority of the peatlands of the Ruoergai Plateau consist of surface flow mires, percolation mires have survived or regenerated locally. This is probably owing to exceptional hydrological and geomorphological conditions and to a limited historical use of these sites as grazing lands. It is of utmost importance that these sites are identified and protected as centres of biodiversity, as nuclei for future regeneration, and as reference sites to increase the knowledge base, all of which are necessary for successful restoration of the degraded peatlands.

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WATER MANAGEMENT FOR MULTIPLE WISE USE OF TROPICAL PEATLANDS

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SUMMARY

Land use changes and associated fires change profoundly the hydrology of tropical peatlands and thus affect the functioning of entire river basins. A hydrological model was used to calculate the effects of drainage on groundwater levels, peat surface morphology and river flows for the Air Hitam Laut watershed in Jambi Province, Sumatra, Indonesia. The model was used to predict consequences of three possible scenarios: i) expansion of oil palm plantations upstream, ii) expansion of agriculture downstream and iii) continuing fire damage. Continued drainage for oil palm plantation development will result in a decapitated and reduced river basin. Reduced river discharge has a detrimental affect upon conservation of the Berbak National Park in the centre of the watershed and agriculture and fisheries in the coastal zone. Expansion of agriculture downstream causes peat subsidence, resulting in exposure of underlying, acid sulphate soils and intrusion of saline sea water. Continuing fires will increase considerably the area of permanently flooded land and thus constrain peatland restoration options.

Keywords: **catchment modelling; scenario analysis; peat subsidence; land use change; fire.**

INTRODUCTION

Peat swamp forests are characterized by their occurrence on organic substrates where the vegetation itself provides the material for the formation of the peat. Poor drainage, permanent waterlogging, high rainfall, and substrate acidification are conditions in which plant residues accumulate faster than they decay (Brady, 1997). Peat swamps are recognized as important reservoirs of biodiversity, carbon and water, and they exhibit a large range of important ecological and natural resource functions (Andriesse, 1988; Page & Rieley, 1998). This study focusses on the basin of the Air Hitam Laut (meaning *"black water flowing to the sea"*) River located in Jambi province, Sumatra, Indonesia (Figure 1). The river bisects Berbak National Park, which was established as a Ramsar site because of its representativeness of peat swamp forest habitats in Southeast Asia (Giesen, 2003; Silvius *et al.* 1984; Van Eijk & Leenman, 2004). In the early 1990s Berbak National Park made up about 30% of the remaining relatively undisturbed peat swamp forest in Sumatra, but over the last decades the area has been affected increasingly by fire. In 1981/82, fires in Berbak occurred mainly in peat swamp forest areas affected by coastal agricultural encroachments and illegal logging but, in 1992 and 1997/98, fires destroyed over 16,000 ha of primary forest in the core zone of the National Park. Hydrology is a key factor in the ecology of this increasingly threatened habitat, and thus water (and water management) plays a key role in maintaining its support functions (Wösten & Ritzema, 2001; Hooijer, 2005; Siderius, 2005). The hydrology of the Air Hitam Laut river basin was studied using the SIMGRO (SIMulation of GROundwater flow and surface water levels) model. Considerable emphasis has been put on collecting the data required to input to this model, including elevation of the river basin (DEM), groundwater levSels and rainfall. The calibrated and validated model is used to evaluate consequences of three possible scenarios:

1. Expansion of oil palm plantation upstream
2. Expansion of agriculture downstream and
3. Continuing fire damage.

SCENARIO 1: EXPANSION OF OIL PALM PLANTATION UPSTREAM

Expansion of oil palm plantations in the upstream area of the Air Hitam Laut River basin is ongoing and may eventually cover the whole upstream area. Oil palm requires up to 70 cm drainage and thus induces subsidence of the peat surface. Figure 2 shows clearly the impact of 50 years of drainage and associated peat subsidence as calculated by the SIMGRO model. It demonstrates that peat elevation inside the plantation will be lowered by as much as 3-4 metres as a result of continuous drainage. Such subsidence will result in reduced water flow towards the Air Hitam Laut River as the gradient in that direction becomes less and less. As a consequence, the direction of drainage from the plantation area will gradually shift from the Air Hitam Laut River towards the lower-lying Kumpeh River (Figure 1). Eventually the whole upstream area will be decoupled from the Air Hitam Laut watershed and become part of the Kumpeh watershed. This will result in a great reduction in the amount of water entering Berbak National Park. Decoupling of the upstream area will also result in considerably decreased discharge rates of river water entering the downstream coastal area leading to a serious decrease in agricultural production.

SCENARIO 2: EXPANSION OF AGRICULTURE DOWNSTREAM (COAST)

Areas under agricultural use downstream in the Air Hitam Laut River basin expanded in response to population growth in the coastal zone. An average subsidence over the whole area of about 4.5 cm/year will result in a total subsidence of more than 2 meters of peat after 50 years. Thus peat in the agricultural area will have totally disappeared after 50 years in about 1/3 of the area, whereas 50% will have only a thin layer of peat left. The mineral subsoil in the agricultural area is located at an elevation of approximately 3 m above mean sea level. Because the mineral subsoil is of marine origin and contains pyrite it is very likely that problems related to the occurrence of acid sulphate soils (now already encountered by the local people) will also increase in the future. Decreased discharge rates of river water caused by expansion of oil palm plantations in the upstream area will also increase the negative effects of salt sea water intrudion in the coastal agricultural areas. Both impacts will make agricultural production in the coastal zone more difficult and less sustainable.

SCENARIO 3: CONTINUING FIRE DAMAGE

Fire damage in the Air Hitam Laut watershed is difficult to predict, but no matter what fire prevention measures are taken, fires are likely to occur in the future. To show the impact of peat fires a new surface map (DEM) was constructed simulating the situation after more large areas have been burned. In the preparation of this map, areas were selected that had a groundwater level deeper than 1 m below soil surface during the long dry period in the El Niño year 1997. These areas are considered to be prone to fires and they are most likely to burn in a future dry year. The assumption is made that fires will cause a lowering of the surface elevation of the affected areas by 1 metre during each major fire incident. The combination of these newly burned areas with the already burned ones results in a new surface map (DEM). This new DEM was used to calculate groundwater levels and flooding patterns. The impact on the hydrology and more important on the flooding extent shows that the deeply flooded areas with more than 1.5 m inundation will increase by almost a factor 5. This will seriously constrain peatland restoration possibilities.

DISCUSSION AND CONCLUSIONS

The many human induced land use changes observed in the Air Hitam Laut River basin all cause groundwater levels to be lowered as a result of drainage. This has negative consequences in terms of increased soil subsidence and fire susceptibility. Restoration and conservation of peat swamp forests in the Berbak National Park necessitate restoring the hydrological integrity of the river basin in order to maintain groundwater levels at or close to soil surface. Sustainable development of agriculture along the coast requires maintenance of the dynamic hydrological balance of the Air Hitam Laut River basin. The envisaged land-use changes in the upper part of the Air Hitam Laut River basin pose a huge and hitherto unknown threat to downstream human livelihoods and biodiversity. The hydrological model has helped to reveal this threat before it is too late to reverse it. Actions, however, require conservation of the peat swamp forest in the upstream area and immediate cessation of further land conversion to agriculture that requires drainage. For restoration and conservation to be sustainable they need to be accompanied by economic measures to improve the livelihoods of local people and by effective law enforcement.

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Figure 1 Location of the Air Hitam Laut watershed.

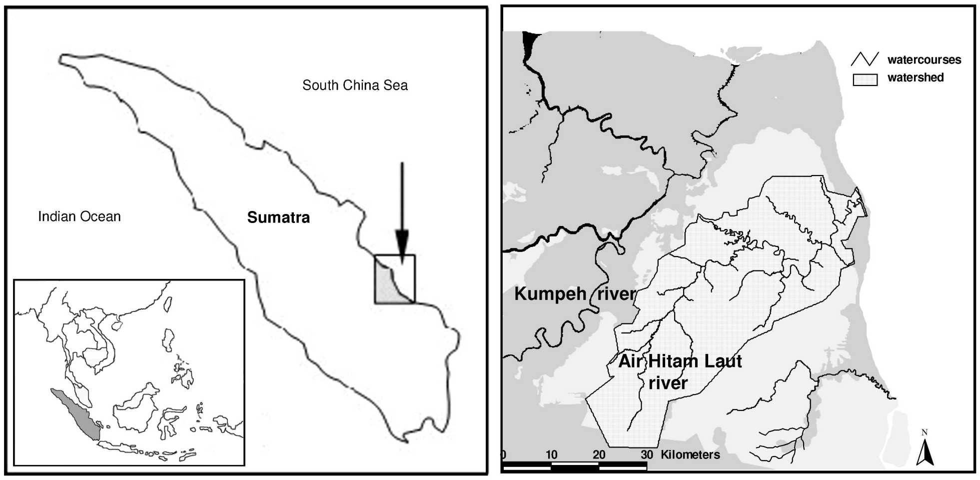


Figure 2 Cross section of peat surface elevation in the upstream area in the present situation (black line) and after 50 years of drainage and associated subsidence (gray line) for oil palm cultivation.

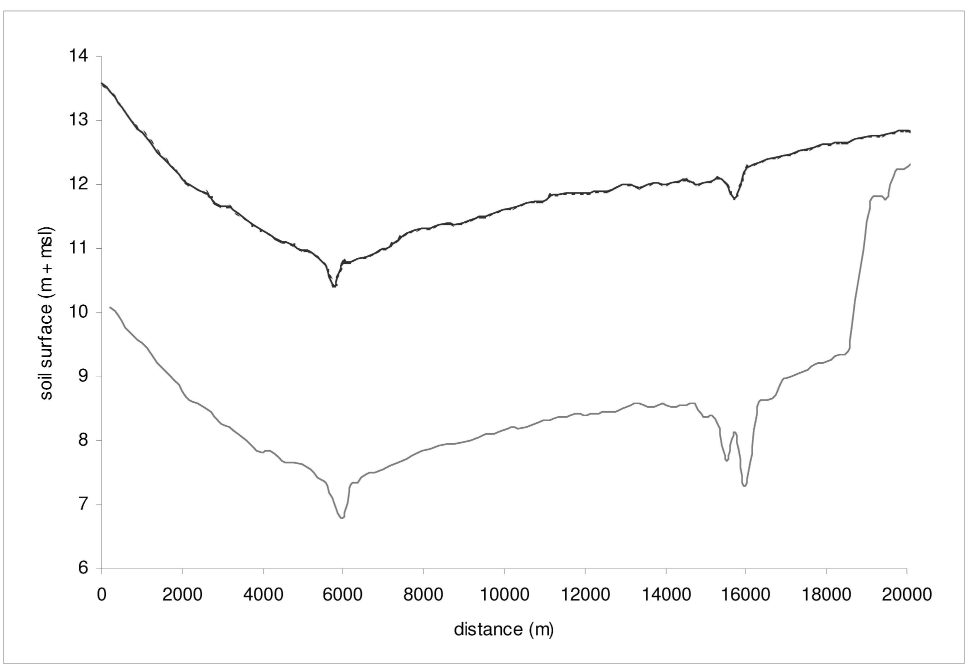
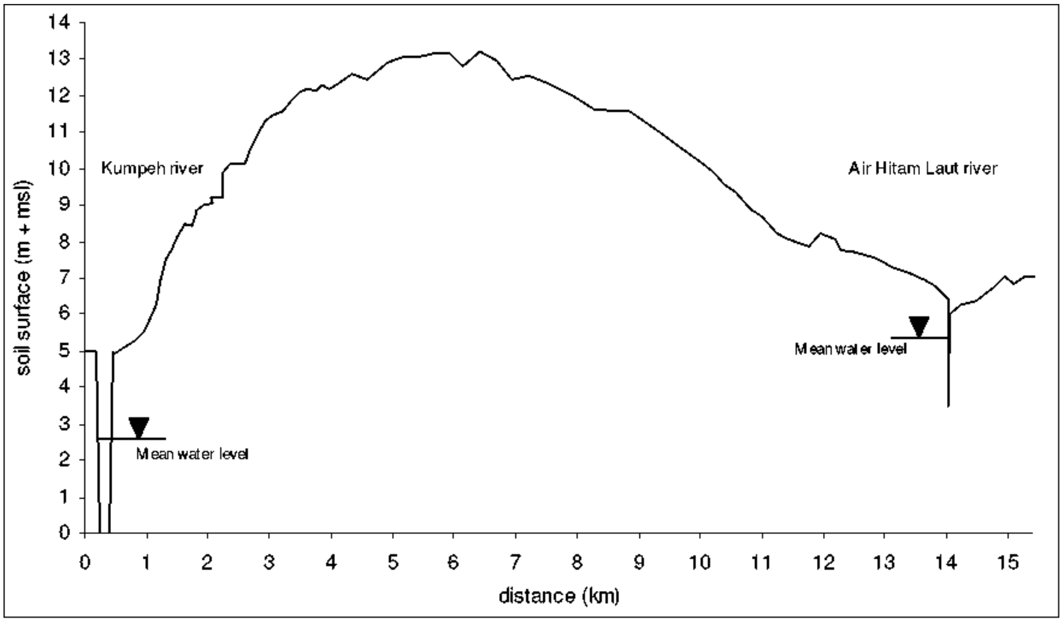


Figure 3 Cross section of peat surface elevation between the Kumpeh and Air Hitam Laut Rivers.



INDONESIAN GOVERNMENT APPROACH TO PEATLAND RESTORATION

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SUMMARY

In order to solve the problems caused by the MRP, Presidential Decree 80/1999, specified "Guidelines for a Mitigation Plan for the ex-MRP Area", based upon management of peat >3 metres thick for conservation and economic development of peat < 3 metres through spatial land use planning. An *Ad Hoc* team and Core Team for Mitigation of the ex-MRP (The Core and Ad Hoc Team - TCAHT) was established by the Minister of Acceleration & Development of KTI in 2002 to implement the guidelines. The rationale behind the establishment of the TCAHT was: because the Mega Ri*ce* Project was started by Central Government the problems must be resolved by Central government. Members of the *Ad Hoc* team were government officials, scientists, and university and professional associations. The tasks of the *Ad Hoc* team were evaluation and mitigation of the ex-MRP, formulation of a concept for rehabilitation of the ex-MRP, formulation of a concept for the mechanism of mitigation, and formulation of recommendations with alternatives. A grading system for the ex-MRP area, based on an impact and evaluation matrix, was developed by TCAHT as a tool to guide the planning of the rehabilitation programme. Advantages of the grading and matrix applied to the ex-MRP area are integration of approaches and options, data co-ordination, monitoring and evaluation, and understanding of the entire ex-MRP area as a holistic entity. TCAHT concluded that there can still be prospects for future development of the ex-MRP area by changing the principles of the approach to development of the area following some of the recommendations of the Pontianak Workshop on Tropical Peat that was held in 2004.

Keywords: **tropical peatland, peatland restoration, mega rice project, mitigation, land use planning**

INTRODUCTION

The one million Peat Area Development or "Proyek Lahan Gambut Satu Juta Hektar" (PLG) in Central Kalimantan Province was executed under Presidential Instruction on June 5th 1995 on Food Resilience, followed by Presidential Decree No. 82/1995 on the Utilization of Peat Area for Food Production purposes in Central Kalimantan Province. The main objective of this project was to convert wetlands in Central Kalimantan to paddies in order to keep the rice self-sufficiency attained by Indonesia in 1984. This programme was in line with the Indonesian Government's policy which is, in its efforts to meet the food demand, to open new cultivation areas (extensification), and to intensify the cultivation as well as other intensification efforts, with production increase as its main aim.

The Peat Development Area geographically located in between the city of Palangka Raya (River Kahayan) toward the east connected by the 187 kilometres Main Primary Canal (SPI) which cuts the Barito River at Mangkatip. On the west side, the PLG location stretches from the city of Palangka Raya towards the south along the eastern side of the Sebangau River up to the Gulf of Sebangau in the Java Sea. On the east side it is bordered by the Barito River, following the Kapuas Murung River towards the south, passing the Kuala Kapuas up to the Kapuas River estuary at the Java Sea. Soil on the area mainly consists of wetland, dominated by peat with a thickness of more than 3 metres (35%), less than 1.5 metres (18%) and acidic sulphate soil (12%), potential acid sulphate soil (33%), and saline soil (2%). The PLG was developed in stages, starting from the beginning of 1996 and during the period 1996-1997 a 187 km long Main Primary Canal (SPI) was constructed, connecting the Kahayan and Barito Rivers. In addition, 958.18 km Dividing Primary Canals (SPU, Saluran Primer Utama) in Blocks A,B,C and D were also constructed. In Block A, the secondary canal, collector canal, primary and tertiary canals all had been constructed, so that this block could provide 30,000 hectares of paddies. For a variety of reasons the PLG was abandoned in 1999 with Presidential Decree No.80/1998.

REASONS FOR THE PLG PROJECT'S FAILURE

The PLG project's main aim was to produce new agricultural land to replace that converted from agriculture in Java. The plan to develop peatland into highly productive food producing agricultural cultivation did not materialize and this failure left many negative impacts that need to be resolved immediately. Most of the PLG Project's failure may be divided into the 3 stages of the project:

Planning and Design stage

(a) Contravening basic procedures in planning and design for wetlands;

(b) Generalising the area's condition in a single unit;

(c) The limited availability of basic data required for natural resources planning;

(d) Limited knowledge of local culture during the planning stage.

Execution stage

(a) The construction of the water system pattern, which cut through the mid-section of the peat domes, caused excessive drainage that degraded the environment;

(b) Settling transmigrants who had little or no understanding of swampy and peat area conditions;

(c) Technical guidance given to transmigrants and local farmers had not made them self-sufficient;

(d) Lack of cultivation preparation;

(e) Sectoral program's coordination was ineffective

Area Utilization stage.

The low cultivation productivity owing to the change from reductive condition to oxidative condition, making the soil acidic;

Low farm productivity;

The little guidance given to the local communities;

Environment al degradation

The closed water system had not met its planned target.

EX-PLG AREA MANAGEMENT BASIS.

Based on in depth evaluation and assessment, the Government concluded that the Central Kalimantan PLG Project was not unsuccessful, so the Government promulgated Presidential Decree 80/1999, which mainly gives guidelines for its rehabilitation.

To execute Presidential Decree 80/1999, The Minister for Acceleration of East Indonesia Area Development, as the chief of Daily Council for East Indonesia Development Acceleration, issued decree No.SK/004/KH.DP-KTI/IX/2002 establishing the Ad Hoc Team to solve the problems of the ex-PLG Project in Central Kalimantan. This was headed by the Secretary General of the Council for East Indonesia Development/Expert Staff of Minister for National Development. Planning/Bappenas, East Indonesia Development Acceleration/ Less Developed Area. The Ad-hoc Team was mandated to undertake the following actions in respect of the Ex-PLG Project in Central Kalimantan: (a) evaluate the manner in which it was planned, designed and executed, (b) prepare a rehabilitation concept, (c) draft an implementation strategy to coordinate the teams involved, and (d) prepare alternative management recommendations. The Ad-hoc Team completed its task and produced the “Plan for Rehabilitation of The ex-One Million Hectares Peat Development Area in Central Kalimantan” document which contains guidelines for Central Government, Local Governments (provinces, regencies or cities) and other stakeholders in their efforts to manage and develop further the ex-PLG Area.

The aim of writing the Planning for Rehabilitation of the ex-Peat Development Area document is to produce a guideline for Government institutions at central and local level as well as other stakeholders in their efforts to rehabilitate these landscapes through the followings activities:

(a) Evaluating the way in which the Project was handled;

(b) Preparing a rehabilitation concept;

(c) Drafting a mechanism for coordinating the institutions involved; and

(d) Preparing alternative recommendations for rehabilitation.

APPROACH AND STRATEGY OF REHABILITATION OF THE EX PLG

Various documents have been examined to develop the plan of rehabilitation of the Ex PLG Project at Central Kalimantan. The documents encompass the report of the Mega Rice Project (MRP), Grand Strategy (Directorate General of Spatial Planning, Department of Public Work), Agricultural Business Development (Department of Agriculture), Rehabilitation Strategy Plan (Department of Forestry), Programs of Technical Services and related sectors at national, provincial and regency levels. Besides that, reviews were also executed on the result of Tim Kaji Ulang (Department of Public Work), Tim 20, WALHI, CIMTROP – Palangka Raya University, STRAPEAT, BPPT, IPB, and UGM. The review also encompasses the output of the seminar held at BPPT in 1998, which was able to push the issuance of Presidential Decree No. 80/1999 that automatically annulled the Presidential Decree No. 74/1998.

REHABILITATION PLAN FOR THE EX PLG

A matrix of guidance activities were established in the form of a rehabilitation plan of the Ex PLG by the various institutions involved. The matrix considers goals (objectives) and locations, institutions in charge, funding sources, and execution time. In its implementation, some factors below should be considered:

(1) Prior to implementation of activities/programs, updating data of land quality and correction of area should be conducted.

(2) Every working block, which is in fact a united ecosystem, should have integrated plans of activities/programs and executed simultaneously by relevant institutions.

(3) The prioritized activities/programs at every working block must be set based on funding availability and executed in a coordinated manner.

(4) Personnel involved in the implementation of the rehabilitation activities/programs must be permanent.

CONSERVATION ZONE

Areas with peat thickness over 3 metres within the Ex-PLG zone must be determined and designated as protection or conservation zones under the Ministry of Forestry's Decree according to function and specificity of habitat, so they will not be used for other purposes. The protection or conservation zone within the Ex-PLG serves the functions of both water management and carbon sink. Opening deep peatland leads to fragile conditions, especially it will be burned easily during dry seasons. Deep peat thickness must be protected to control CO2 emission rate as one factor causing global warming and climate change. In addition, opening peatland for agricultural purpose can cause harmful flood and drought. Considering these facts, deep peatland must be conserved or protected as a reservoir that holds water during the rainy season, and releases it gradually during the dry season.

Damaged peatland with thickness over 3 metres owing to fire, logging and other factors will become colonized by open bush vegetation. Such peatland within the conservation zone must be rehabilitated immediately by planting appropriate, useful plants that can also protect water resources. According to the assessment by the Soil Research Centre, Research and Development Agency of Agricultural Department (1997 – 1998), the area of peatland with thickness over 3 metres is estimated to be 177,373 hectares, located in working zones Block A (91,493 hectares) and Block B (85,880 hectares). This peatland distribution does not include deep peatland in the working zone at Block C, which was estimated by the IPB Team (1997) to be around 202,108 hectares. There is no thick peatland within the working zone Block D. The development of irrigation channels, particularly primary and secondary channels, which crossed peat dome has caused land subsidence of between 1 – 2 metres, but the peat still can be categorized as deep peatland (as the dome peat thickness is still over 5 meters).

Conservation action must be conducted at the very deep peatland since this blackwater ecosystem, which is rare to found in throughout the world, occurs in this zone. By designating the very deep peatland (> 3 metres) as a conservation zone, illegal logging should be able to be prevented.

The conservation activities on very deep peatland (over 3 metres) should be conducted according to reviews from various literatures, which indicate that the deep peatland (over 3 metres) must be allocated as either a protection zone or preservation zone, and various forms of production activities must be avoided. Some activities of the rehabilitation plan of the deep peatland are as follows:

Nature Conservation

The deep peatland (over 3 metres) in Blocks A, B, C, and D are designated to be nature conservation land. The largest area (192,619 hectares) is located in Block D, whereas the smallest area (14,729 hectares) is in Block A. The nature conservation area within all of these blocks totals 284,289 hectares.

Gelam Forest Zone Conservation (Actual Acidic Sulphate)

The rehabilitation of the Ex PLG for gelam forest conservation or actual acidic sulphate should be conducted in Blocks A, B, and D with a total area 70,600 hectares. The gelam forest conservation must be part of the rehabilitation of the deep peatland at the Ex PLG.

Blackwater Ecosystem Conservation

The Black water ecosystem on the very deep peatland must be preserved because of its global rarity (it is believed there are only 2 black water ecosystems in the world). This tropical blackwater ecosystem possesses specific flora and fauna, including the False Gharial (Tomistoma schlegelii) a relative of the crocodile. The blackwater ecosystem occurs only around the Sebangau River (Block C) with an area 18,804 hectares and the Mentangai River (6,650 hectares).

Mangrove Forest Conservation

Mangrove forest conservation is a feature of working zone Blocks C and D. There are 36,304 hectares of mangrove forest that must be designated as protection zone, because of the forest functions as a spawning ground for fish and other aquatic animals.

Kerangas/Quartz Forest Conservation

There are 81,264 hectares of kerangas (heath forest) in working zones Blocks E and C which possesses specific vegetation, and is very fragile to opening owing to the thin layer of peat that overlies a thick layer of quartz sand. Consequently, the kerangas forest zone must be conserved.

Flora and Fauna

Peatland is a unique and fragile ecosystem, possessing specific flora and fauna that are not available in other ecosystems. Because of that protecting and conserving its biodiversity should be conducted to prevent losses and erosion of the gene pool of the ecosystem. Trees with economic value found in this ecosystem are ramin (Gonystylus bancanus), gaharu (Aquilaria sp.), nyatoh (Palaquium sp.), bintangur (Calophyllum spp.) and jelutung (Dyera sp.) Endangered and rare fauna are orang utan, burung rangkong (hornbill), honey bear, tree tiger, and varied fishes. The area for flora and fauna conservation is 126,261 hectares, distributed in Blocks A, C, and E.

Reforestation and Greening

Woody commercial vegetation no longer exists on this large area of thick peatland, but a rehabilitation effort in order to accelerate the restoration of forest must be conducted. Following the Land Use Guidance Map produced by the Soil Research Centre, Research and Development Agency, Agricultural Department (1998), the Ex PLG zone with very deep peat thickness (over 3 metres) must be conserved and restored to forest as a matter of high priority. One of the rehabilitation programs of the peatland at the Ex PLG zone is land replanting of forest and non-forest zone through reforestation and greening. These activities should be conducted in Blocks A, B, C, and D, with a total area of 201,713 hectares.

Water Management (Canal Blocking)

Impacts generated by canal construction with poor planning are diminished land condition, and various problems related to water management, such as drought in dry seasons and flood in rainy seasons. As a result, rehabilitation should be focussed on canals with problems and which do not provide vital access to local communities. Closing those canals will restore the peatland, particularly by reducing fire hot spots in dry seasons which happens quite frequently. Water management should be conducted on all blocks covering a total area of 340,340 hectares.

River Maintenance and Control

The Kahayan, Kapuas, and Barito Rivers in Central Kalimantan not only function to provide water and irrigation for agriculture, but also serve major functions as infrastructure and means of water transportation. Because of these functions, river surfaces, river condition, and the nature surrounding them must be protected and guarded against damage. The maintenance and protection of rivers and canals should be exercised over all Blocks A, B, C, D and E with a total length of 1,600 kilometres.

CULTIVATION ZONE

Thin peat (50 – 100 centimetres) can be utilized for paddy rice, dryland crops, vegetables and fruits and medium peat (101 – 200 centimetres) can support fruits and plantation crops. Deep peat (201 – 300 centimetres) is suitable for plantations and forestry. Some rehabilitation activities for peatland < 3 metres are as follow:

Food Crops and Horticulture Development

The area recommended for cropland development is 163,600 hectares and horticulture 210,600 hectares, with most of this area located in Blocks A, B, C, and D, with the smallest area of 46,000 hectares in Block C.

Plantation Development

Some estate plantations that can be developed in the Ex PLG are rubber, coconut, palm oil, purun, and abaca banana. The most appropriate estate plantation developments in Blocks A and C are rubber and coconut, with a total area of 22,900 hectares. These activities should be undertaken by the private sector, with the Government acting as facilitator.

Fishery Development

The potential fish to cultivate are local species, such as patin, nila (kissing gouramy), and udang windu (penaeid shrimp). Total land parcels for fishery development in all blocks amount to 1,500 packages, with 550, 250, 300, and 400 packages in Blocks A, B, C, and D, respectively.

Husbandry Development

The development of cow, water buffalo and goats can be conducted at all blocks, whereas duck and local chicken could be promoted in Block A. Total number of cows, water buffalo and goats is 1,500, 8,250, and 9,500 animals, respectively; while duck and local chicken is a total of 16,000 animals.

Harvest Processing and Development

Post harvest handling includes reducing harvest losses, quality improvement, processed product development, utilization of side products and waste. Related to these, a harvest marketing network must be developed to allow the products to be absorbed by the market.

Water Management

Total development area of water management at each block is Block A 12,000 hectares, Block B 25,925 hectares, Block C 137,270 hectares, and Block D 79,700 hectares.

Society's *Handil* (Access)

The access of local people from and to the Ex PLG zone and its adjacent area is by water transportation. Because of this the existence of handil is vital to the local society since the majority of people still depend on it for social and economic activities. All the handils within the PLG working zone generally were formed naturally as a result of natural topography following the flow of the rivers. To preserve the function of the handils, national and regional governments must protect them and ensure they function accordingly. The maintenance of handils should be conducted in Blocks A, B, and D, with a total area of 45,722 hectares.

Industrial Forest Development

Plantation forestry is exercised through utilization of forest land for industrial trees. Such utilization of forest land should be conducted in every block, including the conservation zone in Block E. This activity is expected to restore many marginal land parcels distributed around the Ex PLG, that otherwise have the potential to degrade the environment. In addition, the existence of Transmigrant Settlement Units in Blocks A and C can be capitalized to support the sustainability of plantation forests.

SOCIO – ECONOMICS

The suffering endured by local people because of the failure of the PLG Project and efforts to place society as the focus of development are important matters in the establishment of the rehabilitation plan strategy of the Ex PLG zone. Society empowerment, especially of local communities, by providing opportunities to actively participate in development, is vitally important, so the concept of bottom up planning or community based development can be exercised into reality. Society empowerment will be conducted through training, provision of health and educational facilities and infrastructure construction, such as laboratories and libraries.

One of the problems that should be handled immediately is socio–economics of the former PLG and surrounding areas. Besides the existence of 8,487 families of transmigrants, there is also the local society that lives in a low standard. The low standard of life results from the limited accessibility and poor infrastructure of the region, and these limitations must be resolved immediately.

THE KEY TO SUCCESSFUL MANAGEMENT OF PEATLAND IN CENTRAL KALIMANTAN IS CORRECT GOVERNMENT POLICY

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SUMMARY

The utilization of peatland for agriculture in Central Kalimantan always has been in trial and error. Unsuccessful utilization of peatland has occurred ever since the National Government opened the peatland in coastal areas and undertaking water management, successively, with the *Anjir* system, *Polder* system, *Sisir* and *Garpu* systems, *Kolam* system and finally employing giant canals in Mega Rice Project. These programmes were executed without any strategy and they failed largely because: (1) the Government of the Republic of Indonesia did not have guidelines to follow as a result of comprehensive research, and (2) the Government never considered the views of peatland researchers because they believed they already had experts who could plan these programmes by themselves. One example of the Government's neglect of local knowledge and research information was the opening of peatland in coastal and inland areas of Central Kalimantan for the Mega Rice Project (MRP). International peatland experts attending the International Peat Symposium held in Palangka Raya in 1995 already warned the Indonesian Government that it should be careful before using peatland for agriculture. The opening of peatland for the Mega rice Project was indicated a major mistake of Government policy because, although research groups had made their recommendation based upon hard work, this warning was ignored by the Government.

Keywords: **tropical peatland, peatland management, Mega Rice Project, Government policy**

INTRODUCTION

The successful utilization of peatland in Central Kalimantan could be achieved by the correct Government policy which should be based on the experience of scientists who have carried out research on peat and peatlands in Central Kalimantan and other countries. One of problems with Indonesian scientific research on peat is that it is based on results derived from small scale experiment carried out over short time periods and lacking and integration with other aspects. The many Agencies, Departments and Ministries of the Government of the Republic of Indonesia have great difficulty in working together to implement projects in the field, because each of them is used to working alone to fulfill their own specific role in the national planning process. For example, to establish a transmigration settlement, the Department of Public Works will provide infrastructure (e.g. roads, canals and rice fields), and they will be followed by the Department of Transmigration Department that will construct houses and provide public facilities, while the last step is the planting of crops, the means for which are the province of the Department of Agriculture. By this system many Government projects whose main purpose was to improve community welfare have ended mainly in failure. The failure of Government projects has also been caused by the lack of experience of Government officials and Government scientists to predict the impact of projects in the long term. In reality, the Government has always neglected local knowledge when establishing a new project. One example of the Government's mistaken interpretation of the success of local people in management of peatland (shallow peat) in Central Kalimantan was that they extended this "Handel" small-scale system to justify construction of the excessively large canals used in the Mega Rice Project. According to Limin (2005) the technologies to utilize peatland in Central Kalimantan have to be determined by trial and error, especially after the Government neglected the local knowledge which had successfully managed peatland in a limited area. The efforts of the Government to extend the area of rice fields based on "Handel system" then the "Anjir system", "Garpu and Sisir systems", "Kolam system", and eventually the giant canal system of the MRP was a mistaken interpretation of the success of the traditional way of growing rice in tidal areas *("Handel system")* .

GOVERNMENT POLICY AND PROBLEMS

The basis of Government policy in the case of peatland development should be a Presidential Decree which has comprehensive socio-economic and environmental considerations providing high benefits for human society and sustainability of environmental functions. Consequently, Government policy must be based on comprehensive research findings based upon detailed work carried out by professional researchers. In Indonesia, many scientists have carried out research not for science, but for family economic sufficiency. This behaviour of researchers arises because their salary incomes from their normal work are too low. Therefore many Indonesian researchers use research projects in order to obtain extra money and sacrifice research quality as a result. In addition to this unethical behaviour of researchers, the Government has also made severe mistakes in the interpretation of the results of research once they received them owing to a lack of deep understanding of the accuracy of the data obtained and the research procedures carried out. This situation prevails still because the Government and also the companies involved have never considered research results seriously. Sometimes Government Agencies provide funding for scientists, but the research results must be consistent with the requirements of the sponsors. In other words, the Government and sponsors have known the results even before any field research has been carried out by the researcher. Therefore, many research results have been only for collection and then placed in a cupboard where they are stored for posterity and never seen again.

In reality Government policy has always been erroneous on the feasibility of field conditions or carrying capacity of tropical peat but, if action is taken now, there may still be time to maintain the existing undamaged peat swamp forest and restore some of the peatland that has been damaged already. This will be very difficult to achieve because many Government staff have used their positions of authority to enrich themselves. Therefore, in the past and even now, Government policy was operated as a simple procedure, so that development programmes were never based on comprehensive considerations.

A general statement of considerable importance that is enshrined in a President Decree relates to peat thickness for agriculture and conservation. Presidential Decree No 32/1990 states that peatland less with less than 3 m of peat can be converted for agriculture while that with more than 3 m should be conserved. This regulation presents many problems for the environment, because it does not include other criterion related to the unique characteristics of tropical peat and peatland. For example, the Mega Rice Project was opened based on this decree. Planning of the MRP was carried out by an Indonesian Consultant who stated that all of the peat within the

proposed area of the MRP was less than 3 m and was all shown by the same colour on the planning maps. Unfortunately, that report appears to have disappeared, perhaps destroyed, because this planning proposal contained manipulated data and misinformation.
Another source of error in Government policy has been caused by misinterpreting results of experiments carried out in the field over short periods of time and extrapolating these to determine impacts on very large areas over a long time. One example of this type of mistaken assessment of the carrying capacity of peatland converted to agriculture occurred when President Suharto visited Lamunti in the Mega Rice Project in 1998 to inaugurate the first rice harvest. Four months before the harvesting schedule, officials of the Provincial Government visited Lamunti area in order to supervise planning arrangements to ensure that some rice would grow, so that the President could harvest rice and be satisfied the project was a success.

Based on field observation, I have made two versions of field preparations for growing rice. Firstly, an experimental unit under natural condition and water supply using existing canal construction. Secondly, water supply provided by pump, so the water needed for rice can be supplied according to the phase of growth. After President Suharto visited Lamunti for his inaugural harvest it was reported in the press that the productivity of rice in the MRP is almost same as the national standard for non-peatland areas.

Following this apparent success of harvesting a large amount of rice in Lamunti it was reported that the President had not harvested rice that had been planted and grown there but the rice plants were brought from another area and replanted one or two days before the President arrived. The same was true for other crops that had been 'grown' at Lamunti, for example mature banana plants were standing alone without the presence of either young plants or new buds. This was not the first time that project implementers deceived high officials and politicians because the results of small-scale experiments have not provided a true insight into the consequences of large scale land development.

INDICATORS OF GOVERNMENT MISTAKES

Several indicators of Government mistakes in the utilization of peatland can be explained by the history of peatland development, local income and rice imports by the Indonesia Government.

History of peatland utilization

Traditional way

For centuries Dayak people in Central Kalimantan have employed two types of rice field *("ladang")* in peatland which were managed in traditional ways.

1. "*Petak Luwau*", identical with "*sawah tadah hujan*" that was located in upstream areas with the following characteristics:
   - Peat thickness less than 50 cm with clay in the bottom
   - Located behind the river bank or between two hills
   - Cultivation without canal
   - Rice field blocked by a soil bank
   - Land preparation by slash and burn

- Always saturated and generally flooded by river water.
- Productivity 1.75 – 3.00 t/ha
- Seedling transplanting after ~ 2 months in nursery

2. "*Sawah Pasang Surut*" in coastal areas with characteristics as follows:
    - Peat thickness less than 50 cm and clay in the bottom
    - Cultivation using small canal ("*handel*")
    - Rice field blocked by bank with water gate
    - Land preparation slash and burn
    - Located behind river bank at a distance from the river of less than 1 km
    - Productivity 1.90 – 4.00 t/ha
    - Seedling transplanting after 2 months in nursery. (In the beginning, seedling need 3 times before transplanting, i.e.; teradak (30 – 45 days), *lambak/ampak* (25 – 35 days) and *lacak* (70 – 85 days)).
    - Always influenced by tidal movement of sea water (flooding) 1-2 times a day.

Canal technology for irrigation

The Government of Indonesia started to develop peatland for agriculture in upstream and coastal areas using a system of canals for water management.

1. Upstream area in "*Petak Luwau*"
    - Government constructed a canal in *petak luwau*. (e.g. In Goha and Tabak Kanilan villages)
    - Government opened inland peat e.g. Kalampangan (1980s), *Transbangdep* (1991s) and Bukit Rawi (2002).

2. Coastal area "*Sawah Pasang Surut"*
    - *Handel* system (traditional way)
    - *Anjir* (1920 by Dutch Government)
    - *Polder* system (1950 by Schophuys/Dutch expert)
    - "*Garpu*" (UGM)/ "*Sisir*" system (IPB and ITB) (1980s)
    - "*Kolam*" system (1980s)
    - Giant canal system (1996, Mega Rice Project)

The main purpose for establishing the MRP was to maintain Indonesia's self-sufficiency in rice production that was achieved in the 1980s and which was lost in the 1990s when approximately one million hectares of rice fields in Java were converted to commercial, industrial and urban land uses. It was realized early in the planning of the MRP that the initial concept of establishing rice estates in areas where it is possible for rice to grow successfully and without opening new areas of land was impossible.

In order to understand the problems confronting the MRP it is essential to realize the area of landscape involved and the dimensions of the canals constructed.

1. Total area: 1,457,100 ha.
    1. Block A: 227,100 ha (15, 59 %)
    2. Block B: 161,480 ha (11, 06 %)
    3. Block C: 568,635 ha (39, 03 %)
    4. Block D : 162,278 ha (11,14 %)
    5. Block E : 337,607 ha (23,17 %)
2. Total length of canals:
    1. First Primary Canal 183.1 km
    2. Secondary Primary Canal 620.5 km
    3. Support Primary Canal 241.1 km
    4. Tertiary Canal 964.0 km
3. Transmigration people
    - In 1999/2000 about 15,600 families (60,000 persons) of transmigrated people were settled in 45 units
    - 30,000 ha of rice planted by these people resulted in total failure because of a plague of rats.

The real condition of peatland cultivation in Central Kalimantan.

Upstream areas

1. "Petak *Luwau* "
    - After canals were established, the status of the land changed from wet to dry land
    - Rice production decreased. In Tabak Kanilan less than 50% of farmers are still growing rice owing to low production and in Goha village it has totally stopped
2. Inland peat or deep peat
    - About 80% of land has become un-productive land ("*lahan tidur*").
    - Not economic, because high inputs are required (ash, lime, fertilizer, etc).
    - The farmers disappeared e.g. Transbangdep, Bukit Rawi, etc.

Coastal areas "sawah *pasang surut* "

- Rice production decreased after excessively large canals were constructed.
- The status of land changed from wet to the dry, because the water cannot flood the surface any longer
- Rice fields have been replaced by other crops including, rubber, banana, coffee, jack fruit, zallaca palm, nephelium, pineapple and the weed grass alang-alang (*Imperata cylindrica)*.

Farmers' welfare and income

Based on research results in a village near Palangka Raya city (~ 24 km distance), average family income is about Rp. 661,348 per month. This income is very low, however, because it has to cater for the living costs of 3-6 persons (Socio-economic activities of local communities at Mega Rice Project (MRP) area in Palangka Raya District, Central Kalimantan, (CIMTROP, 2003).

Regional Income per Capita Kalimantan Tengah Province

a. The cost of living (prices) increased constantly from 1995 to 2000. During this period, the highest increase of 44,79% occurred in 1998. In 2000 the increase in regional income per capita was 13.81%.

b. Regional income per capita based on constant price of 1993 in the period of 1996 to 2000 increased significantly. The highest increased was in 1996 of 11.85%. But in 1998 it decreased by 6.92% while in 2000 it increased again but by only 2.17%.

Regional incomes per capita, based on prevailing prices and constant prices in Central Kalimantan from 1999 to 2004 are shown in Table 1. Although the income per capita in 2004 was around 7,176,364 (US $ 717.64) this value differs from the real condition at the grass roots level. Based on the poverty limit in the same year of about Rp 128,382 in villages and Rp 148,964 in cities the total of poor people was about 12.20% in the villages and 6.13% in cities showing that poverty in Central Kalimantan is still high. Related to the income above, the population of poor people in Central Kalimantan and Indonesia is presented in Table 2.

Table 1: Regional income per capita based on the prevailing price and constant price

Year	Regional income per capita based on prevailing price		Regional income per capita based on constant price 1993	
	Value (Rp)	Growth (%)	Value (Rp)	Growth (%)
1999	4,258,398	-	1,779,576	--3.04
2000	4,650,803	9.21	1,725,533	0.83
2001	5,146,481	10.66	1,739,919	1.80
2002	5,687,035	10.50	1,771,295	2.72
2003	6,386,932	12.31	1,819,485	2.35
2004	7,176,364	12.36	1,862,281	

Source: antan Tengah in Figures (2004)

Table 2: Population of poor people in Central Kalimantan and Indonesia

Place	Poverty Limit (Rp/capita/month)		Total of poor people (thousand)		Percentage of poor people (%)	
	2003	2004	2003	2004	2003	2004
Central Kalimantan	114,357	128,382	166.40	161.10	12.64	12.20
Villages City	134,788	148,964	41.30	33.00	8.10	6.13
Indonesia	105,888	108,725	207.70	194.10	11.37	10.44
Villages City	138,803	143,455	25,075.70	24,777.90	20.23	20.11
			12,263.70	11,369.00	13.57	12.13
			37,339.40	36,146.90	17.42	16.66

Rice Imports

The high total rice imports by the Indonesian Government over the 11 years from 1994 to 2004 are proof of the country's unsuccessful management of its rice fields (Table 3). This situation is very contradictory when compared to the amount of land available and the number of farmers.

Table 3: Total of rice imports by Indonesian Government

Year										
1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
* (million ton)						** (million ton)				
0.6330	1.8079	2.1498	2.5000	7.1000	5.000	1.3557	0.6447	1.8054	1.4285	0.2369

Source: * Noor, 2001
** Statistik Indonesia, 2004. BPS Jakarta-Indonesia

DISCUSSION

Based on the history of peatland utilization as explained above, the Indonesian Government has shown its weakness on the importance of research findings. The failure of the transmigration projects that used peatland have never considered past experience when opening new area which have same characteristics or more less. In the other words, the opening of peatland for agriculture and placement of transmigration people has involved movement of poverty from one area to another. The contradiction between the livelihoods of transmigration people compared to that of the Government officials who manage these projects is very significant. On the one hand, the farmer are living in poverty while, on the other hand, the Government people are living in luxury. Limin (1999) stated that failure of peatland utilization in Central Kalimantan was caused by the Government because it never considered local knowledge, carrying capacity, culture and marketability. Consequently, peat utilization in Central Kalimantan has always been by trial and error.

Real evidence that the Government neglected local knowledge, carrying capacity and culture was shown by the opening of a new area of peatland for transmigrate after UPT Bereng Bengkel (Kalampangan) in Tahai (called Transbangdep), Bukit Rawi and other areas in coastal part of Central Kalimantan. If the Government's policy was good they would never open new areas of inland peat for agriculture. For example, if the Government was aware that extending the "handel system" on a large scale would lead to decreasing rice production they should not have implemented this policy. Decreasing in the rice production in coastal peat areas was evident from the return to their traditional homes of large numbers of Dayak people who had been persuaded to join transmigration programmes to develop rice fields in coastal areas. According to these farmers, decreasing rice production occurred after the Government constructed the over-size canals that led to drought and pollution of both land and water.

The main purpose of establishing these enormous canals was for water management on the rice fields where transmigrant people from outside of Kalimantan were to be settled. Relocation of people from Java, Bali and other Indonesian islands to Central Kalimantan through the transmigration project was carried out in order to increase their welfare through managing land for agriculture. But, in reality the management of land in transmigration settlement was not successful, so many of the transmigrants moved to other areas. They were unable to cultivate their land so they chose to seek alternative jobs as labourers in towns and cities. The largest area of converted that has not been cultivated by the transmigrants is located in the interior, especially is very far from the major rivers. This area is unaffected by tidal sea water movement and therefore because the volume of water available is always draining away along the large canals it is impossible to irrigate the farmers rice fields. Therefore most of the land located far from the rivers has becoming unproductive (called "lahan tidur"). Limin et al. (2003) and Limin (2005) stated that because of Government policy in these large scale areas, many centres of rice production have lost their status as 'rice barns'. Based on real facts obtained in the field, the traditional way of rice cultivation used by local people before the land was developed by the over dimension canal system, for example, at Basarang, Palingkau, Tamban, Mintin, Pembuang and Tabak Kanilan, was more successful. Changes to the status of these areas have never been considered by the government before extending development to open new areas, so that the mistakes always accumulated year by year.

Almost all of the transmigration projects on peatland have been unsuccessful and are now becoming a heavy responsibility for the local government, a potential threat to the environment and a cause of friction between native and transmigrant people.

Levels of community welfare are indicated by food materials. In block A sub block A2 ex. MRP, transmigration people must be satisfied to eat cassava, because they cannot grow rice and do not have money to buy rice. Based on CIMTROP research (2003) the level of average income in the community at the Kameloh Baru village and Bereng Bengkel village which are located near to Palangka Raya city is Rp 661,348/month/family (Rp 7,936,176/year/family) (about US$ 73,48/month/family) and indicates the difficulties of community economics. This income has decreased compared to the year before because the natural ecosystem changed after the MRP was established. The income rate of communities as listed in Table 1, showed that the increase of income year by year was not significant, and many of these communities have an income lower than Kameloh Baru and Bereng Bengkel.
The number of people living in poverty has not decreased significantly almost 30% of people living below the poverty level reside in cities. Factual data on the lack of success of rice cultivation in Indonesia is indicated by the amount of rice imported from other countries. The total of rice imports is in contradiction with the Indonesian population of which about 80% are farmers or live in villages. This situation occurred because farmland which was fertile and productive became unfertile and unproductive because the ecosystem surrounding the farmland was changed. In other words, the extension of rice fields through the transmigration projects has caused existing of farmland to become un-productive or to have lower yields making them uneconomic. The opening of large areas for rice fields without considering the ecosystem surrounding them results in unsatisfactory yields and even crop failures.

Unsuccessful utilization of peatland for agriculture has been showed through the ill-fated MRP. The main purpose to provide a major centre for rice production has, in fact, become as a major centre for fire and the production of thick smoke and dense haze every year. The MRP area is now sensitive to fire because the surface peat becomes very dry during the dry season because the water table falls to very low levels. Limin et al. (2003) explained that changing the hydrological status of peatland in the MRP was caused by the over dimension of the canals constructed there and since these were connected to the big rivers, so the water will flow from the land system to the river.

According to Limin (2000), fire will occur in peatland wherever there is human access e.g. road, canal, river, lake, plantation, settlement, and illegal activity in the forest. This is confirmed by satellite imagery that shows the majority of fire hotspots occur around or near to routs of human access.

Finally, because of the mistaken planning of the MRP it is now extremely difficult to restore, repair and/or redesign this vast peatland area because all of the environmental components that need to be made functional again require a new approach based upon new information obtained in the field.

CONCLUSIONS AND RECOMMENDATIONS

1. The utilization of peatland for agriculture, although still may provide economic value, always has negative impacts on the environment which are related to socio-economic problems in the long-term that are always bigger than the economic value in the short-term.
2. The peatland areas (including ex MRP) which were designed for agriculture and/or transmigration, should be re-designed before implementing other projects, through comprehensive and extensive research.
3. The Government must stop sending new transmigrants to Central Kalimantan because it is better to use the money to improve the livelihood of existing transmigrants, including re-locating them from un-feasible to feasible areas.
4. The peat swamp forest area should be maintained for producing timber on a sustainable basis, so that the ecosystem will be capable of supporting the community activities in its surroundings. It is better if the peat swamp forest should be the lung of Indonesia.
5. The opening of peat swamp forest for food crops and plantation have a need high cost and will initiate new problems for the future.
6. The government should consider how to improve the salaries of Government employees in order to stop corruption, but this must be accompanied by increased professionalism of the staff.

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FIRE OCCURRENCE IN BORNEO'S PEATLANDS BETWEEN 1997 AND 2004 AND ITS IMPACTS

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ABSTRACT

Fire is a major factor for forest loss in Borneo and especially in Kalimantan. Impacts are especially serious in peatlands as illustrated by the vast fire incident of 1997/98 and the recurrent fire occurrence in 2002. A complete set of active fire measurements, i.e. hotspots, acquired by three different satellite systems (ATSR, NOAA-AVHRR and MODIS) between 1997 and 2004 was analysed to investigate the spatio-temporal pattern of fire occurrence on the island of Borneo. Hotspots and fire scars derived from high resolution Landsat ETM+ images show a reasonable spatial correlation, which could be used to estimate burned areas on the basis of the hotspot data. Recurrent burning and converting peatland forests changes this ecosystem from a "carbon sink" into a "carbon source".

FIRE MANAGEMENT ROLE IN LOWLAND PLANTATION DEVELOPMENT

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ABSTRACT

Effective forest fire management systems in tropical lowland fiber plantations consisting of fuels management, fire prevention, specialized equipment, and rapid response procedures can mitigate the negative impacts of fires, smoke and haze with similar effectiveness as experienced in more developed countries. Clear assessment of the wildfire threat and commitment to consistent and sustainable development of the needed fire response capabilities will be presented

INVOLVING LOCAL COMMUNITIES IN THE ALLEVIATION OF POVERTY AND ENVIRONMENTAL DEGRADATION: A SUSTAINABLE LIVELIHOODS APPROACH.

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ABSTRACT

In the wake of post-colonial and post-development critiques (Crush, 1995; Escobar, 1995), students and practitioners of development are now thankfully more aware of and sensitive to development's negative impacts. Socio-economic methodologies such as DfID's 'sustainable livelihoods' (SL) approach seek to unite project activities with poor people's livelihood priorities. As people's ability to both escape from poverty and attain sustainable livelihoods is critically dependent on their access to assets, SL approaches focus on five main categories of assets, namely human capital, natural capital, financial, social capital, physical capital.

INVESTIGATING DIFFERENCES IN ORANG-UTAN AND GIBBON DIETS IN THE SEBANGAU NATIONAL PARK, INDONESIA: IMPLICATIONS FOR CONSERVATION

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SUMMARY

The Sebangau National Park is home to the world's largest orang-utan population, and one of the largest populations of Bornean agile gibbon. Knowledge of those food trees most important to these apes' continued survival in the Sebangau is essential for their conservation. By factoring in food nutrient contents and phenological patterns we can compare past (pre-illegal logging) and present food availability in the Sebangau. This will provide important insights into the effects of illegal logging on orang-utans, based on long-term monitoring. The effects on the gibbon population will be evaluated based on orang-utan data and on-going gibbon density studies).

Keywords: **Orang-utan, gibbon, conservation, feeding ecology, nutrition, peat swamp forest**

INTRODUCTION

Recently, it has been shown that the Sebangau peat swamp forest, Central Kalimantan is home to the world's largest orang-utan population, estimated at 6910 individuals in 2003 (Morrogh-Bernard *et al.,* 2003). This finding led to the Sebangau being designated a National Park in October 2004. Only one short study has been conducted on the gibbons in the Sebangau and this estimated about 5,700 individuals in the mixed swamp forest habitat sub-type (Buckley, 2004). This habitat sub-type occupies only 40% (Morrogh-Bernard *et al.,* 2003) of the total area of the Sebangau forest and so it has been estimated that the total gibbon population in the Sebangau could be as high as 20-30,000 individuals (Cheyne unpublished data) and thus of massive conservation importance. Despite this, information on the health of the gibbon population and on the contribution of different foods to the two species' energy budgets is currently unavailable. Logging is a serious problem facing Indonesia's forests, and both orang-utans (e.g. Rijksen & Meijaard, 1999; Singleton *et al.,* 2004) and gibbons (e.g. Brockleman & Chivers, 1984; MacKinnon, 1984) are highly susceptible to logging disturbance. Declines in food availability, increases in gap size and frequency, the compression effect for orangutans (Rijksen and Meijaard, 1999; Morrogh-Bernard *et al.,* 2003), and decline in territory size and hence quality for gibbons (Chivers, 1990) are all important mechanisms through which logging disturbance can affect the two species. Other serious threats in the Sebangau include fire, which leads to peat collapse, as a result of the peat being drained by canals used to extract logs (Morrogh-Bernard *et al.,* 2003). While gibbons and orang-utans are sympatric, they are very different both behaviourally and biologically and, as a result, are likely to be affected by logging disturbance in different ways, creating a need for species-specific management plan. Only with sufficient information on feeding behaviour, ecology and the affects of habitat degradation on the two species, can the habitat be managed to ensure their long-term survival.

METHODS

Data on feeding bouts

This will be obtained both opportunistically and systematically by observers collecting foods processed by the study species. A feeding bout will be scored whenever the focal animal processes and consumes a food item. Wherever possible, feeding rates (the number of items consumed per minute) will be obtained following Knott (1998). Instantaneous data on general activity (e.g. resting, feeding, travelling, socialising) will be recorded at five-minute intervals (Altmann, 1974). Detailed data on food-processing techniques will be recorded during feeding bouts. The frequency with which different processing techniques and processing sequences occur, as well as the frequency with which different food are processed can then be calculated from these data. The frequency with which different foods are orally or manually processed will also be calculated.

Discarded foods will be collected during focal-animal follows and, where this is not possible, by tree climbing. Invertebrate matter is difficult to collect, which will limit its use in the analyses of food mechanical properties. However, plant materials are usually quite easy to retrieve, if either un- or semi-consumed portions of food are discarded by the primate. Identification of fruits and flowers will be carried out with the aid of field assistants and the CIMTROP herbarium. All plant specimens will be photographed and catalogued to aid future identification.

Physical properties of foods

These do not survive long-term storage and so must be estimated while in the field. Prior to testing, the best way to preserve most material in the field in the state in which they are eaten is to place them in plastic bags with damp paper towels to preserve moisture content. All foods will be tested within two hours where possible. Young leaves are particularly friable and so must be tested quickly. All mechanical tests will involve the use of the portable tester (physico-chemical field kit developed by Lucas et al., 2001, 2003a, 2003b).

Surface characteristics of foods

The size and shape of food particles can be obtained easily from a combination of the use of engineering callipers, a thickness gauge and image analysis. Frictional tests are needed for two reasons: (i) to get a measurement of the yield stress from the cutting wire tests and (ii), to estimate the friction between teeth and food. Tannins precipitate salivary proteins, so exacerbating friction, and are also measured.

Non-surface characteristics

Toughness, Young's modulus and yield stress are all directional properties and the amount of information required to fully characterise a food object depends on its structural heterogeneity. The type of mechanical test used to measure these characteristics will be guided by observation of how the primates feed. Toughness is probably the vital mechanical element in the resistance of most foods to consumption by primates. In plant tissues, toughness arises from cellular architecture and dimensions of the cell walls while, in insects, the characteristics of their cuticles are all-important.

AIMS AND EXPECTED RESULTS

(a) To identify the tree species of greatest importance in ensuring the orang-utan's and gibbon's continued survival in the Sebangau catchment, i.e. those species providing the greatest energy contribution overall and in times of greatest food stress. Mather (1992) compiled a list of the 40 most important gibbon foods and a list of all known gibbon foods based on his study at Barito Ulu, Central Kalimantan and a search of the literature. Morrogh-Bernard (unpublished data) has a similar list of orang-utan food plants in the Sebangau. Cheyne (2004) has similar data for gibbons in the Bukit Baka Bukit Raya National Park and an updated list for Barito Ulu (unpublished data), which will be compared with the orang-utan list for Sebangau and used as a basis for identifying the important gibbon feeding trees in the Sebangau National Park. Mather's list will be used for comparison with the data collected on gibbon food trees in the Sebangau and with the orang-utan food data already available to identify dietary overlaps and differences between the two species.

(b) To assess the effects of past illegal logging disturbances on orang-utan food availability and numbers in the Sebangau and to use the above data to infer the likely effects these disturbances have had on gibbons.

(c) To assess how differences in the two species' biology (ranging patterns, birth intervals, age-sex ratios, territoriality and density-dependent factors) may influence their susceptibility to logging disturbance.

DISCUSSION

This long-term study on sympatric orang-utans and gibbons will provide a unique insight into how these apes cope with uncertain food supply in the forest. While most of the Sebangau catchment has now been designated as a National Park, it was previously unprotected. Much of the forest is degraded and many areas inside the park boundary are still being logged (Husson and Morrogh-Bernard, 2005). A clearer knowledge of the apes' feeding strategies will improve our understanding of how they survive in the forest, information important for the development of species management plans for the park. Furthermore, the risks of continued habitat disturbance will be identified, sowing the seeds for long-term monitoring of the health of the orang-utan and gibbon populations. This information will enable conservationists to predict the effects of sudden changes on the park's ape populations.

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WHAT CAN APES TELL US ABOUT THE HEALTH OF THEIR ENVIRONMENT? A REVIEW OF THE USE OF ORANG-UTANS AND GIBBONS AS INDICATORS OF CHANGES IN HABITAT QUALITY IN TROPICAL PEAT SWAMP FORESTS

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SUMMARY

Considerable effort and resources are often spent on conservation in protected areas, but unfortunately research to identify the success of these efforts is often lacking. The advantages, disadvantages and potential use of orang-utans and gibbons as indicators of changes in habitat quality in peat swamp forests are discussed and potential methods for using these apes as indicators of changes in habitat quality are reviewed. It is proposed that long-term monitoring of orang-utan and gibbon population size and behavioural ecology should be an integral part of research into the effectiveness of conservation methods in protected areas where these animals are found.

Keywords: **Orang-utan, gibbon, biological indicator, monitoring, peat swamp forest**

INTRODUCTION

As our appreciation of the importance of the natural environment grows, so does the time, effort and financial resources spent on conservation. Millions of dollars are now spent on conservation around the world each year (WRI, 2000), but it is often difficult to assess how effective these efforts are in conserving what they are supposed to conserve, as long-term monitoring of their effectiveness is often lacking (e.g. Hockings *et al.*, 2000). When the aim of the programme is for conservation of the entire ecological community, assessing the effectiveness of conservation efforts is difficult, as it is physically impossible to monitor their effects on all of the species in a community. In such a situation, what is required is to select a suite of 'indicator species' that can be monitored to assess the effectiveness of conservation measures (Carignan & Villard, 2001; Dale & Beyeler, 2001). Without such monitoring, it is impossible to tell whether conservation actions have been successful or not and how management plans should be adjusted to best conserve the community (Parrish *et al.*, 2003).

In order to know that conservation efforts are having the intended benefits, careful selection of indicator species is required. Dale and Beyeler (2001) have studied this in detail and conclude that a good indicator of environmental change should:

1. Be easily measured
2. Be sensitive to environmental stresses
3. Respond in a predictable way to these stresses
4. Be anticipatory of future environmental changes
5. Predict changes that can be averted by changes in management practices
6. Be integrative (i.e. be able to form part of a suite of indicators working at all the different levels in the ecosystem)
7. Have a known response to disturbances, anthropogenic stresses and changes over time
8. Have low variability in their response to disturbances

The present conservation efforts in the Sabangau catchment in Central Kalimantan were instigated largely because of the discovery that the area is home to the world's largest remaining contiguous orang-utan (*Pongo pygmaeus wurmbii*) population (Morrogh-Bernard *et al.*, 2003; Singleton *et al.*, 2004). The Sabangau catchment is also a very important area for agile gibbon (*Hylobates agilis albibaris*), the population of which has been estimated tentatively at 26,300 (±5,600) individuals, making it potentially one of the largest remaining populations of this sub-species in Borneo (Buckley *et al.,* 2006). In addition, this extensive area of peat swamp forest is home to a large number and diversity of other fauna and flora (Page *et al.*, 1997; Page *et al.*, 1999; Shepherd *et al.*, 1997; Husson & Morrogh-Bernard, pers. comm.), which will also benefit from increased efforts to protect the area's ape populations. Thus, orang-utans and gibbons can be considered as the Sabangau's 'flagship' species, with the awareness created, and funds and efforts spent, on their conservation benefitting many other species. As conservation attention in the Sabangau is largely focussed on its ape species, assessing the effectiveness of conservation efforts for their survival is essential for identifying the most successful management strategies.

The few research projects that have monitored orang-utan and gibbon populations over long periods have generally been conducted with the aim of detailing only what is happening to the target species' population. The use of these species as potential indicators of the overall health of the environment has received virtually no attention to date. In this paper, we address this by reviewing the potential ways in which these species can be used as indicators of environmental health and assessing how well they meet the above criteria for indicator species.

THE USE OF ORANG-UTANS AND GIBBONS AS INDICATOR SPECIES

A number of different methods of studying orang-utans and gibbons might suit their use as indicator species, and these methods, plus their advantages and disadvantages are summarized and compared in Table 1.

Table 1: Advantages and disadvantages of different methods for studying orang-utans and gibbons as indicators of environmental health.

Indicator	Method Used	Advantages	Disadvantages	Criteria Satisfied	Criteria Not Satisfied
Population Size	Orang-utans – line transects to count nests [1,2]. Gibbons – triangulations of groups from morning loud calls [3, 4].	Both methods now well established and tested in the Sabangau [1, 4]. Long-term population trends are the overall criteria against which the effectiveness of conservation measures must be measured. Both species known to respond negatively to human disturbance and the nature of these changes are well documented [5]. Does not require finding or following animals.	Gibbon surveys are time consuming and require a lot of manpower, making them expensive. Orang-utans (and probably also gibbons, though possibly to a lesser extent) are known to have a lag period from when disturbance occurs to when the population crashes, and to shift ranges to escape human disturbance [5]. Responses to human disturbance are inconsistent between areas [5].	1 (orang-utans), 2, 6, 7	1 (gibbons), 3, 4, 5, 8
Energy Balance	Urine is collected and urinalysis strips of the type used by human doctors are used to detect ketones (bi-products of fat metabolism) in the urine [6, 7].	Urine is easily collected and analysed. As female reproductive condition is suppressed during periods of negative energy balance [6], prolonged production of large amounts of ketones may provide an early indicator of population crashes. Responses should be consistent and have low variability.	Not tested on gibbons yet, collection and analysis should not be problematic, but the smaller size and fat reserves of gibbons relative to humans may make ketones harder to detect and smaller readings more important. Requires finding and following animals.	1 (if already following animals), 2, 3, 4, 5, 6, 7, 8	

Advantages

Both methods now well established and tested in the Sabangau [1, 4]. Long-term population trends are the overall criteria against which the effectiveness of conservation measures must be measured. Both species known to respond negatively to human
disturbance and the nature of these changes are well documented [5]. Does not require finding or following animals. Urine is easily collected and analysed. As female reproductive condition is suppressed during periods of negative energy balance [6], prolonged production of large amounts of ketones may provide an early indicator of population crashes. Responses should be consistent and have low variability.

Disadvantages

Gibbon surveys are time consuming and require a lot of manpower, making them expensive. Orang-utans (and probably also gibbons, though possibly to a lesser extent) are known to have a lag period from when disturbance occurs to when the population crashes, and to shift ranges to escape human disturbance [5]. Responses to human disturbance are inconsistent between areas [5].

Not tested on gibbons yet, collection and analysis should not be problematic, but the smaller size and fat reserves of gibbons relative to humans may make ketones harder to detect and smaller readings more important. Requires finding and following animals.

Table 1 (continued)

Indicator	Method Used	Advantages	Disadvantages	Criteria Satisfied	Criteria Not Satisfied
Parasite Loads	Faeces collected, stored and taken to a lab for analysis [8, 9]	Faeces easily collected. Method tested in Sabangau [8, 9]. High parasite loads are a good indicator of poor condition and environmental stress. Changes will be rapid, as an animal's ability to resist infection will decline rapidly with deteriorating body condition. Analysis can be done on site if equipment available.	Difficult storage and requires expert analysis. High variability and inconsistency of response [10]. Responses are poorly documented and increases in parasite loads could be caused by many factors aside from changes in habitat quality. Requires finding and following animals.	1 (if already following animals), 2, 3, 4, 5 (?), 6	7, 8

References cited in the table: 1. Morrogh-Bernard*, et al.* (2003); 2. van Schaik*, et al.* (1995); 3. Brockelman & Srikosamatara (1993); 4. Buckley*, et al.* (2006); 5. Rijksen & Meijard (1999); 6. Knott (1998); 7. Morrogh-Bernard & Harrison (unpublished data); 8. Dench (2005); 9. Foitova, Morrogh-Bernard, Harrison & Cheyne (unpublished data); 10. Stuart & Strier (1995); 11. Commitante (2005); 12. Caldecott (1980); 13. Singleton & van Schaik (2001).

The different methods are not equally effective for use as indicators of environmental change. Only energy balance fulfils all the criteria (although urine collection would be difficult if animals are not already being followed). Energy intake fulfils most of the criteria, except for ease of collection and predictability of response. Its expense and the difficulty of data collection will make it unfeasible for most. At present, insufficient data are available to predict accurately how energy intake will change with environmental stresses in peat swamp forest, but work currently being undertaken on the nutritional contents of food items and feeding rates for the two ape species in the Sabangau (see Cheyne, et al., 2006) will go some way towards rectifying this. Once these data have been collected, it will be possible to monitor energy intake through merely observing the length of feeding bouts, making this a suitable indicator for use in the Sabangau, as long as animals are still being followed. Parasite loads also fulfil many of the criteria and, owing to the ease of collection, if animals are already being followed, this method is also recommended.

Population size, possibly the most obvious candidate initially, actually fulfils few of the criteria and would appear to be a poor indicator of present environmental health, because of the long lag period between disturbance and response as animals slowly starve (Rijksen & Meijaard, 1999). Despite this, the ease of data collection, ease with which the information produced can be understood by non-experts, and the fact that the overall aim of any orang-utan or gibbon conservation project is to conserve as large a population as possible, means that monitoring population size is essential.

Stress hormones would appear to be a poor indicator, owing to the difficulty of storing and analysing samples, and the high natural short-term variability in stress hormone levels (shown for rehabilitant orang-utans by Commitante, 2005), making teasing apart changes in hormone levels as a result of natural and anthropogenic disturbances very difficult. If a field kit could be developed, the natural variability in wild animals' stress hormone levels could be established and the need for expensive storage and analyses would be overcome, making this technique much more useful.

Range responses to human disturbances are currently poorly understood and unpredictable, and are very difficult to measure (especially for orang-utans) making them less suitable for use as an indicator at present. Future advances in radio tracking technology may make this method more feasible.

CONCLUSIONS

1. Energy balance, parasite loads and energy intake fulfil most of the criteria for a good indicator and should be the best indicators of environmental health, but assessing energy intake is too expensive and time consuming to be of wide-spread use.
2. Population size, though not a good indicator of *present* environmental health, is important for raising awareness and funds for conservation, and for assessing the long-term effectiveness of conservation efforts (the overall aim of which is, after all, to conserve as large a population as possible).
3. Stress hormones and ranging responses are of little use as indicators at present, though further developments in these fields may make them more useful.
4. Using a number of methods (e.g. energy balance, parasite loads and population size) should give a good indication of environmental health.
5. Long-term monitoring of orang-utan and gibbon populations should be an integral part of research into the effectiveness of conservation methods in protected areas where these animals are found.

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THE POTENTIAL EFFECTS OF NATURALLY LOW RATES OF SECONDARY SEED DISPERSAL, COUPLED WITH A REDUCTION IN DENSITIES OF PRIMARY SEED DISPERSERS ON FOREST TREE SPECIES DIVERSITY IN REGENERATING PEAT SWAMP FOREST.

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SUMMARY

A pilot study carried out at the *Laboratorium Alam Hutan Gambut (Natural Laboratory for the study of Peat Swamp Forest,* LAHG hereafter*)*, observed the extent of secondary seed dispersal and in-situ predation of seeds found on the forest floor. Predation in-situ and removal rates were found to be similar, with little evidence of seed caching, suggesting secondary seed predators do not play an important role in the seed dispersal loop. This is unlike many other tropical seed-fate studies in which removal rates frequently reached 100%, and evidence of caching was high. As such, the role of primary seed dispersers, in dispersal and maintenance of tree species diversity in tropical peat swamp forest (TPSF), is fundamental, yet their population densities are in decline. This study considered alongside a case study of the Mega Rice Project area, which collaborated that tree species diversity in areas burnt in 1997 has declined and become even further reduced after a second large-scale burn in 2002. In light of the previous study, one of the potential reasons for this continued forest diversity decline can be linked to a decrease in the adjacent primary disperser populations. The implications from this indicate therefore, that if this decline continues tropical peat swamp forest may struggle to regenerate naturally in disturbed areas.

Keywords: **Seed dispersal, tropical peat swamp forest, regeneration, seed predation, tree species diversity.**

INTRODUCTION

Indonesia hosts nearly 30,000 species of vascular plants, of which nearly 60% are endemic. (Butler, 2006). The tropical peat swamp forests (TPSF) of Central Kalimantan are no exception, and whilst a complete classification list is lacking, over 100 tree species have been identified (Shepard *et al*., 1997). It has been suggested one of the main reasons for this high biodiversity is the narrow niche specification that species evolved, allowing a very high level of coexistence (Wright, 2002). Coupled with this niche separation, however, is the potentially high level of species vulnerability to local extinction, through a minimal level of habitat disturbance.

The degradation of 1.5 million hectares of peat swamp forest in Central Kalimantan occurred in the mid 1990's owing to the construction of extensive canals, created for the failed Mega Rice Project (PLG) (Schwiethelm, 1998). The canals enabled peat swamp forest water to be drained from the surrounding areas of TPSF into the Sungai Kahayan and Sungai Sebangau. Furthermore, many of the forested areas adjacent to the canals were clear-felled and the timber sold. The combination of these two processes led to the drying of the peat in the adjacent forested areas with an annual loss of peatland carbon estimated at 545g Cm^{-2} (Page *et al* 2002). In 1997, this was further exacerbated by the cyclic southern oscillation weather front of El Niño, leading to the fires of 1997 destroying forested areas of over 200,000 Ha in Central Kalimantan (Cane, 1983; Gurhardja *et al.,* 2000). Subsequent fires occurred in 2000 and 2002, and during this time, much of the tree species diversity and over all biodiversity was lost.

In order to determine if biodiversity is in recovery, two aspects are considered in this paper. Firstly, a 5-year study based in the fire-disturbed PLG area monitored the level of tree species diversity from 2001 to 2005, with comparison control study sites located in the Natural Laboratory for Peat Swamp Forest (LAHG) within the Sebangau National Park. This study shows the impact the fire has taken on the fauna, and the rates of recovery of the tree species diversity. Secondly, after disturbance, to determine if the processes necessary for regeneration frequently become altered, as key species may not have been able to adapt to the drastically altered environment. Therefore, establishing the natural sequence for regeneration in an undisturbed site is essential and this knowledge transposed to the area of disturbance. Thus, in the LAHG, a study was conducted to assess secondary seed dispersal by terrestrial seed predators across the forest floor. From this, the relative importance of both primary and secondary seed predators, acting as seed dispersers, in promoting forest regeneration were determined.

Numerous studies have been made of the success ional patterns of tropical forest following disturbance, especially in dipterocarp forest of Borneo (Fox, 1976; Whitmore, 1975 & 1984; Woods, 1989; Pinnard & Cropper, 2000). Whitmore (1984) expanded the simple model of forest growth from gap, building and mature phase to a more generalised pattern. If a gap is small then shade tolerant seedlings (particularly climax tree species) already present in the forest structure tend to dominate the gap. If the gaps are larger, shade tolerant tree species mortality is increased or growth is suppressed by fast growing species, which exhibit rapid germination responses at high light levels. These light tolerant pioneer species grow at an accelerated rate, ultimately closing the gap to form a new, lower canopy. Over a longer period of time more shade tolerant trees replace those of the lower canopy, reforming the original tall canopy. Whilst this pattern could be used to describe small areas of disturbance within TPSF of the PLG, the massive spatial gaps generated from the fires of 1997 and 2002 requires a longer term study of tree species diversity to determine the success ional pattern in operation there, and whether the forest will be able to recover to a pristine state.

The importance of seed dispersal and seed predation in determining forest dynamics, ecology and regeneration has received much attention since the 1970's (Levey & Benkman, 1999, Nathan & Casagrandi, 2004, Wilson & Traveset, 2000, Stiles, 2000, Webb & Peart, 2001). Further, recent work demands that seed dispersal, along with seed production, predation, germination must be considered, each as sections of the 'seed dispersal loop', in order to understand the crucial factors necessary for continued forest regeneration (Wang & Smith, 2002) (Figure 1).

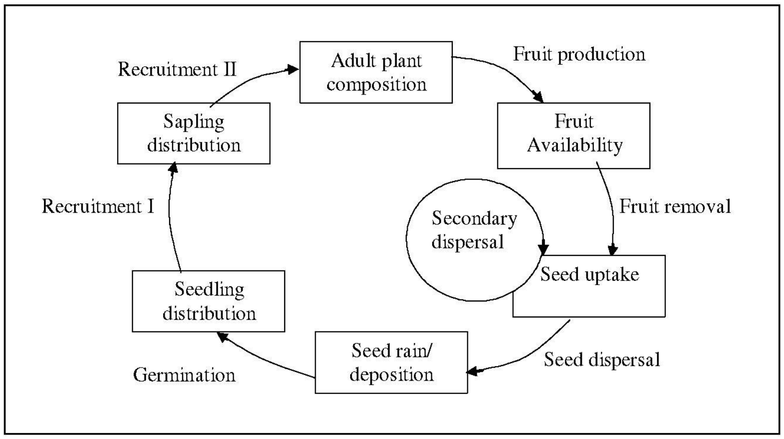

Figure 1: The seed dispersal loop, as proposed by Wang and Smith (2002)

Early studies suggest large birds and primates are the essential primary dispersers e.g McConkey, 2000, whilst smaller birds and insects are the key secondary dispersers. Work pioneered by Forget (1990) showed, however, that rodents cached 70% of foraged seeds, dropped from the parent tree either by windfall or primary dispersers. Then a significant number of these caches were forgotten, leaving seeds dispersed and protected. Several studies (e.g. Wenny, 2000), across three continents in different evolutionary lines of seed predators (Forget & Van der Wall, 2001) found similar results, thus establishing small mammals as seed dispersers, rather than just seed predators (Jansen & Forget, 2001).

Little work has been done in the TPSF of Central Kalimantan, Indonesia, on the role of seed predators as seed dispersers, and much of the evidence is anecdotal (Corlett, 1998). Within this habitat there are many primary dispersers including tree shrews, pigs, deer, rodents, orang-utans, macaques, of which gibbons and hornbills are considered amongst the most important (Corlett, 1998). Where orang-utans and gibbons coexist, it is thought they are both important in primary seed dispersal, both for local/macro dispersal through spitting and dropping seeds during feeding bouts in the parent tree and on a larger scale by excreting the seeds in their faeces.

METHODS

Regeneration studies

In 1999 a single belt transect was establish in the burnt area of the PLG, to measure diversity, density and regeneration through seedling and sapling counts. For the purpose of this study only adult trees over >6cm dbh were analysed. The transect was surveyed in 1999, 2001, 2003, 2005, but not in 2002 as the area was burning and considered unsafe to survey. The study was expanded in 2001 to include saplings over 1 m in height with a dbh >2 cm. This enabled the identification of the key tree species that were regenerating after the disturbance, and thus the regeneration patterns could be established.

Disperal study

A study was carried out in the LAHG to determine the activity of secondary seed predators: to compare the removal rates of seeds from beneath seed shadow of the parent tree to the level of in situ predation. More specifically, this study focused on seed fate after the fruit had been primarily displaced onto the forest floor during a feeding bout by an orang-utan. Three tree species were selected, of which, all the fruit were known to be predated upon by orang-utans and gibbons, in high fruiting abundance and showed different morphological characteristics (Appendix 1). The species chosen were Parartocarpus venenosus (Moraceae), Eugenia grandifolia (Myrtaceae) and *Blumeodendron tokbrai (Euphorbiaceae).*

Of the seeds collected, half were used to create non-threaded 'natural' sets, to give natural predation rate (results not discussed here), and half to create sets of threaded seeds - using white cotton and a unique identification tag, to establish seed-fate (Forget, 1990). After threading the sets were set around the parent tree (Figure 2).

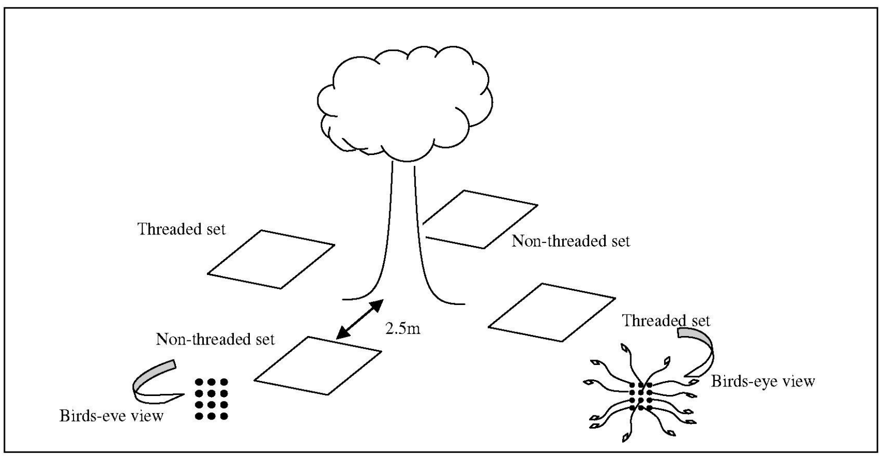

Figure 2: Diagram of the layout of threaded and non-threaded sets around the parent tree. (Diagram showing 12 seeds per set is in accordance with the abundance of *Eugenia* and *Blumeodendron.* For *Paratocarpus* seed sets would each contain 25 seeds all at a radius of 2.5 m from the parent tree.)

Each setted parent tree was checked every three days for fifteen days and recordings of seed movement noted (Table 1). When a threaded seed had been removed from a set, a search was conducted for the thread and ID tag within a 10m radius from the tree. At the site of recovery (deposit point) the seed fate was recorded as consumed, cached or abandoned.

Table 1: Description of the type of recordings made when inspecting the seed sets, plus associated assumptions.

Set type	Observation	Recorded as	Assumptions	Validity of assumptions
Threaded	Seed no longer in set, thread remaining	Vertebrate predated in-situ	Before removal there were no insects in fruit	Work in this study showed after insect predation, vertebrate predation appeared much lower.
Threaded	Seed and thread no longer in set	Vertebrate removal	Before removal there were no insects in fruit	Work in this study showed after insect predation, vertebrate predation appeared much lower.
Threaded	Infested with insects	Insect predated	Infestation by insect prevented seed from germinating	Opening of infested seeds revealed extensive decay

RESULTS

Regeneration plots

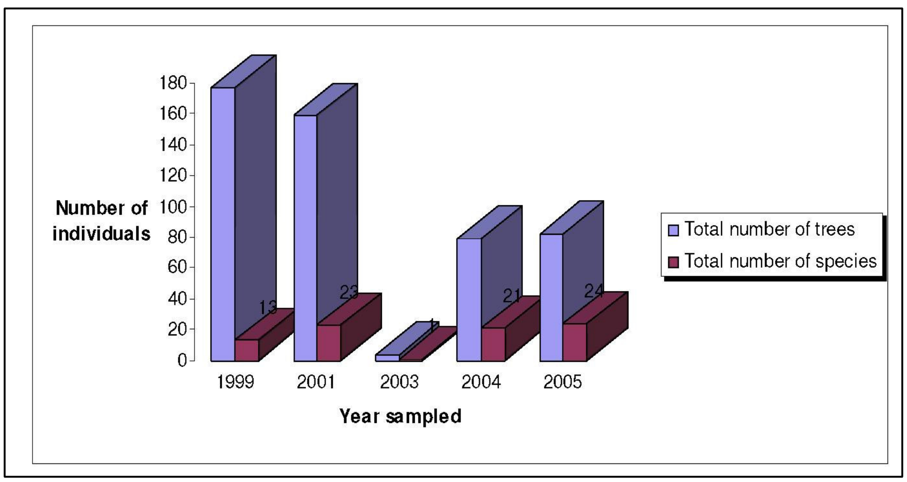

Figure 3: Graph showing the number of individuals and species recorded over a 6-year period in the PLG Block C area, Central Kalimantan, Indonesia.

After the second burn of 2002 the number of adult individual trees in the transect was found to have decreased dramatically (Figure 3). The sample first taken in 1999 only took into account trees > 6cm dbh, but the recovery rate in 1999, two years after the initial burn, was double the recovery rate observed in 2004, two years after the second burn. It should be noted that improved accuracy in species identification may have contributed to the slightly higher tree species diversity in 2004 and 2005. To avoid this variable, newer species were classified and group for analysis to genus rather than species.

The dominant tree genera pre-2002 were determined to be of the Santiria sp. and Sterculia sp groups, with more commercially interesting trees included Shorea sp, Dyera sp, Eugenia sp.

Gonystylus bancanus appearing two years following the 1997 fires. Post 2002 re-burnt transect species diversity changed dramatically with Elaeocarpus sp, Syzygium sp. and Ilex sp becoming more dominant. Of the trees >6cm dbh, only *Combretocarpus rotundus* was found to be viable. Adult trees of *C. rotundatus* (tumih) had been found to have survived both fires, but sapling numbers (2 cm – 6 cm dbh) of this wind dispersed species were low in number.

Following the second burn overall tree species diversity for the emerging species was found to have decreased even 3 years after the second fires (Figure 3). Therefore the removal from the habitat of potential fruiting species such as Santiria sp. and Dyera sp. which are known to be orang utan food would ultimately have a direct impact on the remaining frugivore species in the area.

Determining seed-fate

Eaten in-situ versus removed

The results for the predation *in situ* by vertebrates versus their removal rate was analysed using a pair-wise t-test. Unlike many other studies, high levels of *in situ* predation by vertebrates were observed, such that there was no significant difference between the levels of predation in-situ versus the removal rate (Table 2).

Table 2: Summed levels of predation in-situ of vertebrates, versus removal rates. The p-values of the paired t-test for predation in-situ versus removal rates are also given.

Tree sp.	No. of seeds predated in-situ	No. of seeds removed	p-value
Parartocarpus	13	11	0.351
Eugenia	7	6	0.791
Blumeodendron	10	6	0.726

Recovery of removed seeds

Seed searches for the removed threaded seeds proved successful with a recovery rate of over 70%. However, of the removals, 38% of the seeds were removed less than 1m from the set. Distances of recovery from the source set ranged only up to 8.4m. A larder-hoard cache (with multiple seeds) was discovered in *Eugenia sp.* and a scatter-hoard cache (with single seed) was discovered in *Parartocarpus sp.* Of the consumed seeds, threads were discovered, taken down holes and lodged up trees branches.

DISCUSSION

The secondary seed dispersal study found no significant difference between the predation rates of vertebrates eating the seeds in-situ and those removing them (Table 2). Conversely, other studies have shown very high removal rates of seeds from under the parent tree, with 70-100% disappearing within 3 days (Forget & Milleron, 1991, Yasuda, 2000). Very few studies have recorded predation in situ, and those which have done so usually record much lower predation in situ than removal rates compared to the present study (Wenny, 2000).

Reasons for the different findings of this study may be the unusual living environment created by the peat swamp forest within which terrestrial animals are often well-protected and hidden from view or, at least, near to vegetation cover from above. Thus there is less need for the seed predators to remove the seeds to an area of high vegetation density to consume the seeds in safety, previously observed in other studies (Forget, 1990; Forget & Milleron, 1991). A second possibility for the low removal rates is that, in other studies, high removal rates were associated with a high caching rate, and caching would occur at a particular microhabitat (Jordano, 2000). Reduced caching may be a feature of the environment of the peat swamp, particularly where extensive flooding occurs annually, in turn destroying any caches. It should be noted this study was carried out only during the dry season. Caching can be seasonally affected, and caches in this forest may be formed at other times during the year. As such due to the limited temporal and spatial scale of this study, it cannot be assumed the animals in this area do not cache at all.

These results highlight that natural regeneration does not always proceed either at speed, or towards its previous end point following repeated, high levels of disturbance. Work across many tropical areas show similar findings that after high levels of disturbance, forest ecology is affected to such an extent that normal regeneration may not proceed. Once an area had been opened up through deforestation, previous stands of Dipterocarp pioneer species have a propensity to form monostands (Fox, 1976). Furthermore, tropical rainforests are one of the most bio-diverse ecosystems in the world, and as such, some species are found at very low density. A survey in Los Tuxtlas Mexico, covering 20 Ha, found more than 50% of tree species had a frequency of only 1 (Alvarez-Buylla *et al.*, 1996). Although after a forest has been regenerating for 40 years, post disturbance it has been shown key forest features; such as above-ground biomass and tree density can return, and even species richness. Yet, these low-density late-successional species may still be absent, and the species composition may be quite unlike that before the disturbance (Aide *et al.,* 2000). It is thus essential to understand the diversity and frequency of species in natural forest, in addition to the natural regeneration processes, which occurs in the TPSF environment.

Forest fires have been found to greatly restrict the regeneration of an area, through the deterioration of seed banks (Uhl *et al.,* 2000), reduction in the plants that normally re-sprout post disturbance, removal of parent trees and a decline in soil fertility owing to loss of organic material. The regeneration capabilities of burnt primary forest, rather than logged forest, have previously been found to be good (Woods, 1989). The results of the 1999 survey support this, however, resurveys of the area after the second burn of 2002 show a much greater reduction in species diversity and stand density suggesting repeated high levels of disturbance may prevent natural regeneration occurring.

The similarity of TPSF at the LAHG and at the PLG (before its extreme disturbance) allows the conclusions of seed dispersal study to be compared with the findings of the PLG study. Although the seed dispersal study is only a preliminary work into one section of the seed dispersal loop, it already highlights that in this unique ecosystem, it is not possible to simply extrapolate from other studies elsewhere, despite apparent convergent evolution witnessed across the globe in caching and seed dispersal by secondary seed predators. This study suggests once fruit reaches the forest floor, movement occurs only over short distances and removal from the parent tree seed shadow is rare. Instead, most seeds once dropped suffer predation or germinate on the floor, where they fall.

In this study all the fruit considered were adapted to vertebrate dispersal and were known food species. If secondary dispersal does not occur, this suggests that the most abundant primary dispersers, in this instance orang-utans and gibbons must play a much more crucial role in seed dispersal compared to other known forest types. As such, a reduction of primary vertebrate disperser would in turn reduce the dispersal ability of the tree species and ultimately the numbers of adult individuals of those tree species. Therefore with a much reduced habitat to support such large herbivores population numbers would surely fall. It should be acknowledged that seed dispersal may also be achieved through other means, for example, abiotic (wind or water/rain splash) (Van der Wall *et al.,* 2004, however, this study focused on only tree species with a preference for vertebrate dispersal.

The spatial distances covered by the primates illustrates how large-scale distribution of tree species may occur, though Van Shaik *et al.* (1993) noted that few dipterocarp fruits could be successfully dispersed further than 40m, in primary forest. At the LAGH the orang utan density has decreased by almost half in the last 5 years. (Husson pers com). In 1996 orang utan numbers at forest edge, bordering the area of the LAGH, were found to be 2.01 individuals per km^2 this dropped to 0.39 individuals per km^2 in 1999 post fires and has now been levelled in the last 4 years at 1.22 individuals per km^2 (Husson *et al.,* 2005). The PLG area has only once been surveyed for orang utan density, in 1999, and was found to be 0.42 individuals per km^2, similar to that of the LAGH at that time. It could be extrapolated then that the orang utan density at the PLG should still mimic that of the LAGH but since the fires in 1997 and 2002, there is anecdotal evidence (*per obs*) to suggest that orang utan and gibbon densities has since dropped much lower than those recorded in LAGH. This would be in agreement with numerous other studies that state that high levels of disturbance has detrimental effects on many of the floral and faunal species including the orang utan (*Pongo pygmaeus*) (MacKinnon, 1974; Kuuluvainen, 1988; Huth *et al.,* 1997; Uuttera *et al.*, 2000).

Connell and Slayter (1977) stated that tropical rainforest maintains such a high level of diversity through a constant state of stress and flux, created by persistent low level disturbance. Though this may be true for low levels of disturbance, the study at the PLG shows that after repeated high levels of disturbance, TPSF loses a large percentage of its tree individuals and tree species. Furthermore, this work gives no indication the forest and species composition are in recovery. Whilst this study, at present, has not been conducted over a sufficiently long period of time to determine if any forest recovery is possible, we can draw on other studies to ascertain how likely future recovery is. The initial work based at the LAHG suggests that in TPSF secondary seed dispersers play a minor role in facilitating tree species seed dispersal. As such, this shifts this crucial role in supporting natural forest regeneration to the dominant primary dispersers, the orang utans and gibbons. However, if their densities have truly reduced at the PLG, as is suspected, this may define one crucial regeneration barrier, preventing the fire-disturbed TPSF returning to its former state through natural regeneration alone.

ANNEX I

Details of the fruiting tree species selected for the study.

Tree Species	*Parartocarpus venenosus*	*Eugenia grandifolia*	*Blumeodendron tokbrai*
Fruit characteristics	Large fruit with prickly ectocarp and thick layer of soft flesh. Medium sized seeds dispersed throughout flesh, ranging from 2-18 per fruit.	Small fruit with soft flesh, with 4 small seeds at centre.	Tough thick ectocarp, with thin layer of flesh surrounding 3 large seeds with thick testa.
Seed characteristics on the forest floor	Flesh fell away as fruit hit the floor, leaving exposed individual seeds.	Seeds remained enclosed in flesh.	Seeds remained enclosed in ectocarp
Approximate mean no. fruit dislodged after an orang-utan feeding event	100	50	50
No. of tree individuals in the study	4	5 (though with total of 6 seed data sets, as one tree was time replicated)	5
Number of sample sets per tree	4	4	4
Exact number of seeds per set	25	12	12

N.B. Although some of the seeds remain inside the fruit during their potential dispersal, for the purposes of this study they are always be referred to as seeds, not as diaspores.

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LIMNOLOGY OF TROPICAL BLACKWATER ECOSYSTEMS: THE ROLE OF MACROPHYTES ON FRESHWATER FISH PRODUCTION IN BEJE

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SUMMARY

Local people in Central Kalimantan have been living very closely associated with the tropical peatland ecosystem in the region. In association with their very fertile fishery ground of blackwater wetland ecosystem, local fishermen use a method of capturing fishes called beje. The production of one beje is between 500 and 2,000 kg of freshwater fish per year. This very environmentally friendly indigenous knowledge that has been developed for generations was mostly destroyed during the development of the so called Mega Rice Project in Central Kalimantan during the period between 1995 and 1999. After the project was terminated in 1999, it has been the major issue for the Government of Indonesia to compensate the loss of local peoples' income owing to the destruction of their beje. This study investigates the mechanisms of the very high production of growing trapped fishes in the beje. Results show that 6 common freshwater fish species are usually trapped and grown in the beje. To support the life of these fish, local fishermen usually allow aquatic macrophytes to grow naturally inside their beje. A common macrophyte, *Echinochloa stagnina* Retz, provided a very good habitat for various species of planktonic organisms especially rotifers and cladocerans. This finding indicates that a possible reason for maintaining the *Echinochloa stagnina* Retz vegetation was to enhance the habitat of planktonic organisms thereby providing more natural food for trapped fishes in the beje.

Keywords: **limnology, beje, fish, tropical peatland, blackwater**

INTRODUCTION

Beje is a method of capturing freshwater fish that has been practiced by local people for generations in blackwater swamp ecosystems of Borneo. This method can only be practiced in a certain type of floodplain area. Several conditions of floodplain areas that make them suitable for developing a beje are a regular inundation of water during much of the year, the natural occurrence of macrophytes or other water adapted vegetation, a water source either as rainfall or river flood, and also the availability of a land basin, either man-made or natural (Nihin, 2000). A beje is connected to the main river by digging a ditch called *tatah*. The dimensions of the *tatah* are 1-2 m width, 1-2 m depth with a length up to 40 m. Several beje are usually constructed along one *tatah*, (Figure 1). During periods of high water level, fish enter the beje from the river through the *tatah* by means of their migration behaviour. With subsequent decrease in water level, these fish will then be trapped inside the beje, and they can only grow naturally inside the beje until the beje becomes dried out during the dry season when they are ready to be harvested. The beje is usually harvested once a year between August and September. In Central Kalimantan, the production of one beje is between 500 – 2,000 kg of fish per year (Anitae & Gumiri, 2003).

Since the occurrence of natural macrophytes or vegetation is very important to maintain the production of a beje, this present study focuses on the role of *Echinochloa stagnina* Retz, a type of macrophyte that usually grows inside the beje, in supporting high production of freshwater fish. It is hypothesized that the reason why local fisherman maintain the growth of *Echinochloa stagnina* Retz inside their beje is to support zooplankton production, so this will provide an important natural food source for the fish trapped inside the beje.

STUDY SITE AND METHODS

This study was carried out at a network of 10 bejes located at the Bakung Merang Village about 5 km to the northeast of Palangka Raya City, the capital city of Central Kalimantan province of Indonesia. The study was carried out over a three month period from March until May 2004. During the study, several basic limnological parameters were measured and zooplankton samples were also collected from both the water column and attached to the aquatic plant *Echinochloa stagnina* Retz. Free swimming zooplankton were collected by filtering 30 litres of pond surface water using a plankton net with 40 **u**m mesh opening, whereas those attached to the plants were collected by the picking up method (Sakuma *et al.,* 2003). The types of fish species usually captured in the beje were determined by interviewing local fishermen.

RESULTS

Limnological characteristics of beje

Figure 2 shows the values of several environmental parameters measured during the study. At the 10 beje studied, water transparency varied between 37 and 72 cm, whereas water depth ranged from 144 to 204 cm. The surface water temperatures were similar at around 30oC, but pH values and dissolved oxygen concentrations varied from 5.5 to 7.1 and 1.6 mg/L to 3 mg/L, respectively.

Zooplankton Community Composition

During the study it was found that zooplankton communities at the 10 beje were dominated by rotiferan zooplankton. For both rotiferan and cladoceran zooplankton, the number of genera attached to aquatic plant was higher than those swimming freely in the water column (Table 1).

Fish species captured in the beje

Among all fish species that are usually trapped in the beje, there were 6 dominant species , namely *Trichogaster trichopterus, Polyachantus haselti, Anabas testudineus, Channa striata, Clarias batrachus* and *Channa lucius.*

The role of Echinochloa stagnina Retz in maintaining fish production in the beje

The total number of rotiferans encountered in each beje varied between 4 and 22 species. When these were grouped according to their habitat, there was a very clear phenomenon whereby most other rotifers tended to occupy only either the water column or attached themselves to aquatic plants. Only small numbers of rotiferan species were found in both habitats (Figure 3).

DISCUSSION

This study reveals that, unlike blackwater lake ecosystems, blackwater swamps such as beje provide a very fertile fishery ground in Central Kalimantan. The typically very low pH values that usually occur in blackwater lakes were not found in these blackwater swamps. The study shows that this type of man-made pond supports high species richness of zooplankton. Aquatic plants e.g. *Echinochloa stagnina* Retz are a very important habitat for zooplankton. This finding is in line with the report by Gumiri (2002) that rotiferan zooplankton in Central Kalimantan Lakes were dominated mostly by littoral species.

A very clear habitat separation among most rotiferan zooplankton was also observed during the present study. It is presumed that this habitat separation is one important explanation of why local fishermen always maintain aquatic plants in their beje. By maintaining *Echinochloa stagnina* the diversity and population density of zooplankton increase so more natural food is available for the trapped fish to grow inside the beje.

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Table 1: List of zooplankton genera found in the water column and the aquatic plants

No	Genera	Water	Plant	No	Genera	Water	Plant
	Rotifera				**Cladocera**		
1	*Anuraeopsis*	-	+	1	*Alona*	+	+
2	*Cephalodella*	+	-	2	*Epheroporus*	-	+
3	*Colurella*	+	+	3	*Euryalona*	+	+
4	*Dipleuchlanis*	-	+	4	*Leydigia*	-	+
5	*Epiphanes*	+	+	5	*Ophyryoxus*	+	+
6	*Euchlanis*	+	+	6	*Sida*	+	+
7	*Lecane*	+	+				
8	*Lepadella*	+	+		**Copepoda**		
9	*Monommata*	-	+	1	Cyclopoid	+	+
10	*Philodina*	+	+	2	Harpacticoid	+	+
11	*Platyias*	-	+	3	Nauplii	+	+
12	*Testudinella*	-	+				
13	*Trichocerca*	-	+				
14	*Trichotria*	+	+				
15	*Trochospaera*	-	+				

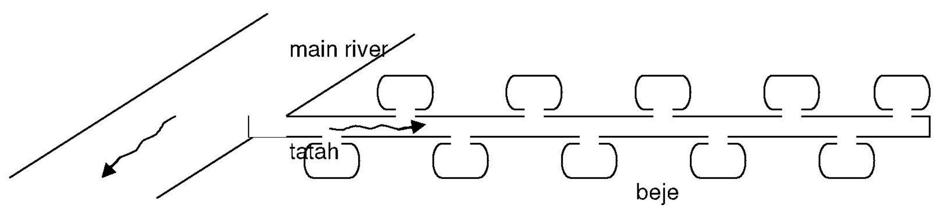

Figure 1: An illustrated connection between beje and main river

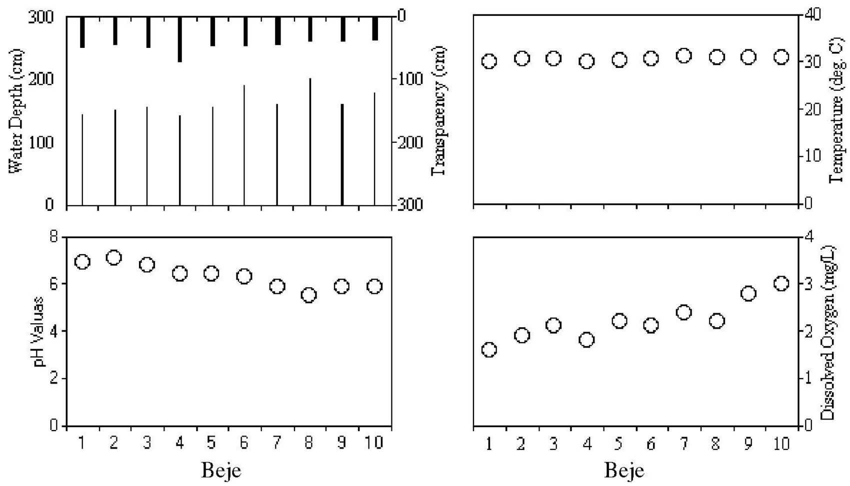

Figure 2: Limnological parameters: (a) water transparency (upper) and water depth (lower), (b) Water temperature, (c) pH values and (d) Dissolved oxygen concentrations

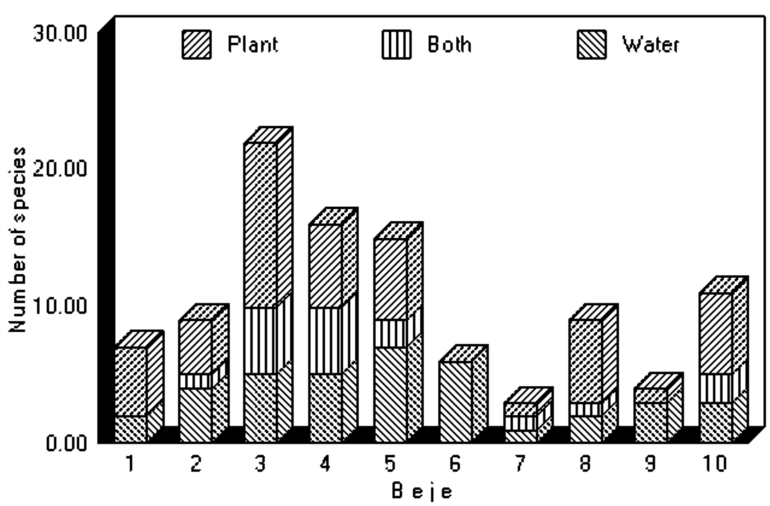

Figure 3: Habitat separation among rotiferan communities

PRELIMINARY STUDY OF FISH BIOLOGY AND ECOLOGY IN TROPICAL PEATLAND OF CENTRAL KALIMANTAN, INDONESIA

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SUMMARY

Fish are a very important protein source to local communities in Central Kalimantan. Information on fish biology and ecology from tropical peatland is little-known compared to river and lake habitats. The principal objectives of this study are to investigate fish biology and ecology, and to evaluate plankton and benthos composition in a blackwater canal. The environmental factors were also studied to obtain additional information related to biodiversity of peatland organisms. The study site is Block C of the ex-Mega Rice Project near to the transmigration village of Kalampangan. The fish species found in this site were *Anabas testudineus*, *Belontia hasselti*, *Betta anabatoides*, *Channa lucius*, *Channa pleuropthalmus*, *Clarias* sp., *Hemirhamphodon* sp., *Luciocephalus pulcher*, *Mystus micracanthus*, *Osteochilus schlegelii*, *Osteochilus spilurus*, *Pristolepis grooti*, *Puntius lineatus*, *Rasbora pauciperforata*, *Sphaerichthys osphromenoides, Wallago leeri,* and crabs. These fish must be adapted to low pH and low dissolved oxygen. However, phytoplankton are dominated by Chlorophyta, while Rotifera dominated the zooplankton in terms of taxa numbers while protozoa dominated zooplankton in terms of density. Macrozoobenthos were dominated by members of the Chironomidae family in terms of abundance and number of taxa.

Key words: **tropical peatland, fish, plankton, benthos**

INTRODUCTION

The peat swamp that covers much of Central Kalimantan is characterized by low pH values Haraguchi *et al*., 2004; Imai *et al*., 2004) and poor nutrient content (Haraguchi *et al*., 2004; Tachibana *et al*., 2004), with a thick peat layer varying from 0.5 m up to 12.6 m (Rieley *et al*., 1998). This habitat, although it is unique and fragile, supports a large diversity of flora and fauna and it is also of considerable value to local communities especially for fisheries as a major source of livelihood. Fish are a very important protein source for local people in this region (Hartoyo *et al*., 2003). Nevertheless, peat swamp habitats have received little attention from limnologists compared to other habitats such as rivers and lakes. Thus, the main objectives of this study are to investigate fish biology and ecology, and to evaluate plankton and benthos composition.

MATERIALS AND METHODS

The study was carried out in Block C of the ex-Mega Rice Project area in Central Kalimantan, located at 02°20'31.4''S, 114°02'12.0''E. Fish samples were collected on 12th and 18-20th August 2005 using several types of fishing gear, including gill net, hook and line, stage trap, pike trap, push net and other traps. Interviews were conducted with members of the local community who lived around the canal.

Plankton and benthos were sampled monthly from April to July 2005. Environmental parameters namely, depth, transparency, temperature, dissolved oxygen, pH and conductivity, were measured *in situ* with secchi disk, thermometer, DO metre YSI model 55, and Orion pH meter, respectively. Water samples were also collected for analysis of chlorophyll-a calculated by the formula of UNESCO-SCOR (Yatuka & Osamu, 1997).

RESULTS AND DISCUSSION

Most of the fish collected belonged to Anabantidae, Belontiidae, Channidae and Clariidae families. These are fish that may adapt to unfavourable environmental conditions, with low pH and low dissolved oxygen owing to having an accessory air-breathing organ allowing the them to live in oxygen-poor water. This is supported by the findings of Kottelat *et al*. (1993) that the catfish *Clarias* and anabantoids have an additional respiratory organ in order to survive in shallow, standing water and low oxygen conditions.

Compared to freshwater from lakes and rivers, the number of species in this area is relatively low with 16 fish species and 1 crab species (Table 1). Similarly, Page *et al*. (1997) reported that there were fewer fish species found peat swamp forest pools (17 species) than in the adjacent river (23 species). Yurenfrie *et al*. (2003) also reported that there was a low number of fish species (11 species) in the Sebangau River (blackwater ecosystem) with a dominance of anabantoid species.

Spirogyra sp. and *Mougeotia* sp. (Chlorophyta) dominated the phytoplankton community in terms of abundance and number of taxa. The highest individual number of zooplankton communities was protozoan, however, while the highest taxa number belongs to the rotiferan group. Similarly, Ardianor and Trisliana (2005) and Ardianor and Veronica (2003) reported that in oxbow and backwater lakes there was an abundance of small size plankton protozoa (euglenid flagellates). Yantrinata *et al.* (2003) also reported that in the peatland ecosystem there was high taxa number of rotiferans. The Chironomidae family dominates bottom communities in terms of abundance and number of taxa. This may be also the result of the low dissolved oxygen concentration and low pH. Additionally, in the lake with low water pH and debris substrate there was a dominance of Chironomidae (Yulintine, 2004).

CONCLUSIONS

The anabantoid group dominated the fish communities while green alga, protozoa and rotiferans dominated the plankton assemblages and insect larva (Chironomidae) dominated benthos organisms in the blackwater canal in the tropical peatland in Block C of the former Mega Rice Project area in Central Kalimantan. It shows that in peatland fish are found a great number of individuals although there are low numbers in certain taxa. There was also great diversity of plankton as well as benthos organisms to support food for fish although the environment was unfavorable and the organisms were able to survive in low pH and DO concentrations. Therefore, further study of food habit of fish with relation to other biota should be carried out.

ACKNOWLEDGEMENTS

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Table 1: List of fish and crab species found in the canal near Kalampangan Block C of ex-Mega Rice Project area

No	Family	Species	Local Name
1	Anabantidae	*Anabas testudineus*	Betok, Papuyu
2	Bagridae	*Mystus micracanthus*	Pantik, Darap
3	Belontiidae	*Belontia hasselti*	Kapar
		Betta anabatoides	Sambaling, Kalatau
		Sphaerichthys osphromenoides	Upaupi
4	Channidae	*Channa lucius*	Mihau
		Channa pleuropthalmus	Kerandang
5	Clariidae	*Clarias* sp.	Lele
6	Cyprinidae	*Osteochilus schlegelii*	Banta
		*Osteochilus spiluru*s	Banta
		Puntius lineatus	Saluang wunrung
		Rasbora pauciperforata	Saluang
7	Hemiramphidae	*Hemirhamphodon* sp.	Julung-julung
8	Luciocephalidae	*Luciocephalus pulcher*	Julung-julung
9	Nandidae	*Pristolepis grooti*	Patung
10	Siluridae	*Wallago leeri*	Tapah
11	Grapsidae	*Hemigrapsus*	Kepiting

THE RELATION BETWEEN THE REGENERATION OF PLANTS AND SMALL MAMMALS IN PEAT SWAMP FOREST IN CENTRAL KALIMANTAN

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SUMMARY

The relationship between reproductive phenology of plants and seed predation by small mammals was studied in peat swamp forests in Central Kalimantan. The seed productivity of plants was monitored with seed traps. The potential seed predation ratios were investigated using artificial populations of jack fruit seeds placed periodically in the forests. According to camera traps, major seed predators were small mammals. It was revealed that seed predations synchronized with other plant species of the same forests result in reduction of seed damage: i.e. the premise of predator satiation was revealed to be satisfied.

Key words: **seed productivity, seed predation, small mammals**

INTRODUCTION

It is thought that the reproductive phenology of plants is determined evolutionally by various factors including climate, seed predator pressure and nutrition. Previous studies have shown that the inter-specific synchrony of seed-fall reduces seed predation rate by vertebrates. They also suggested that the population fluctuation of mammals that eat fruits or seeds is an important factor in determining the plant productive intervals in tropical rain forests (Curran & Leighton, 2000; Curran & Webb, 2000).

In peat swamp forest in Central Kalimantan, the relation between phenology of plants and seed predators has not yet been investigated, nor has plant phenology been made clear. This study aimed to discover the important factors that determine the reproductive phenology of plants. The relationship between seed productivity phenology and seed predation rate was then investigated. The seed productivity phenology was investigated by monitoring the seed productivity using seed traps and the seed predation rate by seed setting examinations. In addition, small mammals that ate seeds, which were thought to be principal seed predators on the forest floor, were also investigated.

STUDY SITE

Present study was carried out at the Natural Laboratory of CIMTROP, University of Palangka Raya in the upper catchment of the Sebangau River, southeast of Palangka Raya, Central Kalimantan. This peat swamp forest exhibits obvious changes in structure, species composition and density ranging from the river to inland (Page *et al.,* 1999). Thickness of the peat deposit varies according to distances from the rivers and the vegetation types also vary depending on the peat depth (Shepherd *et al*., 1997). Therefore, there is a sequence of four obvious forest types, Riverine forest (RF), Mixed swamp forest (MSF), Low pole forest (LPF), and Tall interior forest (TIF).

MATERIALS AND METHODS

Three plots (50×50 m) were established in each forest type, the transition forest from RF to MSF (R-MSF), MSF and LPF.

Seed traps

25 seed traps (0.8×0.8 m) were positioned on (10×10 m) grids in each plot to investigate the amount of seed production. The seeds which fell into the traps were collected, identified and the dry weighed mass once a month.

Examination of setting seeds

In order to investigate the potential seed predation ratio, 25 jack fruit seed masses, including 4 seeds in each mass, were put on (5×5 m) grids and counted for 5 days. This examination was carried out at other small plots (20×20 m), which were established at a distance of 100 m or more from big plots so as not to affect the other experiments taking place in them.

Camera trap

Seed predators in the forest were observed using camera traps. Infrared sensor cameras were installed to view with 20 jack fruit seeds on the forest floor at a distance of 50 m or more from big and small plots for 6 nights every month.

Trapping small mammals

Small mammals on the ground were investigated using terrestrial traps. 25 or 48 wire mesh live traps (11×12×20 cm) with plastic sheet for protecting from rain were positioned on (10×10 m) grids in a plot for 5 consecutive nights. Ripe bananas were used for bait. The mammals captured were weighed, measured, identified, and marked by toe clipping, and then released. This procedure was carried out twice in every plot during the rainy season in January and March 2005. The censuses were carried out every month from January 2005 and are still continuing.

RESULTS

Seed traps (Figure 1)

In all 3 forest types, the amount of seed production increased from March onward, and was less in LPF than in R-MSF or MSF.

Examination of setting seeds (Figure. 2)

The potential predation ratios, indicated by the seed loss ratios obtained in seed setting examinations, decreased markedly from March to May in R-MSF (26.3%, 41.0%, and 15.7%) and also February to May in MSF (34.0%, 5.7%, 18.3%, and 16.0%). In LPF, however, the decline was not clear owing to the great variance between the three plots in the same forest type.

Camera traps

The photographs taken by the sensor cameras were classified into 4 groups, mice or rats, tree-shrews, squirrels, and others. The ratios of small mammals, especially the first three groups were in a majority throughout all forest types and all observation periods, occupying more than 80% except in March and April in MSF. In addition, rats carrying seeds were often recorded in photographs. The group of "Others" included macaques, sun bear, Malay civet and birds.

Small mammal trapping

Eight species of small mammals, including rats (Muridae), squirrels (Sciuridae), and treeshrews (Tupaiidae) were captured. Painted treeshrew (*Tupaia picta*), common treeshrew (*Tupaia glis*) and Whitehead's rat (*Maxomys whiteheadi*) were trapped in all forest types. Lowe's squirrel (*Sundasciurus lowi*) was in R-MSF and MSF, plantain squirrel (*Callosciurus Notatus*) was in R-MSF and LPF, and grey tree rat (*Lenothrix canus*) was in MSF and LPF. Slender treeshrew (*Tupaia gracilis*) and Muller's rat (*Sundamys muelleri*) were trapped only in R-MSF. In March, rats and tree shrews in breeding season or pregnant were plentiful, and some small tree shrews (considered to be immature painted tree shrews) were also captured.

DISCUSSION

According to the camera traps, almost all pictures were of small mammals. The result suggested the major seed predators in the forest were small mammals, especially rats. In a previous study of small mammal trapping in the dry season, no small mammals were captured in LPF (Page *et al*., 1997). In this study, however, five species of small mammals were recorded. It is not yet certain whether the population and diversity of small mammals in LPF is low or not. The trapping study will be continued in the dry season and results will be compared with those of the rainy season.

Seed productivity increased from March onwards because many species produced seeds at the same time, and the ratio of seed predation decreased during February or March to May. It was suggested that seed productions synchronized among many species resulting in a reduction of seed damage: i.e. the premise of predator satiation was probably satisfied.

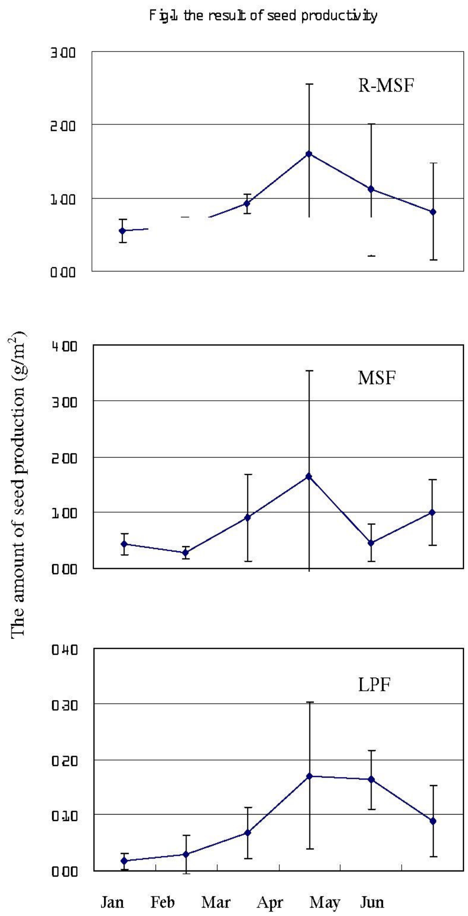

Figure 1: Seed productivity monitored by seed traps

The amount of seed production increased from March in all 3 forest types, and was less in LPF than in R-MSF or MSF. The bars show standard deviations (SD).

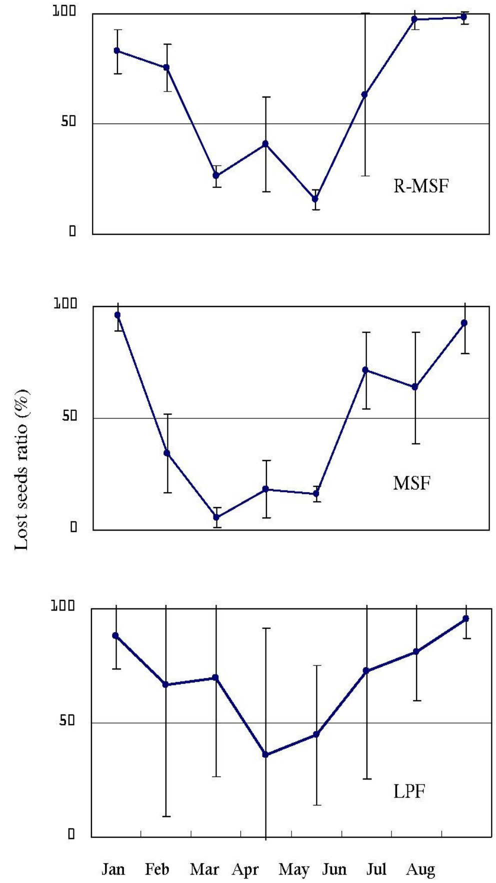

Figure 2: Ratio of lost jack fruit seeds placed on forest floors

The lost seed ratios were obviously dropped during March to May in R-MSF and also February to May in MSF. However in LPF the dropping was not clear owing to the great variation between 3 plots in the same forest type. The bars show standard deviations (SD).

Conversely, is it possible that seed damage by small mammals has affected the seed productivity phenology in the evolutionary process? Do the plants produce seeds in a schedule that enable them to avoid seed predation by small mammals effectively? To investigate these possibilities, seed productive phenology needs to be compared between plants species whose seeds are favored and less favored by mammals as their diet. This study will be continued for several years to follow the seasonal as well as the supra-annual changes. In addition, examination of inter-species comparison of seed consumption ratio by small mammals using collected and stored seeds will be carried out.

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FIRE BEHAVIOUR AT DIFFERENT LEVELS OF PEAT DECOMPOSITION

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SUMMARY

Transboundary haze pollution has been a major problem in Indonesia every dry season for the last 10 years. The smoke is produced by fires used by estate crop companies and local people to clear and prepare their land for planting. The resultant dense 'haze' has had a significant impact on Indonesian ecosystems during and after burning, but especially in peatland areas, which are usually burnt every year. Experience and observation of peat swamp forest fire events in recent years have shown that nothing can be done to solve the problem. One major reason why efforts to prevent fires have failed is a lack of knowledge of fire behaviour on the forest floor. High forest fire intensity resulting from the high potency of the fuel load produces a high flame temperature, which hampers the success of the high-technology equipment used to control these fires. The behaviour of fire in peat at different levels of decomposition in terms of forest fire prevention management is discussed.

Keywords: **Fire, fuel, peat, sapric, hemic, fibric,**

INTRODUCTION

Transboundary haze pollution has been a major problem in Indonesia every dry season for the last 10 years. Smoke pollution reached a record during the 1997/98 fires, which released more carbon dioxide in four months than all the cars and power stations of Western Europe in one year (WWF, 1997). In total, these fires contributed 22% of the world's carbon dioxide released in that year, or more than 700 million tonnes, which made Indonesia one of the largest contributors of carbon emissions in the world (UNCHS, 1999). It has been shown that, of the smoke produced by fires used for land preparation, most (60-80%) was derived from oil palm and industrial forest plantations while the remainder is believed to be produced by shifting cultivation. The former is illegal under Indonesian law and unfortunately the latter is usually attributed most of the blame for smoke production. A zero burning policy was introduced by the Indonesian Government as a promising solution for reducing smoke, which would therefore reduce greenhouse gas emissions, but this has not been successful owing to the pressure for land conversion to oil palm and industrial forest plantation. Consequently, law enforcement has not been applied strictly and the smoke pollution has increased. This paper will present evidence that different states of peat decomposition have different impacts on smoke and greenhouse gas release and the implications these have for peatland management will be discussed.

FIRES IN PEATLAND

Most tropical fires are ignited or spread by humans accidentally or intentionally with several causal agents, some of which are related to subsistence livelihood and others to commercial activities (Qadri, 2001). Foremost amongst the various underlying causes of catastrophic fires in Southeast Asia in 1997-1998 is the use of open burning techniques for conversion of forest land to other land uses, e.g., estate crops, industrial plantations, various commercial enterprises, traditional slash and burn agriculture and speculative burning to stake land claims (Qadri, 2001).

Utilization of peatland for commercial use is not only occurring in Kalimantan but also in Sumatra, especially the provinces of Riau, South Sumatra and Jambi. South Sumatra province has received large influxes of transmigrants since 1969 and around 30,000 ha of pristine coastal peat swamp forest were reclaimed by chainsaw, drainage and fire to accommodate many of these new arrivals (Dis, 1986). At least 28,000 ha of tidal swamp to the north and east of Palembang were settled with people from Java, Madura and Bali (Danielsen & Verheugt, 1990).

Extensive legal and illegal logging activities have devastated widespread areas of forest and increased fire risk in others parts of the swamps. Some of the most heavily exploited areas are now being planted with pulp and timber species. The use of fire to clear the land is standard procedure and, for example, in 1997 one logging company that had applied to the Government for authorization to convert peat swamp forest to pulpwood estate, systematically burnt 40,000 ha of peatland in anticipation of approval (Nicolas & Bowen, 1999).

The growing of "sonor" rice is a tradition of people living along rivers in the wetlands of South Sumatra and has now been taken up by transmigrants (Bowen *et al,* 2000). It is practiced only at the end of at least a three months drought when long-straw local rice varieties are direct-sown into a rising water table. The crop is harvested by boat. The dangers to the environment come from the fires used to clear the land. The farmers' prospect to find the most fertile soils and clear up to five times more land than is sown, wildfires are an inevitable consequence (Bowen *et al,* 2000).

In 1997, at least 75,000 ha were cleared for sonor rice in South Sumatra (this is still practiced today) while the total of coastal wetlands burned was 500,000 ha. Bowen *et al.,* (2000) identified that the source of fire in South Sumatra was mostly from commercial logging, which produced high fuel load, forest conversion and shifting cultivation.

FIRE MANAGEMENT

In Indonesia, forest fire management lacks relevant data derived from forest fire research, making effective action against forest fires very weak. To solve the problem Indonesian forest fire management must be based on information and knowledge obtained from targeted research and not just transferred directly from the experience of other countries without any adjustments.

Research on different peat decomposition states, carried out during the dry seasons of 2001 and 2002 in Pelalawan District, Riau Province, Sumatra, show that different degrees of peat decomposition have different effects on fire behaviour (Tables 1, 2 and 3).

Rate of spread of fire

Rate of spread of fire during burning was slowest in a sapric site (0.47 to 0.99 m/minute) compared to hemic (1.1 to 1.9 m/minute) and fibric sites (1.47 to 3.31 m/minute) (the fastest). A spreading forest fire involves complex combustion processes in which the flaming front is heating and igniting unburned woody and herbaceous fuels (Johnson, 1992). The lowest rate of fire spread indicated that the burning process in the sapric site was quite slow compared to the hemic and fibric sites. In addition, fire intensity was also low in sapric peat, ranging between 791 and 1401.6 kW m^{-1} while in hemic peat it was 2949.9 to 5050.9 kW m^{-1} and in fibric peat 5300 to 6721.24 kW m^{-1}. These differences are probably related to the different degrees of peat decomposition.

Flame height

Flame height during burning in sapric peat (1.55 to 2.11 m) was the lowest compared to hemic (2.9 to 3.6 m) and fibric peat (3.69 to 4.12 m). The low flame height during burning of sapric peat is believed to result from the lower fuel bed depth (82.8 to 96 cm) (Chandler *et al*., 1983).

Fire Intensity

Flame height and fuel availability during burning was related directly to the fire intensity, which means that a low flame height will have lower fire intensity. Flame height in the sapric site (1.55 to 2.11m) was the lowest among the sites, which explains why fire intensity in the sapric site (791 to 1401.6 kW m^{-1}) was the lowest compared to the other sites. The low fire intensity in sapric sites implies that fire in these locations can be controlled soon after they occur or they can be managed with less destruction than in sites where the peat is less decomposed. Fire on the hemic and fibric sites, with higher fire intensities of 2949.9 to 5050.9 kW m^{-1} and 5300.28 to 6721.24 kW m^{-1}, respectively, will be more difficult to control and more of their natural resources will be burnt or destroyed.

Flame temperature

Flame temperature is one indicator of how the burnt site could or could not be controlled during burning because it provides information on the actual burning condition. The highest flame temperature obtained in the hemic site (900 to 1000°C) indicates the worst extent of damage that would occur during burning. Peat with a higher level of decomposition will have fuel characteristics more porous than that with a lower level of peat decomposition (fibric). This means that the chance of heat transfer through penetration underground from fire on the surface is greater in peat with a low level of peat decomposition. As a result it had been found that the flame temperature during burning at 1 cm below the peat surface was different between sapric (70 to 80°C), hemic (100 to 130 ℃) and fibric (75 to 90 ℃) peat.

Peat destruction

The impact of flame temperature during burning and different level of peat decomposition has a significant impact on peat destruction. The depth of peat destruction depends on how much fuel is present and the peat characteristics, especially moisture content, which if high would prevent fire. The higher the degree of peat decomposition the greater is the damage caused by fire. In the sapric site where peat decomposition is highest the peat has burned to a deeper level (18 to 31.87 cm) compared to the hemic site (7.16 to 12.6 cm) and the fibric site (no burned peat was found).

CONCLUSIONS

Results of this research suggest that in peat with a low level of decomposition (fibric) there will be a lower rate of fire spread; the higher flame height is related to fire intensity which results in less peat being destroyed. This means that fire in the low level of peat decomposition is relatively difficult to control.

ACKNOWLEDGMENT

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Table 1: Fire behaviour parameters during burning in sapric peat

Parameter	Plot 1	Plot 2
Fire behaviour		
Fuel load (ton/ha)	(119.16±27.17)a	(110.83±27.17)a
Fuel bed depth (cm)	(96.0±45.89)b	(82.8±21.33)a
Fuel moisture (%)		
* Litter	(6.8±1.1)a	(7.3±0.9)b
* Branches	(11.5±2.8)a	(14.3±3.9)b
* Peat surface	(81.8±1.5)b	(77.2±1.4)a
Flame length (m)	(1.55±0.52)a	(2.11±0.26)b
Fire int. (kW/m)	(791.96±572.7)a	(1401.61±355.17)b
R.of the spr.(m/mnt)	(0.47±0.15)a	(0.99±0.26)b
Flame temp. (°C)		
- 1 cm below ground	70	90
- Ground	800	985
Burned peat depth (cm)	18	31.87
Burned peat size (m^2)	12	7
Burned peat %	3	1.75
Slope (%)	0	0
Duration (mnt.)	22.13	21.30
Burning time	11.22 a.m	13.43 p.m

- Means are significantly different when standard errors are followed by different letters ($p \leq 0.05$)

Table 2: Fire behaviour parameters during burning in hemic peat

Parameter	Plot 1	Plot 2
Fire behaviour		
Fuel load (ton/ha)	(39.5±8.0)a	(51.8±5.7)b
Fuel bed depth (cm)	(71.8±4.28)a	(101.6±9.09)b
Fuel moisture (%)		
* Leaves	(11.92±3.52) a	(12.35±1.87)a
* Branches	(21.64±6.65)a	(24.54±7.01)a
*Log		
* Peat surface	(81.8±1.5)b	(77.2±1.4)a
Flame length (m)	(2.9±0.3)a	(3.6±0.4)b
R.of the spr.(m/mnt)	(1.1±0.2)a	(1.9±0.2)b
Fire int. (kW/m)	(2949.9±547.3)a	(5050.9±1052.4)b
Flame temp. (°C)		
- 1 cm below ground	100	130
- Ground	900	1100
Burned peat depth (cm)	(7.16±0.9)a	(12.6±1.3)b
Burned peat size (m2)	4.7	13
Burned peat %	1.75	3.25
Slope (%)	0	0
Plot size (ha)	0.04	0.04
Duration (mnt.)	18.0	9.3
Burning time	16.30 p.m	13.05 p.m

- Means are significantly different when standard errors are followed by different letters ($p \leq 0.05$)

Table 3: Fire behaviour parameters during burning in fibric peat

Parameter	Plot 1	Plot 2
Fire behaviour		
Fuel load (ton/ha)	(188.0±6.02)b	(184.5±6.95)a
Fuel bed depth (cm)	(97.0±25.26)a	(106.0±13.73)b
Fuel moisture (%)		
* Leaves	(8.63±1.10)a	(9.19±4.59)a
* Branches	(15.60±3.59)b	(12.85±4.85)a
* Peat surface	(85.6±1.34)a	(84.75±0.78)a
Flame length (m)	(4.12±1.53)a	(3.69±1.8)a
Fire int. (kW/m)	(6721.24±5018.34)b	(5300.28±4117.48)a
R.of the spr.(m/mnt)	(3.31±1.27)b	(1.47±0.39)a
Flame temp. (°C)		
- 1 cm below ground	75	90
- Ground	875	900
Burnt peat depth (cm)	0	0
Slope (%)	0	0
Plot size (ha)	0.04	0.04
Duration (mnt.)	15.18	16.30
Burning time	12.25 p.m	13.30 p.m

- Means are significantly different when standard errors are followed by different letters ($p \leq 0.05$)

SEASONAL CHANGES OF THE CO AND PM_{10} CONCENTRATIONS IN THE AIR AND PEAT FIRE EVENTS IN PALANGKA RAYA, CENTRAL KALIMANTAN, INDONESIA

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SUMMARY

Dense haze emitted from peat land and forest fires in 1997/98 and 2002 damaged not only the peatland and forest themselves but also the social activity and human health in many countries of South East Asia. Several components of air quality, carbon monoxide, sulphur dioxide, nitrogen oxide, nitrogen dioxide, ozone and particulate matter less than 10 um in diameter have been monitored since 2001 by the Environmental Impact Agency of Palangka Raya at three sites in Palangka Raya, Central Kalimantan. Daily concentrations of carbon monoxide (CO) and particulate matter less than 10 um in diameter (PM_{10}) from 2001 to 2004 were focused in this paper. Concentrations of CO and PM_{10} increased clearly during the dry season of every year. The levels of CO concentration in 8 hours average were higher than 15 ppm on 42 days during the dry season of 2002, the El Nino year. The MP_{10} values were also very high during the dry season of 2002. The PM_{10} values were higher than 250 ng m-^{3} for 84 days in 2002. The high levels of air pollutant materials suggested that people living in Palangka Raya were under unhealthy conditions for a long time during the dry season in 2002. The rates of solar radiation on the ground (S_r) against extra-terrestrial solar radiation (S0) showed a good correlation to the PM_{10} values with a high coefficient of determination, 0.92 during the dry season in 2002. The regression curve was applied to the solar radiation on the ground in 1997. The result shows the level of PM_{10} in Palangka Raya was same level in September and October in both years, but such high level of PM_{10} continued until November in 1997.

Keywords: **tropical peatland, fire, carbon monoxide, PM_{10}, solar radiation**

INTRODUCTION

The El Niño event in 1997/98 was the largest one since 1946 and the drought in Kalimantan was also estimated to be the most serious of the 20th century (Takahashi *et al.,* 2001). Transportation in Southeast Asia was seriously affected by the low visibility resulting from the dense haze emitted by peat and forest fires. The most tragic accident occurred on the flight arriving to Medan in Sumatra on 26 September, 1997. The aircraft collided into a mountain near the airport because of low visibility for flight and 234 people on board were killed. In several cities, including Jambi, Pontianak and Banjarmasin, visibility at times declined to 20 metres (Potter, 1997). The peat and forest fires have had large impacts on tropical forest ecosystems not only by being burned but also by reducing solar radiation and photosynthetic photon flux density (PFD) as a result of the dense haze caused by fires (Tang, *et al.,* 1996, Takahashi*,* 1999).

In 1997 alone haze caused by air pollutants from fire spread for more than 3,200 kilometers, covering six Southeast Asian countries. In the Malaysian state of Sarawak, air pollution reached one the highest recorded indices at 839 \ig m-^{3} (levels over 301 \ig m-^{3} are equal to smoking 80 cigarettes a day). The fires in Southeast Asia put 20 million people at risk of respiratory problems and cost US$ 1,400 million in healthcare (Shrestha, 2004). Kalimantan was one of the largest sources of haze emission during the peat/forest fires in 1997 (Potter, 1997).

Particles that are small enough to get into the lungs (those less than or equal to 10 µm in diameter) can cause numerous health problems and have been linked with illnesses and deaths from heart and lung diseases. All of the 716,000 residents of Central Kalimantan lived under the serious air pollution by haze in 1997/98. But 29 people died, 17,270 had asthma, 3,366 had bronchitis and 83,772 had infections of the respiratory tract (Widen, 2005).

After the haze problem in 1997/98, the Indonesian government established the monitoring network for air pollution with the support of the Austrian Energy & Environment SGP at several cities including Palangka Raya. Daily values of six components of air pollution, namely, carbon monoxide, sulphur dioxide, nitrogen oxide, ozone and particulate matter less than 10 \\m in diameter, have been measured in the city area of Palangka Raya since 2001.

The authors have shown that the ground water level in tropical peat swamp forest was a suitable indicator for damage level of peat/forest fire (Takahashi, *et al.,* 2003). Muraleedharan *et al .,* (2000) studied the chemical components emitted from the combustion of tropical peat sampled in Brunei. According to their results, 185 g of CO2, 37 g of CO and 6 g of CH_4 were emitted from combustion of 1 kg of dry peat.

The concentrations of CO and PM10 were focussed on in this paper as the important components impacting on human health. The seasonal changes of two components for four years from 2001 were analyzed and compared to the behaviour of ground water level in a tropical peat swamp forest located in same area.

LOCATION AND INSTRUMENTS

The urban area of Palangka Raya City, the capital of Central Kalimantan, is located on the right bank of the River Kahayan. Air pollution of the urban area was monitored at three points, Tijilik Riwut, Tilung and Muriani (Figure1). Elements of the air pollution monitored were carbon monoxide, sulphur dioxide, nitrogen oxide, nitrogen dioxide, ozone and particulate matter less than 10 (im in diameter. The monitored results were transferred to the Air Quality Management System Regional Centre and compiled to calculate the Pollutant Standard Index (PSI) for every one hour. The PSI level was displayed on the notice board in the city center automatically. Concentration of carbon monoxide was measured by using a nondispersion cross modulation infrared analysis method (APMA-360, Horiba). The amount of the particulate matter less than 10 lim in diameter was measured by using the P-ray absorption method (APDA-361, Horiba). Ground water level was measured at the monitoring plot, named Plot-1b, in a tropical peat swamp forest in the catchment of the River Sebangau. Location of Plot-1b is about 12 km south of the city centre. Ground water level was measured by using a data logger with pressure sensor (Kadec-Mizu, Kona System and DL/N, STS). Solar radiation on the ground was measured by using a pyranometer (PCM-01, PREDE) and a data logger (Kadec-up, Kona System) at the open area near the border of the forest. Data for rainfall measured at Palangka Raya Meteorological Observatory near the airport was used in this paper.

RESULTS AND DISCUSSION

Weather and hydrological condition of peatland

Annual total amount of rainfall in Palangka Raya is 2,856 mm on based on data for 27 years from 1978 to 2004, with a maxim of 3,613 mm in 1983 and a minimum of 1,841 mm in 2002. The total amount of rainfall falling during the dry season is an important index to estimate the potential risk of fire in tropical peatland (peat, forest, opened areas) (Takahashi *et al.,* 2001). The total amounts of rainfall during the normal dry season from June to October in Palangka Raya are shown in Figure 2. The least rainfall during the dry season was 117.0 mm in 1997 whilst the highest was 255.2 mm in 2002. Ground water level at Plot-1b decreased to 100 cm deep below the ground surface in 2002, which was lower than that in 1997 (Figure 3). The very low ground water levels during the dry seasons in 1997 and 2002 confirm that the risk of hazardous peat/forest fires in this area was extremely high in those years.

Air pollution in Palangka Raya

The daily maximum values of 8 hours average of CO concentration in the air from 2001 to 2004 are shown in Figure 4. Ground water levels are also shown to provide an index of the likelihood of drought and peat/forest fire events. One abnormal value in the data set of CO concentration was deleted from the data set. CO concentration clearly increased corresponding with changes of ground water level during the dry season in each of the four years and the concentration in 2002 was very high. The U.S. Environmental Protection Agency proposed a new category index of air pollution, PSI (Pollution Standard Index) (Environmental Protection Agency, 1998). The index values, descriptors and definition of PSI for CO and PM_{10} are shown in Tables 1 and 2. The PSI of CO in Palangka Raya shows that unhealthy conditions for sensitive groups or more serious levels prevailed for 77 days in 2002. In 42 days of those days conditions were very unhealthy while one day was very hazardous with CO concentration higher than 30 ppm (Table 3).

Diurnal mean PM10 values in the air and ground water level in a peat swamp forest from 2001 to 2004 are shown in Fig. 5. This shows that the amount of PM_{10} in the air also increased with lowering of ground water level during the dry season of each year. This proves that the particulate matter was emitted from peat fires. The PM10 values reached unhealthy levels in every dry season and were seriously hazardous in 2002. PSI of PM_{10} remained at unhealthy levels for sensitive groups for 92 days, in the very unhealthy level for normal people for 79 days and at a hazardous level for 72 days. It is incredible that PM_{10} values exceeded 600 **u**g m^{-3} for 61 days in 2002 since these levels exceed the highest PSI category proposed by U.S. Environmental Protection Agency. Such extremely high PM10 values are categorized as "seriously hazardous". Visibility in the Provincial Capital City of Palangka Raya on 23th September, 2002 is shown in Figure 6. The $PM1_0$ value on that day was 1,523 **u**g m^{-3} which was categorized into the seriously hazardous condition. An even higher particulate matter value, 1,890 □ m^{-3}, was observed in Pontianak on 22 September, 1997 (Potter, 1997).

PM_{10} values and reduction solar radiation on the ground

The ratio of solar radiation on the ground to the extra-terrestrial radiation (S_r/S0) was calculated for days with higher PM10 values than 50 **u**g m^{-3} and without rainfall. The S_r/S0 values correlate to PM10 values with the high determination coefficient of 0.92 (Figure 7). The correlation equation, obtained from the relation between PM10 and S_r/S0 ratios in 2002, was applied to the data of S_r/S0 ratios in 1997 to estimate the PM10 values in 1997 (Figure 8). It is known that the PM_{10} values in 1997 were almost the same level as in 2002 until the middle of October. After that the PM10 values in 2002 declined, but in 1997 they remained at a high level until 9 November.

CONCLUSIONS

From the analysis of the air pollutants, CO and PM_{10}, monitored in Palangka Raya for four years from 2001 together with measurements of the ground water level in a tropical peat swamp forest and solar radiation on the ground, it can be concluded:

1. Seasonal changes in CO and PM_{10} values were synchronized with lowering of the ground water level in peat swamp forest.
2. Air pollution during the dry season in 2002 reached serious and hazardous levels with very high concentrations of CO and PM_{10}; especially, the PM_{10} values attained higher levels than PSI 500 for 61 days, which is classed as "hazardous" condition by U.S. Environmental Protection Agency.
3. In 1997 very high PM_{10} values continued until 9th November.

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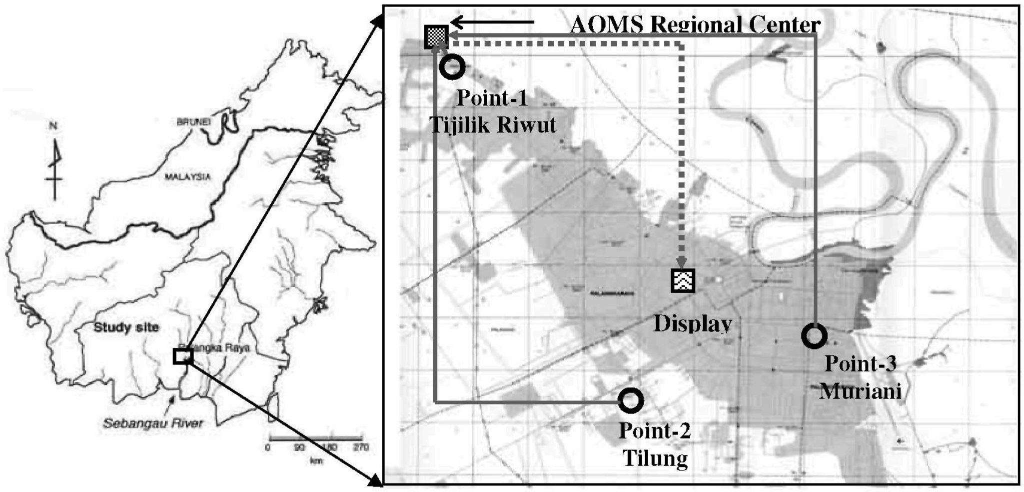

Figure 1: Locations of study site and monitoring stations of air pollution in Palangka Raya

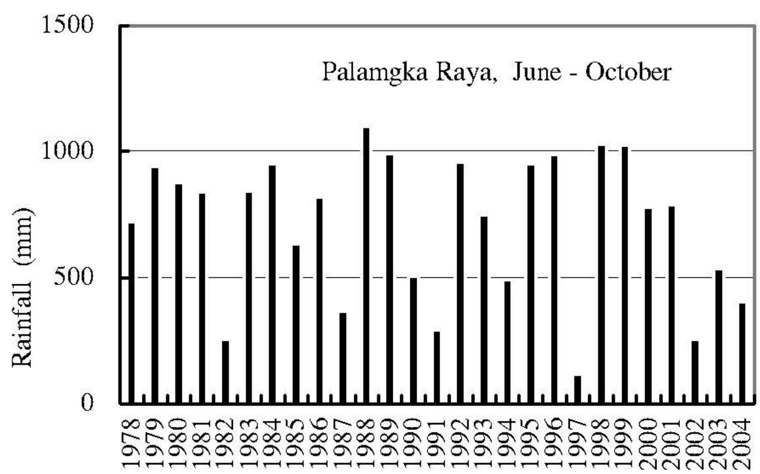

Figure 2: Total rainfall during dry season, June-October, in Palangka Raya from 1978 to 2004.

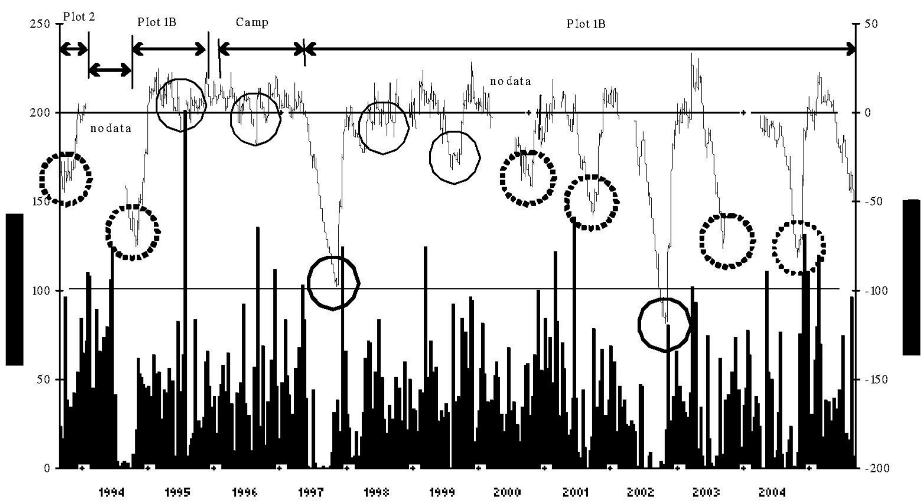

Figure 3: Long term changes of daily mean ground water level at Plot 1b in a peat swamp forest and rainfall in Palangka Raya. (Bold circle: very dry year with El Nino, Dotted circle: medium dry year, Thin circle: wet year.)

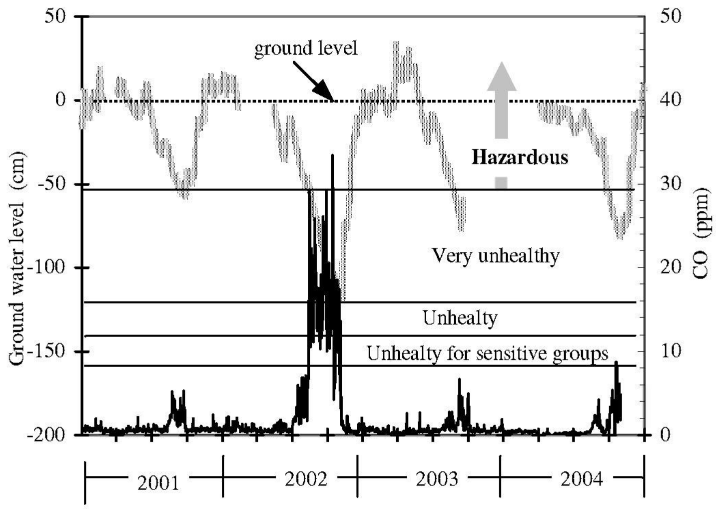

Figure 4: CO values in Palangka Raya and the ground water level at Plot 1b in peat swamp forest.

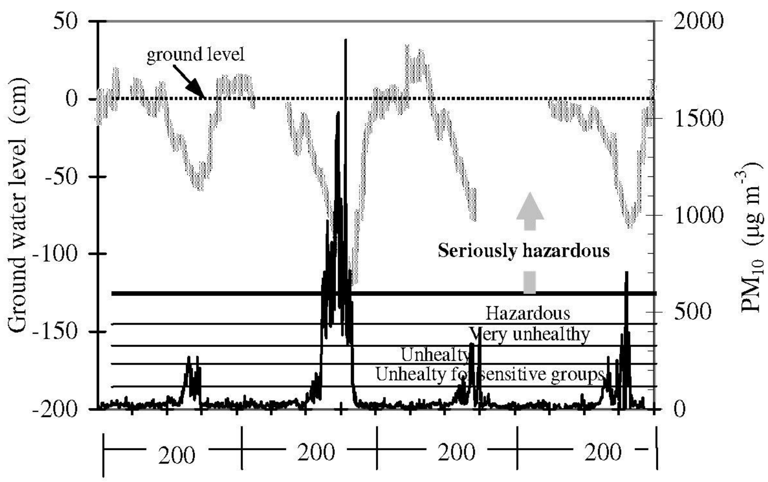

Figure 5: PM10 values in Palangka Raya and the ground water level at Plot 1b in peat swamp forest.

Figure 6: Low visibility in the city area of Palangka Raya with dense haze on 23 September, 2002.

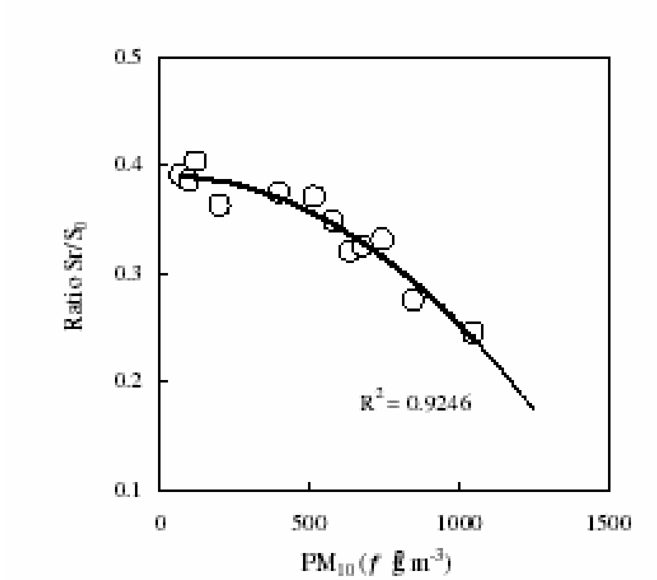

Figure 7: Relationship between S_r/S0 and PM_{10} values in 2002.

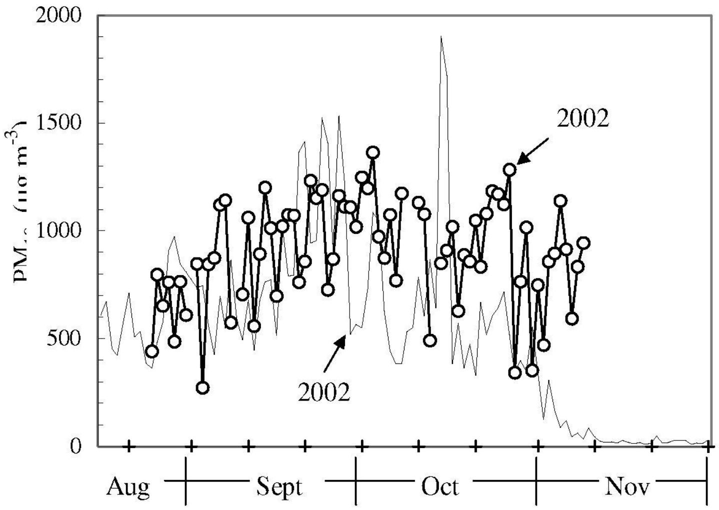

Figure 8: Seasonal changes of PM_{10} values in 1997 and 2002.

Table 1: Pollutant Standard Index, PSI (Environmental Protection Agency, 1998)

Index Values	Descriptor	Purpose
0-50	Good	Convey positive massage about air quality
51-100	Moderate	Convey message that daily air quality is acceptable from public health perspective, but every day in this range could result in potential for chronic health effects; and for O_3, convey a limited health notice for extremely sensitive individuals.
101-150	Unhealthy for Sensitive Groups	Health message for members of sensitive groups.
151-200	Unhealthy	Health advisory of more serious effects for sensitive groups and notice of possible effects for general population when appropriate.
201-300	Very Unhealthy	Health alert of more serious effects for sensitive groups and the general population.
301-500	Hazardous	Health warnings of emergency conditions.

Table 2. Breakpoints for $PM1_0$ and CO Sub-indices (Environmental Protection Agency, 1998)

PSI values	PM_{10}, 24-hr (µm /m3)	CO, 8-hr (ppm)
50	50	4
100	150	9
150	250	12
200	350	15
300	420	30
400	500	40
500	600	50

Table 3. PSI in Palangka Raya from 2001 to 2004 (*defined in this paper)

Index Values	Descriptor	CO				PM_{10}			
		2001	2002	2003	2004	2001	2002	2003	2004
>101	Unhealthy for Sensitive Groups	0	77	0	0	23	92	16	33
>151	Unhealthy	0	64	0	0	2	84	7	15
>201	Very Unhealthy	0	42	0	0	0	79	1	6
>301	Hazardous	0	1	0	0	0	72	0	3
>500	Seriously hazardous*	0	0	0	0	0	61	0	2

ENVIRONMENTAL FIELD TRIALS AND GIS IMAGE ANALYSIS IN THE TANGKILING DISTRICT ALONG RIVER RUNGAN IN CENTRAL KALIMANTAN, INDONESIA

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SUMMARY

Landsat ETM images 118-61+62 acquired on 14 Jan/15 Feb2003 were compared by using detailed analysis of the region around the Tangkiling granite hills and the black water river Rungan north of Palangka Raya. These images show major changes in this large remnant of tropical peatland related to high rates of deforestation and fires in 2002, compared to older Landsat images from 1991/1997/2000. With the establishment of the Mega Rice Project (MRP) and its infrastructure of roads many people were able to enter the previously inaccessible interior of this peatland landscape, exploit residual timber resources, mostly on an illegal basis, and use fire as the most economical method of land clearance. Ground truthing was carried out in this study area in 2004. Several maps were analyzed around the Tangkiling hills, Sei Gohong and Rungan-Sari areas, which revealed peat swamp forest, grassland, agriculture, scrub, riparian gallery, regrowth, secondary forest, home gardens, burnt areas from 2002, settlement, sand and water bodies. Land use strategies for these areas were formulated and prioritized, combining needs of conservation with those of local people to recover biodiversity and improve the land situation. Previous legal logging prepared the ground for further degradation of forests by fire and illegal logging. If this situation continues there is a high risk of most PSF of Central Kalimantan being destroyed within a few years. This would have grave consequences for the local hydrology, climate, biodiversity and livelihood of the local population.

Keywords: **Central Kalimantan, tropical peatland, peat swamp forest, conservation, environmental management, fires, remote sensing, GIS**

INTRODUCTION

Vast areas of peat swamp forest (PSF) cover the coastal plains of Central Kalimantan from the Java Sea up to the provincial capital of Palangka Raya and further North. PSF is among the earth's most endangered ecosystem, with a huge carbon storage capacity that is extremely fragile to disturbance (Rieley et al., 1997 and 2001, Page et al., 2002). The minor El Niño of 2002 in that region led to human health problems, although somewhat less serious than in 1997 (Barber & Schweithelm 2000, Siegert et al. 2001).

Geographic location of the study site

Tangkiling District is located to the North of Palangka Raya in Central Kalimantan. Tangkiling village is 34 km from Palangka Raya, the provincial capital, on the highway to Sampit. Three villages were considered in this study, Sei Gohong with Rungan-Sari, a transmigration village at km38 and Tangkiling village.

The communities around the study side are mainly Dayak and Javanese who work in agriculture, fishing, granite rock exploitation, timber and other harvesting and gathering activities as well as government employees. Unemployment in the region, however, is very high. The landscape is mainly an alluvial peatland plain 30 metres above sea level with the meandering Rungan River in between. The Tangkiling hills, a granite formation of seven hills, are an exception, reaching to a height of 150 m. The area around the hills was covered until the 1980s with primary PSF in which the black water River Rungan runs down to join the River Kahayan and then flows to the Java Sea.

METHODOLOGY

Data Processing

Basic image processing was done using the Remote Sensing Software ENVI4.1. Raw image files were imported into ENVI and bands 5, 4 and 3 were selected to produce a colour RGB image. This band combination proved to be the best in this tropical region. It allowed separating more than 20 vegetation and land use classes. With a Global Positioning Sensor (GPS) points were collected during field trials using the continuous track mode of the GPS. With the Geographic Information System (GIS) software ArcView3.3 the pixel size was set to 30m. LANDSAT images from 1991/1997/2000/2001 and 2003 (Boehm *et al.,* 1995, Boehm & Siegert, 2000, Boehm et al. 2003, 2004, Boehm 2004) were compared in ArcView. The classification was made by visual interpretation with delineation of several classes in the images. Land cover maps were prepared for an area of 26 x 42 km² res. 12 x 18km² around Tangkiling using mainly the Satellite images from Jan and Feb. 2003 (Figures 2, 3 and 4).

Landscape ecology survey

To develop this aspect, several components were defined:

Land cover classes with existing vegetation types:

The maps were prepared from satellite images LANDSAT TM7 of 2003. Firstly, the land cover classes were defined (Figure1). A survey was carried out in the four working areas into which the study site was divided. A printed map of the satellite image corresponding to the area visited was used in order to make image interpretation directly from the site. GPS waypoints and photos were taken to complement this ground truthing. In the case of places to which access was impossible multi-temporal LANDSAT images, as well as some aerial photographs, were used for change detection. The information gathered was installed into ArcView.

Landscape according to structure and pattern:

The landscape ecology analysis helps to understand complex processes that occur in the territory. These processes are the result of social, cultural and natural elements interacting with each other. It is a tool for understanding the environment as a whole. In the field, the analysis starts with identification and definition of every element in the landscape. Land cover classes vary according to their structure and composition. They can play a role in the connectivity between ecosystems when acting as corridors. Forest fragmentation and land degradation are analyzed by the defined classes. If a landscape has classes of vegetation with none or little fragmentation, this reflects as a landscape in a good condition. On the contrary, if the vegetation is limited to isolated classes/patches then the landscape is fragmented and in the process of degradation.

For the landscape analysis, the 'Classes Analysis Extension' of the ArcView program was used and the definition for ecological classes in the landscape is the ones shown in Figure 1. This is a useful tool for incorporating ecological knowledge into the planning process.

Field survey of local communities and their activities

During the field survey of local communities key persons with knowledge of the area under study were identified, addressed and introduced to the main environmental aspects of the area. A preliminary survey was carried out in order to locate human settlements and access roads and determine the hours during which people are active and to identify "wise men" and community leaders. During the survey different actions took place as follows.

Social Ecology Techniques were implemented such as "participants' observation". During the days in the field, observations were made of people undertaking their every day activities, such as agriculture, fishing, gathering and harvesting forest products, hunting and others, including cooking, washing clothes, bathing, resting, entertainment, making handicrafts, taking children at school and so on. Information about infrastructure services, mosques, churches, cemeteries, houses, basic sanitary elements was also collected.

The "wise men" provided information about *history of human settlements*, traditional and present ways of using natural resources, traditional and ways of life and some aspects of local peoples' occupations, health and nutrition. From this project it was possible to obtain information about populations, their origins, quality of life, employment and infrastructure services of the people in the three villages around Sei Gohong/Rungan-Sari.

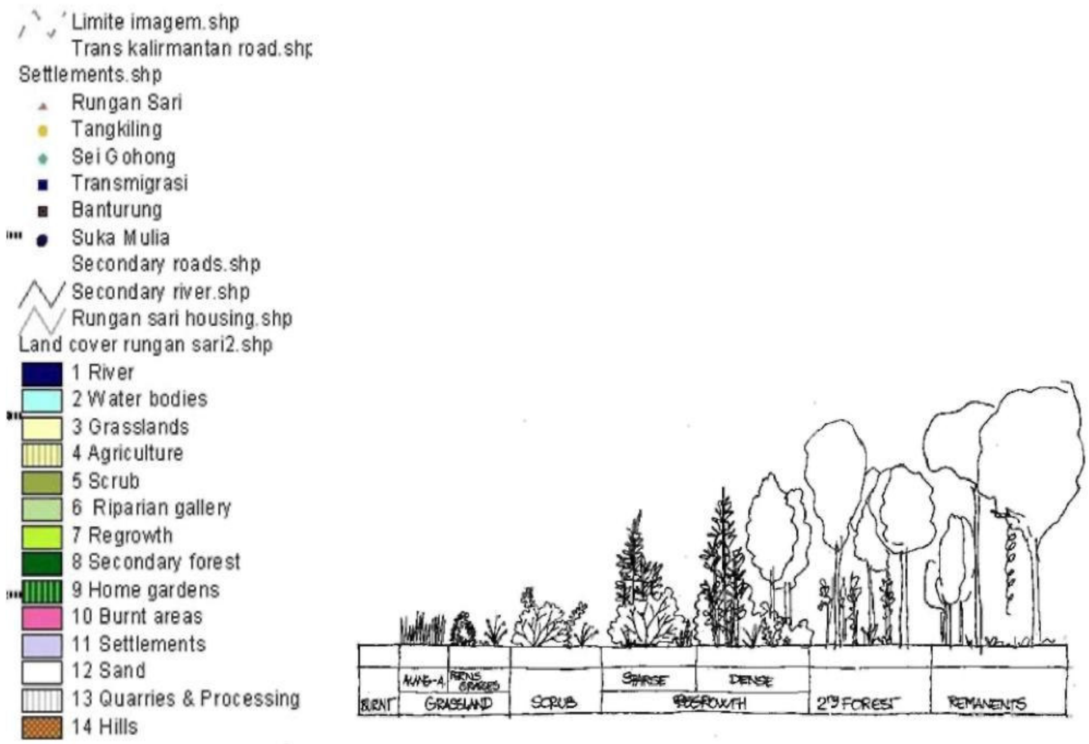

Figure 1: Legend for the Maps (Figures 2, 3 and 4) and definition of vegetation and polygon classes

The collection of data ended with the integrating techniques of social ecology known as "cognitive maps". This activity took place in the form of a workshop and one of the staff members of the TSLiCK-project was the facilitator of the process. The participants were divided into two groups: "the wise men" and the "younger ones". Each group made a "map" in which they illustrated, according to their perception, relevant components of their environment. After the drawings were completed, a member of each group explained to the whole group their "vision" of the territory followed by a discussion regarding "problems and solutions". The facilitator took notes in a visible place listing all the ideas discussed. An environmental diagnosis and conservation plan was prepared. It allowed an analysis of priorities to the situation exposed by people during the workshop.

RESULTS

Evaluated environmental aspects

Ecological aspects

The ecological processes existing in the landscape were described in relation to vegetation changes caused by disturbances, such as forest fires from 2002 and slash and burn activities. A classification of the land vegetation types was made, by which areas with important value for conservation and other degraded lands in need of rehabilitation or restoration were identified. Maps were elaborated showing current land cover and landscape ecological elements such as green corridors and forest classes. The results are shown in Tables 1 and 2 and Figures 2, 3 and 4 for land cover classes. Burn scars from 2002 occupied 7.6% in the larger area and 5% around Tangkiling. The vegetation in these scars is re-growing quickly.

Socio-economic and cultural aspects:

All aspects related to population and territory were analysed, such as type of communities, settlement process (former and present situation), description of villages, ecosystems and adaptive practices in natural resource uses since former times and present day, for example, home gardening, mono-cultural cash crops, harvesting and planting activities including rattan, bamboo, rubber, wood, as well as hunting, fishing, quarrying, mining and livestock. Aspects such as education level, infrastructure, health and other well being conditions were also described.

Institutional aspects:

The presence of Governmental and non governmental organisations (NGOs) was described as tools of development and future institutional cooperation to keep development in this area ongoing.

Land c. classes	Area (ha)	%
River	1016.4	1.06
Water bodies	761.7	0.79
70% Forest PSF	**58637.0**	**61.14**
10% Forest PSF	11786.0	12.29
0% Forest: grass	11641.0	12.14
Burnt scars 2002	7311.0	7.62
Heath Forest	4756.0	4.96
Total	95909.1 ha	100 %

Table 1: Areas - see Figure 2

Land cover class.	Area (ha)	%
Water bodies	401.31	4.32
Burnt scars 2002	459.81	4.95
70% Forest PSF	**3573.91**	**38.44**
Riparian vegetation	382.12	4.11
0% Forest: grass	531.72	5.72
Quarry (granite)	42.87	0.46
Human settlements	155.56	1.67
10% Forest PSF	1098.59	11.82
Home gardens	137.88	1.48
5% forest: scrub	1573.82	16.93
Agriculture	485.52	5.22
Hills	199.74	2.15
River	253.89	2.73
Total	**9296.72 ha**	**100%**

Table 2: Areas see Figure 3

Synthesis of the main problems in the region identified by the local communities

The conservation-diagram (Figure 5) summarizes the problems of peat swamp forest conversion to agriculture land, which has occurred since 1980. The main problems resulting from the land use changes are:

- Deforestation by legal and illegal logging
- Fires nearly every year caused by opened canopies, land-clearing and dry debris
- Loss of fishing resources caused by changing black water rivers into yellow/brown water by sediments
- Lack of technical assistance and self-management process
  - Food insecurity
  - Difficult access to markets for agricultural products
- Little information on the connection of ecosystems, biodiversity and natural resources
- Poor social health care, sanitary conditions and water supplies
- Poor institutional effectiveness
  - High rate of unemployment, causing poverty
  - KKN (corruption, collusion and nepotism)
  - Low level of local investment

CONCLUSIONS

Conservation strategy

Synthesis of the main problems identified by local communities, combined with the environmental diagnosis made it possible to formulate a strategy for natural resources management in Tangkiling and Rungan-Sari area.

This strategy addresses the conservation of the relevant elements of the landscape and the management of the available natural resources, leading to a rehabilitation of degraded lands, conservation of forest remnants and improvement of the economy of local communities.

Potential institutions involved, include:

- World *Subud* Association
- Local Communities
- University of Palangka Raya
- LPKB (TSLiCK Project)-NGOs
- Government
- EU and World Bank

Main points of the strategy

These are:

A. Environmental zoning for land rehabilitation, management, and proper land use

B. Monitoring and research using a GIS

A GIS-database is required in aspects such as:

- Rehabilitation of degraded land, agro-forestry, agriculture and biodiversity

C. Education:

- Technical/business formation
- Academic formation with environmental emphasis
- Programmes for spreading knowledge of the local ecosystem, biodiversity, fire awareness and fire prevention
- Ecotourism

D. Institutional cooperation

- Participation of local, national and international institutions both governmental and NGO
- Community organization, participation and self-management

The strategy can be developed through the establishment of an Institute that leads the environmental research, monitoring and information gathering, analysis and assessment. It should include GIS as well as academic, technical and enterprise formation in order to promote a proper land use, natural resources utilization and a good standard of livelihood for the local communities.

ACKNOWLEDGEMENT

Some interviews were made with one of the executive directors of LPKB Foundation (Lembaga Pengembangan Kehidupkan Berkelanjutan), which has projects in the region under the name of TSLiCK (Towards Sustainable Development and Livelihood in Central Kalimantan, NGO).

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Figure 2

Land cover classes in Kecamatan Bukit Batu

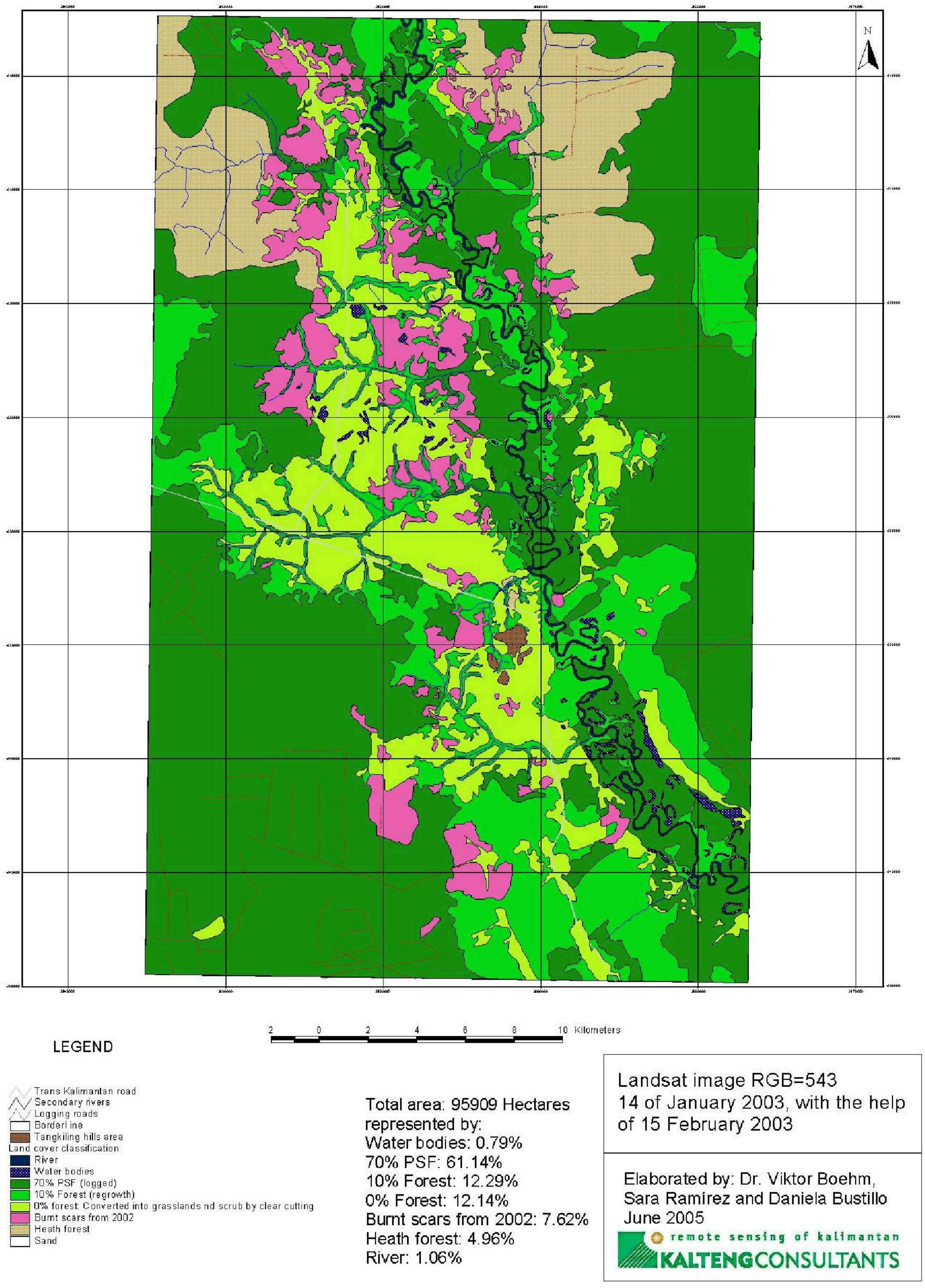


Figure 3

Land cover in Tangkiling area

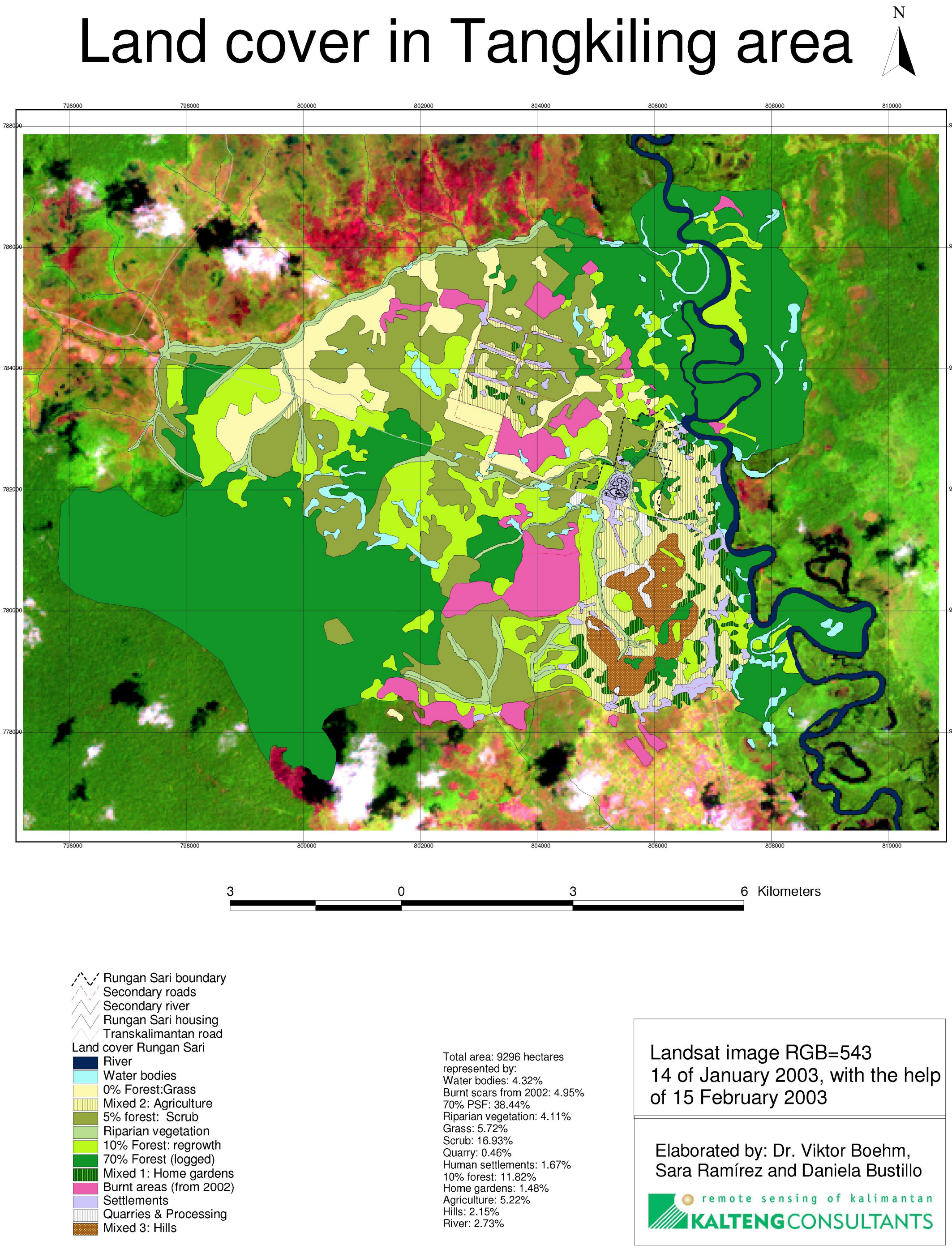
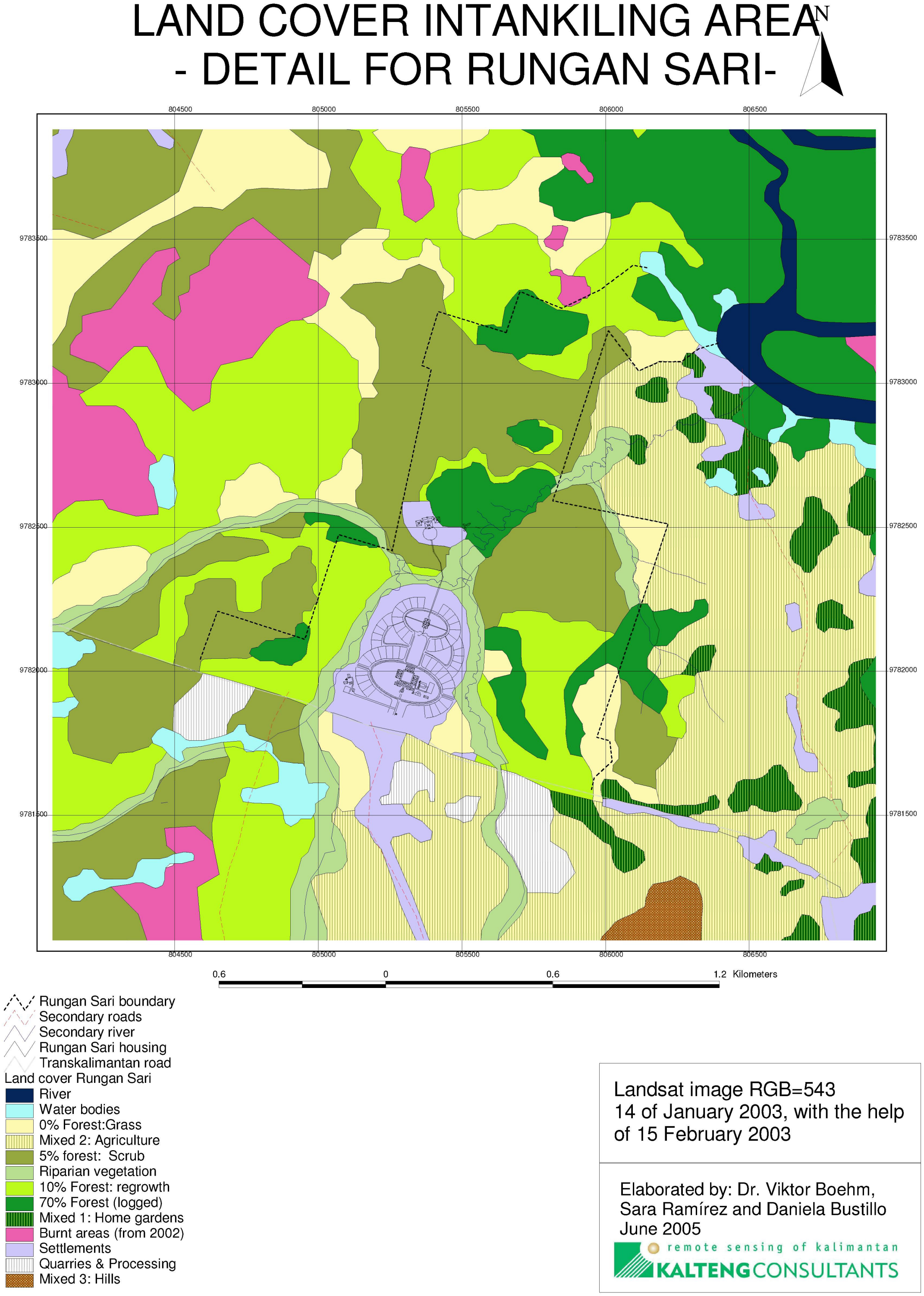


Figure 4

LAND COVER INTANKILING AREA - DETAIL FOR RUNGAN SARI-



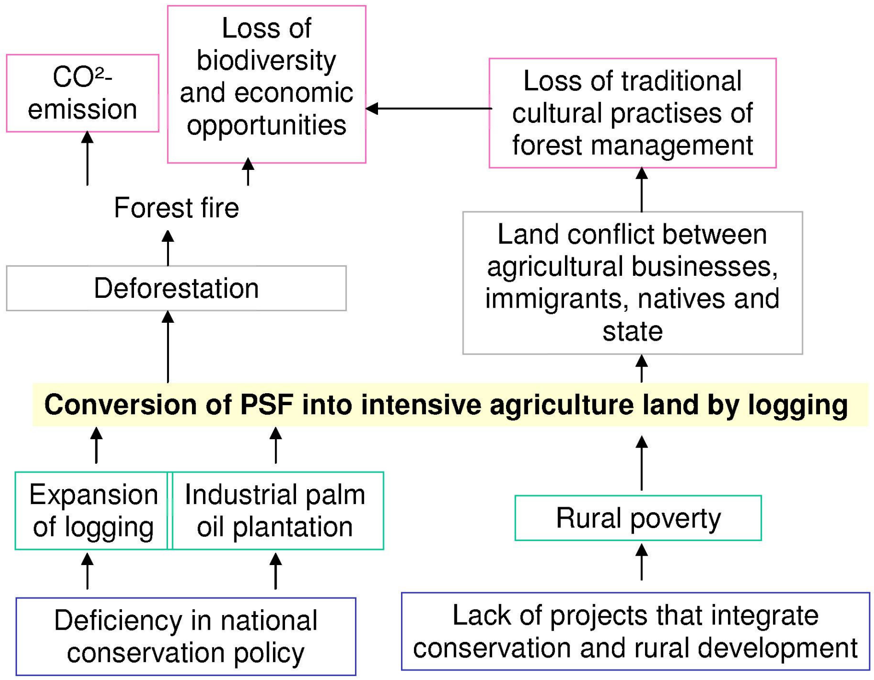


Figure 5: Conversion-Diagram of Peat Swamp Forest into intensive agriculture land by logging

NUTRIENT INPUTS, CYCLING AND RETENTION IN THE UPPER SEBANGAU PEATLAND

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SUMMARY

Nutrient inputs to the ombrotrophic peat swamp forest ecosystem in the Sebangau catchment in Central Kalimantan, Indonesia is mainly from precipitation (rainfall) while outputs are by mass flow of surface and sub-surface drainage water. Internal nutrient transfers are related mostly to maintenance of the forest biomass through gravitational influence (throughflow, stemflow and litterfall) and recycling (decomposition and uptake), and to storage in or release from the surface peat (accumulation or degradation). Retention of nutrients occurred in both mixed swamp forest and low pole forest showing that nutrient inputs were higher than nutrient losses during a 1-year study period. The greatest nutrient gain was calcium followed by potassium and magnesium; manganese was the lowest nutrient in both sub-types of forest. There is evidence that this nutrient surplus being stored in currently accumulating peat.

Keywords: Peat swamp forest, biomass, chemical analysis

INTRODUCTION

Nutrient inputs to a peat swamp forest ecosystem come from wet deposition (i.e. precipitation) and dry deposition (i.e. dust) that are referred to collectively as atmospheric precipitation. Other, smaller, nutrient inputs occur from nitrogen fixation (gaseous incorporation by a biological organism) (Barnes *et al.*, 1998; Wild, 1989) and fauna migration (i.e. faeces of birds and mammals) (Sturges *et al.,* 1974).

Within a forest the tree canopy loses chemical elements through leaching of nutrients from foliage and branches, rainwash of dry deposits, litterfall and also, to some extent, emission of particles by the foliage which do not represent inputs to the system. These processes transfer elements from one part to another in the same ecosystem (e.g. stemflow moves elements from the canopy to the forest floor).

The outputs of nutrients from a peat swamp forest ecosystem are mainly through water drainage (Likens & Bormann, 1999) and harvesting (timber removal), although fire and fauna migration also play a part.

Nutrient budgets of forest ecosystems are commonly characterized by an imbalance between inputs and outputs (Chestnut et al., 1999). When nutrients entering and leaving are measured, the budget will describe the direction of soil fertility (Ranger & Turpault, 1999). A positive budget means that the nutrient is accumulating in the system while a negative budget means the nutrient is being depleted in the system (Pare et al., 2002). Maintaining, and if possible increasing, soil fertility is a major goal for sustainable management, because it determines to a large extent the site's capacity for biomass (wood) production (Jordan, 1985; Ranger & Turpault, 1999; Pare et al., 2002).

In natural ecosystems, losses by drainage strongly decrease when a 'climatic' equilibrium is reached. The nutrient budget is then theoretically balanced apart from catastrophic events such as strong wind, parasitic attack, and atmospheric pollution. Soil fertility decreases very slowly because there is no harvest and because most losses by drainage are compensated for by atmospheric input. In this situation, budgets are of great scientific interest as a reference against which to assess the impact of catastrophic events, for example land use change or fire (Ranger & Turpault, 1999).

MATERIALS AND METHODS

This study was carried out in two sub-types of peat swamp forest, mixed swamp forest and low pole forest, in the upper catchment of the Sebangau River in Central Kalimantan, Indonesia. Three permanent study plots, 50 x 50 m, were established in each forest sub-type to facilitate collection of throughfall, stemflow, litterfall, decomposition, live biomass (above and below ground), peat and water samples.

Rainfall (nutrient input) was sampled in four locations using polyethylene containers located in fixed positions in the vicinity of the research plots. Throughfall was collected in polyethylene containers using a semi randomised sampling procedure that involved resiting the containers after each sampling period. Stemflow was obtained from five trees of different diameter by means of plastic collars placed around their stems. Litter was collected in three containers with 1 mm plastic mesh 0.3845 m^2 (70 cm diameter) positioned 1 m above the forest floor and involving the same semi randomised sampling procedure as used for throughfall. A litterbag method was used for the decomposition study. 75 litterbag samples were placed in each sub-type of forest. Above ground biomass of trees and shrubs was measured in 27 sub-plots in each forest type within 5 x 5 m quadrats. Below ground biomass (living fine roots) was measured after excavating peat from one 1 x 1 m quadrat to a depth of 0.5 m from the middle of each study plot and another four 0.5 x 0.5 x 0.5 m samples from each of the four corners. Surface peat and water were sampled in the same plot as that used for biomass.

Rainfall, throughfall, and stemflow samples were collected every two weeks from the beginning of November 2000 to the beginning of November 2001. Samples were stored in a refrigerator (4oC) after collection. Next day, water samples were filtered. Chemical analyses were carried out on the filtered samples for Ca, Mg, K, Na, Fe and Mn using atomic absorption spectrophotometry (AAS spectra 30). Chemical analysis for surface water was similar to rainfall, throughfall, and stemflow.

Litter samples were air dried for 2 weeks at room temperature, separated into leaves, branches, reproductive parts and other debris, oven dried for 48 hours at 70 C and dry weight determined. Chemical analysis was carried out on samples dried for 48 hours at 70^o C. The determination of total nitrogen was carried out by persulphate digestion (Purcell & King 1996). Ca, Mg, K, Na, Fe and Mn were determined following wet digestion of dried samples by 18% perchloric acid. Ca, Mg, K, Na, Fe and Mn were measured by atomic absorption spectrometry (AAS spectra 30). Chemical analysis for above ground and below ground biomass, peat, and decomposition were similar to litterfall.

RESULTS

The majority of cations in rainfall (nutrient input) consist of Ca and K. Throughfall and stemflow are enriched in most elements analysed compared to rainfall. Nutrient input in rainwater (rainfall), canopy leachate (throughfall), and stemflow showed temporal variation. The order of magnitude of chemical elements reaching the forest floor in throughfall is calcium, potassium, magnesium and sodium in Low Pole Forest, and potassium, calcium, magnesium and sodium in Mixed swamp Forest.

Litterfall in mixed swamp forest was 8,411 kg ha^{-1} yr^{-1} while, in low pole forest, it was 6,534 kg ha^{-1} yr^{-1}. Dry weight of the different fractions of litterfall (leaves, branches, reproductive parts and other debris) for MSF and LPF were 6,216 (74%), 1,246 (15%), 460 (5%) and 489 kg ha^{-1} (6%) and 4,864 (74%), 1,251 (19%), 169 (3%) and 251 kg ha^{-1} (4%), respectively. There were differences in nutrient concentration between the litterfall categories; for example, leaves were high in Ca, Mg, Na, Fe and Mn while reproductive parts were high in N, P, and K. As far as the seasonal pattern of litterfall is concerned, mixed swamp forest and low pole forest exhibited the same bimodal peaks of leaf fall at the end of the wet season (Feb-March) and end of the dry season (August-Sept).

Decomposition rate (k) in the mixed swamp forest and low pole forest was 0.396 yr -1 and 0.285 yr -1 respectively. The live above ground biomass in the mixed swamp forest and low pole forest was 313,899 and 252,548 kg ha-1, respectively. Calcium was the cation present in greatest amount in above ground biomass in both sub-type of forest while manganese was the lowest. The live below ground biomass (roots) 50 cm deep in the MSF and LPF were 26533 and 14382.7 kg ha-1, respectively. Nitrogen was the nutrient present in the greatest amount in root biomass in both sub-type of forest while manganese was the lowest. Nitrogen was the element in greatest amount in the surface 50 cm of peat in the MSF and LPF at 21,478 and 16,426 kg ha– 1, respectively, while manganese was the lowest at 2.7 and 2.7 kg ha–1, respectively. Calcium was the highest cation in water run off in the MSF and LPF with 8.15 and 7.15 kg ha-1 yr-1, respectively, while manganese was the lowest with 0.01 and 0.02 kg ha-1 yr-1, respectively.

Nutrient retention in both sub-types of forest was nearly the same with the greatest retention of Ca in MSF at 7.5 kg ha yr–1 and 8.6 kg ha yr–1 in LPF, followed by K in MSF at 7.4 kg ha yr–1 and 8.3 kg ha yr–1 in LPF, while manganese was the lowest at 0.21 and 0.2 kg ha yr–1, respectively.

DISCUSSION

Rainfall (Nutrient input)

Rainfall data obtained from Cilik Riwut Airport, Palangka Raya, (about 15 km from the study site) for the study period were only slightly different from those in the study area (2760.7 and 2835.4 mm, respectively).

Calcium, magnesium, potassium, and sodium concentrations in rainfall show higher values during the dry than the wet season. Iron and manganese do not show any distinct pattern between dry and wet seasons. These results agree with other workers who also found that the concentration of certain elements in rainfall was higher in the dry than the wet season, for example, magnesium and potassium (Liu et al., 2002), calcium and sodium (Veneklass et al., 1990).

Several reasons have been suggested to explain why nutrient concentrations in precipitation are higher in dry than wet periods, especially, presence in the atmosphere of dust during the dry season originating from soil may contain base cations (e.g. Ca, Mg, K)

(Veneklass et al., 1990). Moreover, biomass burning, especially towards the end of the dry season, may contribute several cations to cloud water and precipitation (Clark et al., 1998).

Biomass burning in the tropics is an important major source of trace gases and particulate matter (including nutrients) to the atmosphere (Prasad *et al*., 2000). Furthermore, intensification of agricultural practices (Prasertsak *et al*., 2001; Goebes *et al*., 2003), fossil fuel combustion (Skiba *et al*., 1997) and emissions from natural soil ecosystems (Skiba & Smith, 2000) also affect the fluxes of trace gases and particulates to the atmosphere**.**

The findings of this study seem to accord with the conclusions of Clark *et al*. (1998) and Prasad *et al*. (2000) who suggested that the majority of elements in rainfall resulted from biomass burning carried out by farmers near to the study areas every year at the beginning of crop cultivation, mainly during the dry season. Other possible sources include fertilizer spray and drift, gas emissions from peat soil and lighting induced fires.

Nutrient Cycling

Throughfall and stemflow

It is well known that when water passes through vegetation it is enriched significantly with macronutrients such as Ca, Mg, and K (Carlisle *et al*., 1966; Liu *et al.*, 2002). Various reasons have been suggested to explain the changes that occur in the chemical composition of precipitation as it passes through a vegetation canopy. Higher nutrient contents in throughfall compared to rainfall may result from the elution of air-borne particles, such as aerosols, dust and pollen grains impacted onto the forest canopy as water passes through and these are then transferred to the forest floor (Potter *et al*., 1991; Liu *et al.*, 2002). Pollen in the atmosphere and that produced by trees can be washed down in the throughfall leading to increased concentration of K (Carlisle *et al*., 1966). This may be the case in the Sg. Sebangau study area where reproductive parts, including pollen, in litterfall have the highest concentration of K compared to other components such as leaves and branches (Sulistiyanto *et al.*, 2002). Other workers believe that enhanced K, Ca and Mg in throughfall and stemflow are derived from foliage leaching (Puckett, 1991; Potter *et al.,* 1991; Hansen *et al*., 1994). Moreover, Ca, Mg and K can be leached easily in the initial stages of wetting (Hansen *et al*., 1994). In addition, ionic exchanges may take place between rainfall and the internal parts of trees (Jean-Paul *et al*., 2000).

Na in throughfall was also greater than in rainfall but not as high as Ca, Mg, and K (Hansen *et al*., 1994; Liu *et al*., 2002); Fe was enhanced (Carlisle *et al*., 1966; Liu *et al*., 2002). This study adds to these finding that the amounts of Na and Fe in throughfall increase slightly compared to rainfall. Analysis of variance between rainfall, MSF throughfall, and LPF throughfall for Na and Fe showed that differences were not significantly different.

Litterfall

The amount of litter collected in LPF was near to the lowest of the range of values recorded for rainforest elsewhere in the tropics (Sulistiyanto, 2004) and in the middle of the range for MSF. T-test between litterfall in mixed swamp forest and low pole forest showed these amounts to be significantly different. Tropical peat swamp forest is less productive compared to tropical lowland forests in general. This relatively low productivity of natural vegetation is believed to reflect the relative poverty of the tropical peat as a result of its an aerobic condition, acidity and low nutrient availability. The low oxygen content and high acidity are known to inhibit biological processes involved in organic matter decomposition, thus resulting in mineral lock up in a form unavailable for plant use.

The seasonal pattern of litterfall in the Sebangau catchment, for MSF and LPF, exhibited bimodal peaks, and accords with the finding of Spain (1984). The first peak occurs in the heavy rain period towards the end of the wet season (Feb-March) and, the second, at the end of the dry season (August-Sept). The first peak (1,083 kg ha^{-1} 4 $weeks^{-1}$) was higher than the second peak (849 kg ha^{-1} 4 $weeks^{-1}$). The maximum litterfall was related, at least in part, to mechanical rather than periodic physiological effects, resulting from high winds at certain times (Spain 1984). It may also result from the washing down of litter retained in the canopy during the wet season (Edwards & Grubb 1977).

Decompositio n

Litter mass loss was very rapid and significant in both mixed swamp forest and low pole forest during the first six months but in subsequent periods of 12 and 18 months the rate of loss decreased and differences between time periods were not significant. Very rapid weight losses have been observed almost universally in the first few weeks of leaf litter decomposition experiments carried out by several workers (for example, Hartemink & O'Sullivan, 2001; Chuyong et al., 2002).

Several reasons have been suggested to explain this loss in the first few weeks of decomposition. Physical and biological processes are involved in this stage (Berg & Wessen, 1984 cit Taylor, 1998) and most of the loss may be from the water-soluble fraction rather than the lignocellulose fraction (Andren & Paustian, 1987). Soluble material in leaf litter consists mostly of simple organic compounds, including reducing sugars, phenolic and amino acids (Suberkropp *et al.,* 1976) while the lignocellulose fraction consists mainly of lignin, cellulose and xylan (Andren & Paustian, 1987).

The annual instantaneous decay constant (k per year) is widely used to compare litter decomposition rates between species or to determine the effects of environmental factors. The higher the k value, the faster the rate of decomposition. In this study k in mixed swamp forest (MSF) was 0.396 and 0.285 in low pole forest (LPF) and is relatively low compared to other decomposition studies of tropical forests except for similar results from another peatland area in Central Kalimantan (Rahajoe 2000). There are several reasons that could explain the low k values obtained in this study. Firstly, anaerobic conditions prevail for most of the year, more so in LPF than MSF. It is well known that the rate of decomposition is reduced during anaerobic conditions (flooding and permanently high water table) (Brady 1997). Secondly, evidence suggests that plant species from nutrient-poor environments produce litter that is more difficult to decompose than litter of species from nutrient-rich environments (Murayama & Zahari 1992; Couteaux et al. 1999). Thirdly, substrate acidity affects the activity of decomposer microorganisms, including fungi, (Murayama & Zahari, 1992) and the peat soil pH values obtained in this study were low (2.82 – 3.80).

Biomass (Above and below ground)

Above ground litter plays a major function in nutrient turnover and transfer of energy between plants and soil, and as a major source of the nutrients accumulated in the upper layer of the soil (Regina & Tarazona, 2001). Moreover, it is currently understood that much of the world's tropical rain forests exist on very poor soils and are only able to do so by retaining a high proportion of the available nutrients within their biomass (Regina & Tarazona, 2001). Furthermore, the vegetation largely depends on recycling the nutrients contained in plant detritus (Regina, 2000). The proportion that is lost is replenished through nutrients imported to the site largely in rainfall (Shanmughavel, 2001).

The total biomass and amount of nutrients in mixed swamp forest was higher than in low pole forest. This difference could be explained by differences in decomposition processes, water table depth and peat-pore water chemistry (Moore et al., 2002). Decomposition and peat soils could affect tree biomass in at least two ways. Firstly, decomposition and peat soil fertility may influence species that contribute to the forest biomass. Faster decomposition processes, releasing more nutrients into the peat, could support a higher forest biomass. A more fertile substrate would be associated with higher forest biomass (Laurance *et al*., 1999). Secondly, trees could simply grow bigger on more fertile substrates regardless of species composition (Newbery & Proctor, 1984). Decomposition processes and peat soil factors appear to have a marked influence on floristic composition in this study, suggesting that the first of these mechanisms could be very important.

Comparison with other workers who carried out research in the tropics indicates that the total above ground biomass in Central Kalimantan is in the middle of the range. The above ground biomass in low pole forest was 252.5 ton ha^{-1}, which is similar to lowland rain forest with above ground biomass of 233 ton ha^{-1} (Greenland & Kowal, 1960) and 200 and 250 ton ha^{-1} in heath forest in Central Kalimantan, Indonesia (Miyamoto *et al.,* 2000). The total above ground biomass in mixed swamp forest in this study averaged 313.9 ton ha^{-1}, which compares to estimates of 310 ton ha^{-1} in lower montane forest (Edwards & Grubb, 1982), and 288-346 ton ha^{-1} in tropical evergreen forest, Amazon, Brazil (Cummings *et al.*, 2002).

Several reasons have been suggested to explain differences in the total above ground biomass including the following: a) differences in sample design and analysis (Araujo *et al.,* 1999; b) differences in tree species and forest types also resulting in different TAGB (Brown *et al.,* 1995); c) soil fertility could also result in different TAGB (Newbery & Proctor, 1984; Laurance *et al.,* 1999; Regina & Tarazona, 2001). Moreover, Laurance *et al.* (1999) state that higher soil fertility results mostly in higher TAGB compared to low soil fertility.

In this study, comparison with other data for tropical forests suggests that the root biomass is near to the bottom of the range. Several reasons have been suggested to explain different result in the amount of roots biomass. For example, different species and type of forest (Binkley & Ryan, 1998); density of trees (Regina & Tarazona, 2001); different sampling depths of roots taken for biomass determination (Schulze et al., 1996); different root diameters taken to categorize samples (Hart et al., 2003).

Comparison with other data for tropical forests suggests that the amount of nitrogen in roots in Central Kalimantan is near to the bottom of the range. Phosphorus is below the range. Potassium and calcium are in the middle of the range. Magnesium in MSF is above the range while magnesium in LPF is below the range. Sodium is lower than Grubb & Edwards (1982) report (only one data set available for comparison). In general, iron and manganese are low in both MSF and LPF although there are no data from other workers for comparison.

Peat

Very few studies have been carried out of mass and amount of nutrients in peat. The few studies available have been of mineral soil and for extractable nutrients. The mass of peat in this study (750 ton ha–1) was higher than Brady (1997) (397.3 to 660.7 ton ha–1). Several reasons have been suggested to explain different results of peat mass, for example, firstly, differences in bulk density. A high bulk density results in a high mass of peat while low bulk density results in a low mass of peat. Secondly, the rate and extent of organic decomposition influences the bulk density. A high decomposition degree (e.g. sapric) results in a higher bulk density (0.1 – 0.30 g cm–3) than a low decomposition degree (e.g. fibric) (0.06 – 0.15 g cm–3) (Widjaja-Adhi, 1988).

Similarly to the mass of peat, the amount of nitrogen in this study was higher than Brady (1997) while phosphorus was lower. There are no potassium, calcium, magnesium, sodium, iron, and manganese data available for comparison.

Similar reasons can be given to explain differences in the nutrient concentrations and total amount of nutrients in peat soil because the amount of nutrients is derived from nutrient concentration multiplied by peat mass. Firstly, the thickness of peat (Radjagukguk, 1992), the nutrient content in thin peat is higher than in thick peat (Suharjo & Widjaja-Adhi, 1976).

Secondly, degree of organic matter decomposition is important (Notohadiprawiro, 1996). Thirdly, the nature of the underlying mineral soil, peat developed over quartz sand is poor in nutrients compared to that developed on top of loam or clay (Widjaya-Adhi, 1988).

Runoff

The amount of nutrient loss through runoff in MSF was higher than in LPF. Comparison using t-test between MSF and LPF indicates that difference in calcium and magnesium are significant while potassium, sodium, iron and manganese are not significant. Differences in the amount of nutrient loss are probably a result of different nutrient concentrations in the runoff water from both sub-types of forest. Nutrient concentration of water in MSF is higher than LPF. Again, differences in decomposition processes, stemflow and throughfall could have resulted in different nutrient concentration of runoff water.

Comparison with other data for the tropics indicates that the amount of nutrients (Ca, Mg, and K) lost through runoff in this study was lower than the range. There are no data on the amount of sodium, iron, and manganese for comparison.

Several reasons have been suggested to explain different results of nutrient losses in runoff from various ecosystems. Firstly, different soil types and soil fertility will influence the chemistry of runoff (Dambrine & Range, 2000). For example, in this study the substrate was peat while in Crowther's (1987) investigations it was mineral soil developed from limestone. Nutrient loss in this study (MSF) was only 8.15 kg ha^{-1} yr^{-1} (Ca) while in Kinta valley, Malaysia it was 795 kg ha^{-1} yr^{-1}(Ca) (Crowther, 1987). Secondly, differences between ecosystems will lead to different results (Lewis, 1986). For example, Bruijzeel (1991) studied an Agathis plantation whilst this study focussed on a natural ecosystem. Nutrient loss of calcium in Bruiijzeel's (1991) study was 29.0 kg ha^{-1} yr^{-1} while in this study (MSF) it was only 8.15 kg ha^{-1} yr^{-1}(Ca). Thirdly, differences in slope give rise to differences in nutrient runoff (Crowther, 1987). Tropical forests on steep slopes lose more nutrients than those in topographically flat areas, such as the vast peatland landscape investigated in this study.

Nutrient retention

There was an annual gain of all nutrients studied and the overall nutrient budgets for LPF and MSF are nearly identical (This study was a natural peat swamp ecosystem). Compared to data for other tropical forests this study shows increases in Ca, Mg, K, Na, Fe, and Mn. In contrast, other studies show mostly annual nutrient losses, especially of Ca, Mg, and K (Crowther, 1987). Phosphorus increase was also reported for an Agathis plantation in Watu Belah, Indonesia (Bruijnzeel 1991), while only a small annual loss of 0.1 kg ha yr^{-1} was reported from the Caura River ecosystem in Venezuela (Lewis 1986). The small gains or losses of P have been attributed to the low mobility of this element (Bruijnzeel, 1991) although this does not explain the much larger degree of phosphorus retention in peat swamp forest in the Sebangau catchment, Indonesia.

CONCLUSIONS

This study provides information on nutrient input, cycling and retention in this ecosystem during the 1-year study period were all of nutrient studied was positive (nutrient input was greater than nutrient output). Moreover, the results of this study highlight that nutrient concentrations in peat soils are low and the substrates are acidic. These factors are likely to be strongly limiting to agricultural development, including plantations of estate crops and trees. Under such conditions the maintenance of intact forest for natural ecosystem services (e.g. carbon storage, watershed, biodiversity maintenance, timber production in certain time period) is likely to be a far wiser land use from a long-term perspective.

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HYDROLOGY RESTORATION OF EX MEGA RICE PROJECT CENTRAL KALIMANTAN THROUGH CANAL BLOCKING TECHNIQUE: LESSONS LEARNED AND STEPS FORWARD

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SUMMARY

The construction of about 4,475 km of large, medium and small canals in association with the Mega Rice Project in Central Kalimantan from 1996-1998 has had a devastating impact on the hydrology throughout this area as a result of: (i) increasing surface run off through the canals, (ii) reducing water retention of existing peatland areas, and (iii) lowering the ground water table in areas surrounding the canals. This situation has led to further negative consequences such as irreversible peat drying and peat subsidence, which can lead to the depletion or complete destruction of peat owing to repeated peat fires that make rehabilitation very difficult. In an effort to overcome the hydrological problems created within the ex-Mega Rice Project, Wetlands International Indonesia in collaboration with Wildlife Habitat Canada have addressed hydrological restoration by blocking canals within the northern part of Block A. Seven dams known locally as "Tabat" have been constructed and these show evidence of hydrological recovery in terms of: (i) reducing the output of water and raising water storage along the canals; (ii) raising the ground water table in the surrounding areas so that peatland humidity can be maintained during the dry season; and (iii) improving the potential for re-vegetation around the blocking sites.

Keywords: **canal blocking, dams, hydrological restoration, rehabilitation, water table, technical design**

INTRODUCTION

As a result of the one million hectare Mega Rice Project (MRP) in Central Kalimantan, Indonesia around 4,473 km of primary, secondary and tertiary canals were constructed across peatland landscapes within three regencies and one municipality, namely Kapuas, Pulang Pisau, Barito Selatan and Palangka Raya. Since the project was terminated in 1999, most of the open canal network within the northern part of Block A within Mantangai sub-district has not been used effectively either for agriculture or other activities (Dohong, 2005). These canals have created hydrological disturbance as over drainage has occurred because of the large dimensions of the, threatening the sustainability of the remaining peat swamp forest in that area. Furthermore, over drainage has led to further problems such as irreversible drying, peat subsidence, and repeated peat fires notably during the dry season. Peat drying is also hindering rehabilitation of the area owing to the low survival rate of plant species (Suryadiputra *et al.,* 2005).

Furukawa (2003) outlined other negative impacts of this open canal system in the ex-MRP as follows: (i) deep canals accelerate decomposition processes within the peat layer and oxidation may expose acid sulphate substrate that is toxic to most crops, (ii) a very long canal with a low hydraulic gradient in the flat landscape results in a very low water flow and hence peat leaching processes will be ineffective, and (iii) the accelerated drainage acceleration that occurs from both canal edges as well as under the hydraulic gradient decreases rapidly during low tide so that it will reduce the effectiveness of back water penetration of the secondary canals.

In addition, from the peat swamp forest conservation point of view, drainage and a continuous penetration of fresh water into the peatland ecosystem will raise the peat soil pH and this, in the long term, will change the peat characteristics as the natural tropical peatlands ecosystem needs high acidity and water logged conditions for its existence and sustainability.

Considering the above negative impacts, the Climate Change, Forests and Peatlands in Indonesia (CCFPI) Project has introduced intervention measures to restore hydrology in the northern part of Block A by blocking canals opened for the MRP. Following blocking some positive result were generated, notably in terms of: (1) reduction in surface water run off and increased water retention, (2) ground water table is maintained as high as possible, (3) the blocked canal could be utilized as a fire break because high water level would be maintained in the canal over a long period, (4) blocked canals could be promoted as fish ponds, which may provide new livelihood sources for local communities and (5) canal blocking is a necessary condition for rehabilitation take place.

The main aim of this paper is to present temporary hydrological results gained for almost a year of blocking activities and necessary recommended actions as steps forward.

PROJECT SITE AND METHODS OF IMPLEMENTATION

Project site

Project sites are focused on 1st and 2nd parent primary canals (PPC-1 canal and PPC-2 canal) and 7th main primary canal (MPC-7 canal), which are situated between Kapuas River and Mantangai River (Figure 1).

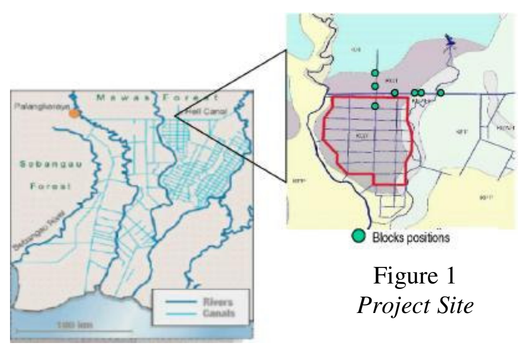

Figure 1
Project Site

Technical Design, Materials Used and Construction Procedures

The first two blockings were constructed in the PPC-1 canal between February-June 2004 when two sheet piles combined with a non-woven geotextile design were applied (Figure 2a). The other five dams were constructed in PPC-2 canal and MPC-7 canal during July-September 2005 in which cases two sheet piles with chambers, combined with non-woven geotextile design were used (Figure 2b).

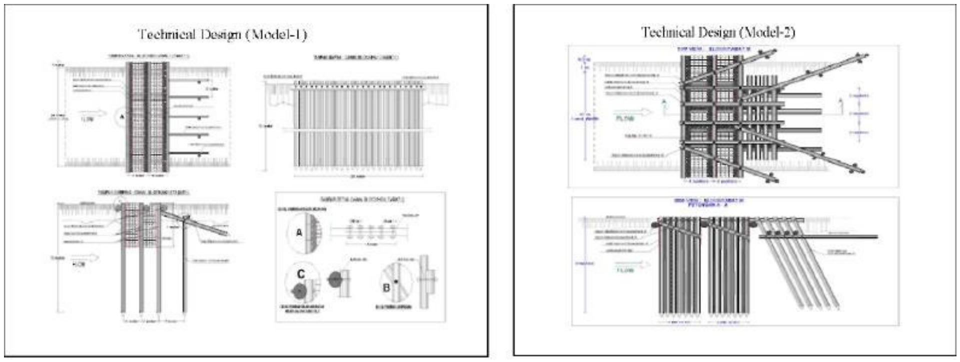

Figure 2: Dam Technical Designs

Materials that have been used for dam construction include log timbers, soil bags, geotextiles, and bolts and nuts. The following basic steps have been applied in constructing dams:

(1) Log poles are sharpened according to necessity;

(2) Log poles are pounded into peat soil;

(3) Bracing system is installed;

(4) Log poles are fasten together with bolts and nuts;

(5) Top of poles is sawn so that they become neat and smooth;

(6) Geotextile is laid down in front of the rows of poles; and

(7) Soil bags are placed inside the block chambers until they reach the top of the dam.

Hydrological Monitoring

To determine hydrological changes resulting from dam construction, monitoring was focused on two hydrological aspects, namely surface water level (SWL) and ground water level (GWL). Other hydrological factors are assumed to remain constant. Rainfall data were also collected regularly to calculate the contribution of rainfall rate to the SWL. The Antecedent Rainfall Index correlation analysis was used in the following formula:

$$DL_i = c + b \times DL_{i-1} + a_0 \times R_1 + a_1 \times R_{i-1} + \ldots + a_1 \times R_{i-7}$$

Where:

DL =*Drain Level = SWL; c, b and an = coefficient*

R = *Rainfall;* *i = day index*

In order to monitor SWL, two measurement meters were established at distances of two metres above and below Dam-1 in the PPC-1 canal. SWL data collection commenced in December 2004 and was recorded on a daily basis. Meanwhile, to measure GWL fluctuations, three PVC observation well transects, namely GWL-A, GWL-B and GWL-C, were established between Dam-1 and Dam-2 in PPC-1 and Dam-7 in the PPC-2. Each transect consisted of 8 PVC observation wells; levels were recorded on a weekly basis and data collection started in December 2004. Finally, to monitor rainfall rate, a rain gauge was positioned close to Dam-1 of PPC-1.

RESULTS AND DISCUSSION

Dam construction

Four dams have been constructed in the PPC-1 and PPC-2 canals, and three others in both southern and northern parts of MPC-1 canal. Dams constructed in the PPC-1 and PPC-2 canals have various widths between 26-28 metres; meanwhile, in the MPC-7 canal, width varies from 9.5 to14 metres. Moreover, canal depth varies between 1.65 up to 3 metres, whereas, peat depth in the dam sites ranges from 10 up to14 metres. Construction of Dam-1 and Dam-2 in the PPC-1 canal commenced in February 2004 and finished in June 2004 (*first phase*), while, construction of the other five dams on PPC-2 and MPC-7 canals took place from July up to December 2004.

Effect of dams on hydrology

Rainfall data, SWL and GWL collected and recorded for the period December 2004 up to September 2005 are shown in Figure 3.

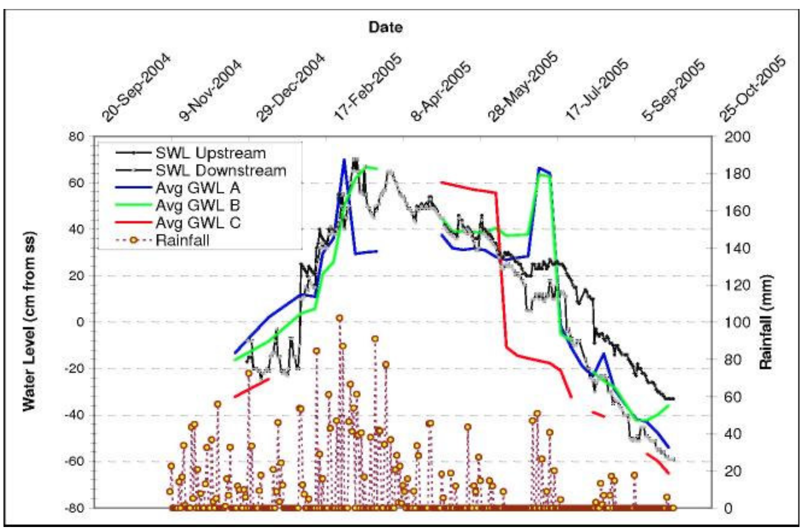

Figure 3: Rainfall, surface water levels and water tables recorded for the period December 2004-September 2005

Figure 3 shows, that in terms of SWL in Dam-1 of PPC-1, there was a significant SWL difference between downstream and upstream of Dam-1. This difference was almost 60 cm during the dry season (up to September 2005). A minimum SWL upstream of Dam-1 was not down more than 30 cm from the peat surface, whereas, SWL downstream was about 60 cm below the peat surface. Hence, there was significant difference in water storage between down and up stream of Dam-1 of the PPC-1 canal and it can be concluded that Dam-1 was effective in storing and retaining water in the PPC-1 canal during the dry season. It should be noted, however, the difference between SWL and peat surface was becoming progressively greater as we move further away from Dam-1. This means that Dam-1 has a limited capability for raising and retaining water in the PPC-1.

In addition, to measure the contribution of rainfall in raising SWL, thus, Antecedent Rainfall Index correlation analysis was applied (Figure 4) in the following form:

$$DL_i = -0.01104 + 0.990789 \; x \; DL_{i-1} + 1.249857 \; x \; R_i$$

The numeric approximation calculation shows that rainfall rate for respective days has contributed significantly to the SWL of PPC-1 (coefficient a0 > 0), whereas, the previous 7 days rainfalls had no significant impact (coefficient of a1 up to a7 = 0). It means that rainfall occurring in the area has been released directly into the canal network as rapid surface run off and rapid groundwater flow.

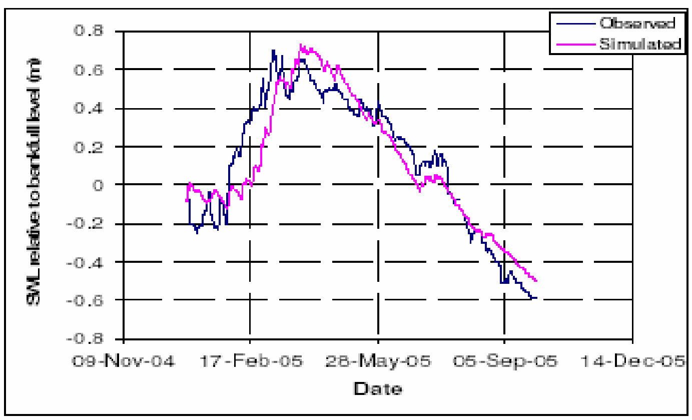

Figure 4: Surface water level of SPI-1 10 meter further up 1st block Observed and predicted with Antecedent Rainfall Index

Similarly, with regards to ground water table (GWL), Dam-1 has significant impact in raising GWL in the dam site as well as its surrounding area. However, the ability of Dam-1 to raise and retain GWL decreased significantly further away from the dam site.

Re-vegetation prospect

The impact of dams on re-vegetation has not been studied yet; however, direct observation in the field shows that new vegetation planted in the block sites has good growth as well as a high survival rate. This was observed for endemic tree species such as jelutung (*Dyera lowii*), pulai (*Alstonia sp*) and belangiran (*Shorea Belangiran*). To investigate further the impact of canal blocking on re-vegetation, it has been planed to establish special monitoring plots in the vicinity of the dam sites in the future.

CONCLUSIONS

1. Canal blocking activities can be seen as a strategic measure in restoring degraded peatlands in the-ex Mega Rice Project area.

2. The trial programme shows that constructed dams are effective in stabilizing hydrological properties of the site and hence, further peat degradation and depletion resulting from repeated fires and peat subsidence can be avoided.

3. Canal blocking is a pre-requisite to rehabilitation activities.

4. It is highly recommended that canal blocking activities are replicated and widened into larger areas within the ex-MRP, notably areas where deep and very deep peat exist.

5. Research activity on the impact of canal blocking in reducing peat fire incidents is highly recommended.

ACKNOWLEDGEMENTS

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POVERTY AMONG THE DAYAK: A CULTURAL APPROACH

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SUMMARY

The Dayaks are one of the indigenous peoples of Indonesia who have been living on the island of Kalimantan for many centuries. Their traditional lives are inseparable from the surrounding forest where they have established their families and obtain much of their livelihood. Even though globalization and modernization have come to interfere with their traditional lives, the Dayak choose to avoid outside interference and retreat into the hinterland in order to save their lives and culture. As a result, their traditional way of life has never changed. This is one of the characteristics of outsiders to view the Dayak as "the People of the weeping Forest" or living in poverty. Poverty among the Dayak of Central Kalimantan is the main problem that will be discussed in this paper. In order to examine the causes of poverty among the Dayak, the writer will use a cultural approach.

Keywords: **poverty, dayak, indigenous people, traditional livelihood**

INTRODUCTION

Who Are The Dayaks?

Many names have been given by outsiders to describe the aboriginals who occupy the island of Kalimantan (Borneo). "The Legendary Wild Man of Borneo"; "The People of the Weeping Forest" and "The Headhunters of Borneo" are among the popular examples frequently written by western writers. In contrast, in Indonesia the aboriginals of Kalimantan are well known as "Kafir" "Manusia Berekor" "Orang Hutan", "Orang Udik", "Suku Terasing", "Komunitas Adat Terpencil", etc. Like or dislike of the aboriginals has never been offended by such peculiar names, because they are proud of being Dayak, although this term has different meanings to different people. To the Dayak themselves, the name is similar and equal to other ethnic groups as Batak, Jawa, Bugis, Banjar, Madura, Manado, etc.

SPECIAL CHARACTERISTICS OF THE DAYAK

Communalism

Communalism is the way that the Dayak live together tied by blood relations. This phenomenon can be observed in the villages, long houses, in towns, and even in offices.

Solidarity

The emergence of ethnic identity among the Dayak of Central Kalimantan at the beginning of the third millennium is because to their strong ethnic solidarity. This is caused by numerous factors such as domination, discrimination, injustice, and the destruction as well as the stealing of their natural resources both by the Government and outsiders.

Mutual Help

Cooperation/mutual help is an important and inseparable part of economic subsistence practiced among the Dayak community. In town, this tradition can be observed still in a number of ceremonies and activities such marriage, death, ethnic association, and Christmas celebration.

Honest and Open

Being honest and open to himself/herself and to other people is an integrated part of the philosophical life of the Dayak

Loyal

Loyalty to their ancestors and obedience to their messages has always been a must for the Dayak. Therefore, the disobedience to *padi/pali* (*taboo*) is considered as sin and their lives will never get ease, happiness, and peace. In addition, the disobedience to taboo and adat (custom) will also destroy cosmic equilibrium/natural harmony.

Past and Present Orientation

The cultural values system is the highest and the most abstract levels of the adat (customs). Life orientation is one of the cultural value system characteristics. How do the Dayak perceive their time? Traditionally and objectively the Dayak do not perceive their future as important. On the contrary, they still defend past and present orientation. This, in my mind, is due to their strong loyalty to their ancestors and the practice of economic subsistence.

Dependent on their Natural Resources

The Dayak cannot live without living in the interior of rich forest in Central Kalimantan. Forest and its natural resources have become the heart and the blood of the Dayak. Therefore, by excessive and uncontrolled exploitation of natural resources (logging and mining) by outsiders, their life is becoming uncertain and unbearable.

TRADITIONAL LIVELIHOOD

Traditional livelihood of the Dayak is classified as economic subsistence. Their primary livelihood is planting paddy on the dry land once a year. Before planting paddy, (1) they have to find and observe the fertile land, (2) slash the grass and small trees, (3) cut big trees, (4) dry the land, (5) burn the land, (6) clear the remaining leaves and logs, (7) plant paddy, (8) clear the grass, (9) harvest and (10) clean and storing the paddy. These processes need 10-11 months (June-April/May) to finish. The long process they need to finish everything has never been equalled with the quantity of rice they get. Based on experience and observation the rice they obtain from *Perladangan Berpindah* (slash and burn technique) can only satisfy about 5 - 10 months of the needs of their household. Besides, much time is wasted and rituals are practiced from the beginning, during, and at the end of the process. Their secondary livelihood is tapping rubber, collecting rattan, fishing, hunting, animal trapping and collecting any edible foods from the surrounding forest.

POVERTY AMONG THE DAYAK

There are at least three approaches that can be used to discuss poverty in general, namely, structural, cultural, and natural approaches. In this paper all three approaches are discussed, although only the cultural approach will be discussed in detail.

Before discussing poverty itself, it is important to pose three questions: (1) are the Dayak poor? (2) Why are the Dayak poor? (3) What should the Dayak do in order to get out of poverty?

Are the Dayak poor?

To answer this question we have to look at it from two points of view. From the ethical point of view (outsiders' view) the Dayak are still poor materially. This point of view is based merely on material criteria, the haves and the have nots are measured by using the quantity of materials they have. On the other hand, from the ethnic point of view (insider's view) the Dayak are not poor immaterially. This point of view is not based on material criteria, but on immaterial criteria or abstract and meaningful cultural values. The most meaningful value in their lives, according to the Dayak, is not measured by the quantity of materials they have, but is determined by their capacity and willingness to keep this universe in harmony. It means that man has to maintain a harmonious relationship with all substances of the universe, including God, ancestors, other men, animals, water, and environment. To keep this relationship in harmony, the Dayak have to obey any taboos and adat-istiadat (customs) belonging to their ancestors. This is the key to get a harmonious and peaceful life in the world.

Why are the Dayak poor?

Based on the ethical (outsiders') point of view most of the isolated Dayak are poor. But why are they poor? By learning the geographic, economic, social and cultural characteristics of Central Kalimantan, poverty among the Dayak is induced by two factors, namely, structural and cultural factors. Natural factors have little impact on the economic life of the Dayak. Structural factors are determined by the Government's policy on local, regional and national developments. For instance, the Government's policy on logging, gold and coal mining, estates, transmigration projects, etc marginalize and distress the Dayak who consider themselves as the owners of the natural resources around them. Excessive exploitation of logs, mining resources and the clearing of land for estates and transmigration projects is decreasing the Dayak's natural resources. This is what we call 'structural' poverty. In contrast, cultural poverty is determined by cultural values the Dayak inherited from their ancestors. A number of traditional cultural values, which are considered a hindrance to progress but achieve prosperous and peaceful lives for the Dayak, are as follows:

Economic Subsistence

Economic Subsistence will never make the Dayak prosperous; instead they will always become poor and poorer.

Cultural Value Orientation

Past and present orientation is irrelevant with this modern era; they must have future orientation in their lives.
Dependent on and loyalty to the power of their ancestors.

Communal life

Communal life is good on the one hand, but on the other it will create conflict and share poverty because they must always take care of other families and assist them financially. .

Loyalty to Adat and taboo

They must be wise to interpret parts of adat or taboos which are still relevant to them but are irrelevant to this modern era.

Lack of human resources

Education is important because it will help them to think scientifically, for example, to be critical, innovative, creative, and initiative.

What the Daya k should do in order to get the way out from poverty?

Like or dislike it I have to propose the followings as the way out of poverty:

a. The Dayak have to change the source of their livelihood. They cannot sustain their economic subsistence based on slash and burn techniques. Instead they should build as many rubber and rattan plantations as possible. This is already familiar to them because it is parts of their habitat.

b. The Dayak have to change their life orientation from the past and present to the future. For instance they have to make themselves consistent in money saving and make good planning for the future.

c. Disobey any irrelevant taboo and adat because they are challenges to achieving prosperous, peaceful and modern lives.

d. Learn to be independent of family bonds. By this way they can save their own money for their own business, their own household, and their own family as well as their own future.

e. Increase their knowledge and skills. Personal qualifications (improved human resources) play a major role in these days; therefore studying also becomes a must.

f. Be competitive. Competition is important in their lives because it will motivate and encourage them to work hard in order to achieve a good life.

g. Running a small business. To be a government employee is now being more difficult and restricted. Therefore they have to learn how to run a small business.

THE FUTURE OF THE DAYAK

What is the future of the Dayak that we dream of together? Firstly, all of the Dayak have to change both traditional profession and their mind (ways of thinking). The Dayak have to leave their economic subsistence and to become modern Dayak in this third millennium. Education is the key to pursue science and knowledge as well as to open our narrow insights in order to know the secret of the universe. Secondly, the current young and educated generation of Dayak have to become the agents of transformation for the Dayak community as a whole. In addition, they must have good commitment for training modern Dayak who will be ready to be professional and qualified managers and leaders in the future.

CONCLUSIONS

There are two controversial commitments Dayak are facing nowadays. On the one hand they have to love, respect, and maintain their own culture, but on the other hand they have to assimilate and interface with other cultures, especially foreign cultures. My suggestion is that we have to be wise to live in this globalization era. We have to make a kind of wise reinterpretation and reposition to our own culture. Why? Because not all substances of our culture are relevant to this modern life. Some of its substance is relevant for today's life but some may become a hindrance for us to achieve a modern life in the future.

GIVING FULL RESPONSIBILITY FOR LOCAL COMMUNITY AS NE WAY OF FIRE MANAGEMENT IN CENTRAL KALIMANTAN:THE TSA CONCEPT

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SUMMARY

Prevention and suppression of forest fires are certainly ineffective and inefficient with the fire brigade units available and without the involvement and full responsibility of the local communities who live within and surrounding the fire sensitive areas. This is mainly owing to the unnecessary bureaucratic systems and dubious tasks assigned to the teams. For example, the Head of the Department for Forest Management and Protection is given limited responsibility for fire prevention and suppression only inside *National Park Protected Areas*, and not within other areas. Based on experience of suppressing fires in 1997 and 2002, a concept has been formulated, which is called the *Concept of Fire Fighting Team* or the *TSA Concept*. This explains how to bring together local people to develop high awareness and responsibility for the prevention of forest fire. This should be carried out through the establishment of TSAs in villages with a planned approach to provide a source of income as compensation for their fire fighting activities and responsibilities. This strategy can also be developed directly to implement community environmental education. This strategy has been formulated clearly and accepted by the local Government of Central Kalimantan through a *Workshop on Strategies and Integrated Action Plan on Land and Forest Fires Prevention* in Central Kalimantan, 14 - 15 April 2003, but it has not been implemented yet.

Keywords: **fire management, tropical peatland, environmental education**

INTRODUCTION

Land and forest fires occur every year in Central Kalimantan, especially in the dry season as a result of human carelessness and natural disaster. The two big forest fires that occurred in 1997 and 2002 were the most disastrous in recent memory and brought about many disadvantages to human life in Kalimantan. Through these two incidents, it appeared that there was less real action to decrease or to minimize the negative impacts on humans, such as controlling the spread of fire and suppressing fires which had become established. In other words, the agencies that were given the task and responsibility for land and forest fire prevention, were in most cases ineffective and gave up in the face of these massive obstacles. The local communities who were most affected by the negative impacts of these fires and expected greater efforts by the authorities to cope with the forest fires were extremely disappointed and felt let down (Limin *et al.,* 2003).

Addressing the forest fire disasters of 1997 and 2002, which totally paralyzed most of the socio-economic activities of the people of Central Kalimantan, it is generally concluded that one of the causal factors was that there was no real preventative action in the field when the fires were still small scale. In other words, many people and agencies could only start thinking that suppression was needed when the fires extended and endangered human life. In these emergency conditions, only a small group of people with limited resources was mobilized to suppress the fires. The reasons for this limited action were lack of funding and the high risks involved (Limin, 2003). The principal threat to the team working in the jungle was to their health and safety. The threat to their physical safety arose because they worked close to fire hot spots that released thick smoke and haze. The negative impacts to the health of the fire fighting team, and also to many people throughout the province, would be effective in both short and long terms, regardless of whether they stayed indoors or out because they could not avoid inhaling the thick smoke.

According to Limin *et al.* (2003), the long-term negative impacts as a result of inhaling highly dangerous polluted air are difficult to determine. If we believe, however, the warnings posted in public places about the hazards to human health caused by cigarette smoke that does not fill the entire atmosphere then, it can be concluded that, there must be severe negative impacts from inhaling the thick smoke produced by forest fires. Therefore, the understanding and opinion from various parties saying that forest fire suppression would be unsuccessful in putting out the burning fires, and waste a great amount of energy and money must be corrected and changed. It indicates the ignorance and low public awareness of the extended disadvantages resulting from the forest destruction, but also that as long as the fires continue burning wildly the danger to human life is prolonged and the suffering caused by inhaling polluted air continues for a long period.

Based on the experience of the TSA fire fighting team since 1997, the Government must allocate full responsibility and proper guarantee to the communities living in or near fire sensitive areas in order to prevent and suppress fires. For the last ten years affected by forest fire, local communities have been mere spectators when Government teams attempted to suppressing fires close to their villages. Government teams have involved some members of the local community for a short time during fire emergencies, but their status has only been as volunteers with very low payment and without compensation for working hard and at high risk.

THE TSA CONCEPT

According to CIMTROP UNPAR (2004), since the *Tim Serbu Api* (TSA) or Fire Fighting Team was established in 1997, the concept to involve the community with full responsibility was already formulated, as follows:

Institutional Requirements

The organization of the TSA must be legal and established as a foundation (Lembaga or Yayasan). The management of the foundation can be by either the local government or by the local community, but there must be good coordination. If the foundation belongs to the community, the Government must support it fully. The organizational network of the TSA is shown in Figure 1.

Membership and clarity of tasks

a. Establishment of the TSA
   In establishing a TSA several aspects should be considered, e.g. sensitivity of the area to fire, determination of the community to protect against fire and dedication to implement the TSA programme.

b. Membership of the TSA should be determined by criteria as follows:
   - Age 18 – 50 years
   - Healthy, free from the colour blindness, nearsightedness, deafness and mute, and heart disease.

- Capable for working in the open night and day.
- A farming background.

c. Training
All of the TSA members must be trained by senior TSA members. Five modules of a training programme have already been written based on the TSA experience since 1997 and this information will be transferred to new members when the training is conducted (TSA UNPAR, 1998).

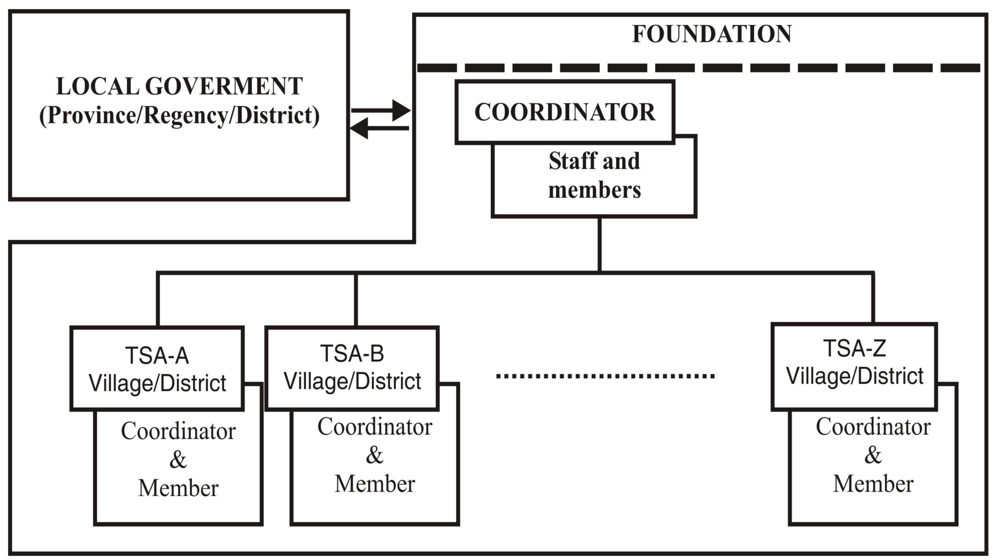

Figure 1: Proposed TSA organizational network

Welfare guarantees

a. Insurance
All of the TSA members must be covered by insurance.

b. Fixed Income
The TSA members must establish their source of income relevant to the carrying capacity and their interests. The income source must be managed according to the cooperative system, so they can provide money for action and put this into a joint account (Limin, 2002a; 2002b and TSA UNPAR, 1998).

Methods and strategy

According to Limin (2000b) and CIMTROP UNPAR (2004), the best methods of fire suppression are (i) *KATIR*; this is the acronym of "*sekat bakar diairi*", meaning the fire transects were watered till saturated, and (ii) *BOMTIK*; this is the acronym for the Indonesian words "*Bom Air Plastik*", or plastic bag which could be filled with about 1.0-1.2 litres of water, and used like a bomb.

The strategy carried out by the TSA team to conduct the two methods can be explained as follows:

(a) In order to work efficiently the assigned TSA members have to stay and sleep in temporary tents near to the fire hotspots;

(b) The TSA team members carry out a prior observation of the fire movement and the hot spot, i.e. by climbing up trees for 12 –20 m above ground;

(c) Make a transect line for 20 – 100 m or so away from the fire, depending on the vegetation type and fire spreading speed;

(d) At the same time while one group makes the transect, other members of the TSA are assigned to drill a deep well through the peat to find underground water;

(e) Take coordinates to determine the exact distance for the next deep wells;

(f) Along the transect, deep wells are drilled every 300 – 500 m, depending on the site condition;

(g) The ditch or transect must be kept saturated with water to prevent the fire from spreading to a larger extent through the deeper peat layer;

(h) Only then can the TSA members start to suppress the fire inside the transect line;

(i) The TSA members are divided into 2 – 4 groups for working at noon and at night or at other times depending on the fire threat level. Under certain condition, fire suppression has to be carried out nonstop for 24 hours by 4 groups in turn;

(j) Each group of 5 – 7 TSA members, equipped with 3 hand radios are assigned to operate one pump machine with 200 – 400 m of hose;

(k) Dead standing trees ("*punggu*") are felled using a chainsaw as they can facilitate the fire to spread over a larger area, through flying embers.

Equipment and finance

The TSA members must be supported by command posts and equipment. The basic equipment needed for suppressing fire are portable pumps operated by petrol engines that can be carried by 1-2 persons only. Another essential item is a borer for drilling deep wells.

Multifunctionality of the TSA teams

Establishment of the TSAs is not only for suppressing fire. Through the TSA, education can be provided to local communities on how to manage their environment better to obtain sustainable livelihoods. TSA members can explain their experience about the importance of the environment and explain the negative impact of forest fire on local communities. They also can also carry out reconnaissance on those destroying the environment and report to the local Government.

Experience of Implementing the TSA Concept

Since 1997, when Indonesia was affected by EL-NINO, the TSA concept was used to suppress land and forest fires which produced thick smoke throughout Central Kalimantan. The results of the TSA actions in 1997 and 2002 are as follows:

TSA Action in 1997

Implementation of well planed action started on 27 September and operated until 10 November 1997, during which the TSA successfully suppressed a total of 50.7 hectares of peat fires at 8 hot spots and established 6 deep wells. Working hours for field operation was 300 hours (238.5 hours, including the operation of water pump machine). TSA managed to pump 1.8 – 2.1 million litres of ground water. TSA also coordinated the provision and the application of 16,000 *BOMTIK* (about 16,000 litres of water).

TSA Action in 2002

Fire Transect

The TSA established 9 fire transects, totalling about 8.75 km that were used for blocking or hampering fire spreading to other areas.

a. Kalampangan zone

a1. Transect 1	:1.40 km	a5. Transect 5	: 0.80 km
a2. Transect 2	:0.30 km	a6. Transect 6	: 1.30 km
a3. Transect 3	:0.25 km	a7. Transect 7	: 1.80 km
a4. Transect 4	:1.60 km	a8. Transect 8	: 0.70 km

b. SMU 5 Plus, Jalan Tingang Palangka Raya : 0.60 km

c. Natural Laboratory for Peat Swamp Forest (NLPSF) : no transect.

Deep Wells

The total number of deep wells established during the 3 months of fire fighting activities by the TSA was: 21 units in Kalampangan zone, and 2 units in SMU 5 Plus. The depth of deep wells varied between 12 to 16 metres.

Dead Trees

A total of about 394 dead trees were felled during the TSA activities to prevent fire spreading from their crowns with the help of wind blowing during the fire.

The Area Saved and Protected

The total area burned and successfully saved and protected from fire (including in SMU 5 Plus) was about 50 – 60 ha near the fire transects. As a result, fire was prevented from spreading to a much greater area of surrounding virgin peat swamp forest.

The total area burned outside the TSA activities is estimated to be about 2,600 ha in the Kalampangan Zone (Mega Rice Block C), 1.0 ha in NLPSF Sebangau, and more than 500 ha near SMU 5 Plus.

Based on the field observations, it was concluded that all of the fires in this area were caused by humans, because the fires always started from locations where there was human activities and access.

Fire Behaviour

a. Fire depth

Based on measurements taken by the TSA during the fire, the depth to which the peat was burnt varied between 0 – 42.3 cm.

b. Fire Speed

The speed of fire in the secondary forest was different from primary forest. Based on TSA measurements in secondary forest, the fire speed was about 1.2 m/hour on average depending on vegetation species and the thickness of dried biomass in the surface. The fire speed was slower at 8 - 14 cm in the peat layer where it burned dry biomass such as root and wood the debris.

Water Spraying Volume

The total water volume in accordance with the size of the nozzle used was 2.5 l/ second on average. It was found that to suppress 1 m^2 of forest fire, took 2-3 minutes and used about 300-450 litres of water.

Number of Work Days

Fire suppression commenced in the field on 25 July and continued until 25 October 2002. The numbers of work days of each team member varied according to their availability and ranged from 7.5 days to 88 days. The total number of man days worked by the TSA UNPAR team was 651.5 days, while local people worked for 770.5 days.

DISCUSSION

Loss of community awareness and respect has been caused by several factors, for example:

1. law enforcement is applied only to people who do not have power and money;
2. all of Central Kalimantan has been divided up and allocated to Forest Companies and community rights to the trees surrounding their villages have been transferred to these;
3. local communities that already fulfill their rights to the environment surrounding them suddenly had these rights removed by Government regulation, and
4. the Government gave full support and attention to these logging companies.

Limin (1999; 2000a) observed that when fire occurred along the roads and spread into the forest, the local people just watched because they know that the owners of the forest are the logging companies. Local communities would have put much effort into suppressing fire, if their land supported trees with high economic value. Since their land was now without economic trees, most people just allowed the fires to blaze.

Suppression of fire by people organized by the Government through the agencies *BAKORNAS* in Jakarta, *SATKORLAK* in the Provinces and *SATLAK* in Regencies involving temporary, short-term action has been neither efficient nor effective (Limin, 2003 and CIMTROP UNPAR, 2004). The lack of responsibility given to people involved in these activities, because they don't receive real guarantees relevant to the risks of the job, has led to thousands of people just sleeping and waiting for something to happen but without contributing. Therefore, in order to obtain a good solution and give real benefits to local people for suppressing fire, the TSA concept as formulated above must be implemented.

Based on implementation of the TSA concept since 1997, many local communities are interested in becoming involved in fire suppression because they have real understanding of rights and obligations. They believe the TSA concept is part of an education process on how to manage their lives, so they can obtain income by managing their business although for the moment in small amount. It is hoped that the effect of implementing this strategy will spread to other communities in the surrounding landscape so all villagers can understand the importance of their environment. One of the important points is that by implementing a part of the TSA concept, they can see real results from their actions, e.g. the rate of fire spread to other area is reduced and stopped totally in some cases. To take action in the field, the TSA members do not depend on the water available on the surface, but they dig deep wells to reach underground water that is available in abundance. During their work in the field, they are also trained to conduct research on the thickness of the peat layer burned, rate of fire spread and other observations. This situation is very different compared to before, when the communities joined with Government groups that worked in the field without strategy, target or real guarantee (Limin *et al*., 2003).

On April 14 - 15, 2003, the Government of Central Kalimantan organized a workshop and invited all of the heads of regencies (*Bupati*) to discuss and formulate a strategy on how to prevent and suppress fires. The main output from this workshop was that the TSA concept was adopted totally by all of the participants as a method and strategy relevant to implement in Central Kalimantan. Through this agreement, every fire brigade must be merged into one institution or foundation as a good solution for effective field work, rather than separate actions by each agency. Limin (2003) stated that the TSA concept was formulated based on real situations and problems when fire spreads rapidly and widely in the dry season. All agencies or groups that have budgets and work separately only in certain hotspots are ineffective and inefficient because they only work near to roads, although the fires have spread already hundreds or even thousands of metres inside the forest. These groups have also concentrated their actions on hotspots only if much water is available on the surface e.g. in ditches and drains. Owing to the limited amount of water in these ditches, these groups always move to another hotspot when the water supply is exhausted even though the fire at the first site is still raging on a big scale. Therefore, the activities of these groups are without strategy and target, and they constantly chase the fire movement and water supply.

To realize the TSA concept, through the agreement of the Central Kalimantan Workshop held in April 2003, it is apparently difficult to succeed because the various agencies that have a budget still work alone. Therefore the EU-funded RESTORPEAT project has been invaluable for initiating the source of income for the TSA team as an important activity in the TSA concept. The incorporation of the TSA into one of the tasks in the RESTORPEAT project is very important to achieve restoration of tropical peatland because fire is a major factor that destroys all possibility of sustainable wise use in locations where peatland restoration is being conducted. The site location of RESTORPEAT is fire prone, because every year fire always occurred there, starting from the road, where farmland is located but without real control activity. Therefore, if this area burns, the owner of land is happy, because it is kept clear of bush and scrub and there is no law enforcement against them for starting fires.

According to the Director of Forest Fire Fighting in the Department of Forestry (CIMTROP UNPAR, 2003 and Limin *et al.,* 2003), forest fire in Indonesia is always caused by human activity in the course of land preparation. Forest fires in Central Kalimantan have almost always been caused by human carelessness, such as people throwing away cigarette ends, lighting fire in the forest, clearing and burning land outside the city along the road sides, as well as land clearance for large scale plantations of oil palm and industrial forest plantation, or by simply setting the bush by the road on fire for fun. In the other words, where there is access to the forest and peat swamp that is where the hotspots started (Limin *et al.,* 2003).

The Government fire brigade is unable to prevent and suppress fires although it has a large amount of money available. Therefore the involvement of local communities is the best strategy to prevent and suppress fire (Limin, 2003; CIMTROP UNPAR 2003). Because of the negative attitude of communities mentioned above, the TSA is very important in the awareness programme. In other words, the giving of trust to the community is very important for raising awareness and providing responsibility to develop this country according to their capabilities. By according full rights, obligations and responsibilities to local people so they can organize and manage their own activities and business, is equivalent to giving them trust on their private personalities, so they feel obliged to contribute to the development of their country. For several decades local communities have only been objects for Government projects without requiring their initiative and creativity. From the other side, they saw the Government staff living in luxury while they established communities of people who would continue to live in poverty.

CONCLUSIONS

1. The strategy for suppressing forest fire as established by Government through the *BAKORNAS, SATKORLAK* and *SATLAK* agencies has been inefficient and ineffective because, for the last decade, the awareness and responsibility of communities have never changed as indicated by the fact that fires occurred everywhere in the dry season.
2. The lost community rights to the environment must be restored back to the people, because before the regulation for forest exploitation, communities lived in harmony with their environments.
3. Recovery of community trust concerning their environments needs a new approach which is relevant to their background, ability and culture. This trust could change all of the negative thinking of communities that is embedded in Government policy.
4. The TSA concept has a stated and full objective that provides a unified platform onto which to invite all of the community to be of the same opinion and devote their attention to the importance of the environment to ensure its survival to support future generations. Implementation of the TSA concept could change and increase community awareness and following by the income guarantee.
5. It is impossible to stop fire totally once it has spread , but action to stop fire entering other areas is feasible and can be achieved by concentrated action at small hotspots.
6. Government policy should consider and incorporate local knowledge, local initiative and local creativity which are relevant to their environment condition and culture. Without the involvement of local communities and the devolution of responsibility to them it is unlikely they will give their full support to fire control initiatives and, as a consequence, forest fire in Central Kalimantan will become a bigger disaster year on year.

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BIOGEOCHEMISTRY OF DEGRADED PEATLANDS

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ABSTRACT

Peatlands are multi-functional natural systems, which perform many globally, regionally, and locally important natural resource functions. The functions are key links in the cycles of water, carbon, and other chemical elements and substances, supporting biodiversity, and accumulating energy, matter and information. Once the natural peatland has been depleted or degraded, especially by deforestation, cultivation and fire, stability of the functions will be damaged including the biogeochemical function of the peatland. The present study, part of the research project funded by EU (INCO-DC No.ERBIC18CT980260), showed that the selectively logged peat forest which is assumed as a pseudo-natural peatland exhibits net acidification of the top peat layer, which increases with depth, and achieves a pseudo-steady state in terms of the nitrogen (N) balance. In contrast, maize-cultivated peatland exhibits net alkalinization of the top peat layer, and enrichment of inorganic N especially during the cultivation period. In fire-damaged peatland the top peat layer experiences net acidification but lower than in the selectively logged peat forest, and depletion of inorganic N owing to leaching. As well as ecological and hydrological states, the biogeochemical states of degraded peatlands have many practical implications for preparing guidelines for the wise use of peatlands and restoration of degraded peatlands.

CONTROLLING HAZE FROM SMALL SCALE AGRICULTURE

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ABSTRACT

Fire associated with land clearing is recurrent, causing transboundary haze pollution. In West Kalimantan, the source of haze is mainly from small scale farmers, who use fire in land clearing for shifting cultivation on peat and mineral soils. At present, efforts to improve this traditional farming method are substantially lacking. As long as values of lands are under-estimated, fire use in land clearing will be persistent. This paper presents a case study of small farmers who control peat fire, and explains why farmers choose a fire option strategy.

INDIGENOUS KNOWLEDGE ON THE USE OF LAND AND WATER RESOURCES IN DANAU SENTARUM NATIONAL PARK, WEST KALIMANTAN, INDONESIA

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ABSTRACT

Danau Sentarum National Park is a unique Ramsar site, which contains high biodiversity in both aquatic and terrestrial ecosystems. The purpose of this paper is to describe indigenous knowledge that regulates the use of wetland resources. The result of this study shows that local knowledge has declined as a result of globalization and poor government policies in the management of protected areas. A collaborative, pro-community based management scheme should be developed in order to reduce anthropogenic impacts on this park.

INVENTORY OF FRESHWATER FISH IN TROPICAL PEATLANDOF CENTRAL KALIMANTAN

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SUMMARY

The presence of freshwater fish in Central Kalimantan comes from rivers, lakes and swamps. Generally, much of lowland Central Kalimantan is covered by peatland forest, which is wet almost throughout the year when the area is utilized by fish as a spawning ground. Many small ponds persist throughout the dry season. Information on fish species of peatland forest in Central Kalimantan is still lacking so the aim of this study was to prepare an inventory of the freshwater fish species of tropical peatland. The study site was Block C of the ex-Mega Rice Project area. The data were collected by catching fish directly and by interviewing people living around the area. The sampling equipment included Trap (*Kabam*), Stage trap (*Tampirai*), Fike (*Pangilar*), Push net (*Tangguk*) and Gill net (*Rengge*). The fish species found included *Puntius lineatus*, *Osteochilus schlegelii*, *Osteochilus spilurus*, *Bellontia hasselti*, *Anabas testudineus*, *Sphaerichthus osphromenoides*, *Rasbora pauciperforata*, *Channa pleurophthalmus*, *Channa lucius*, *Betta anabatoides*, *Clarias* sp., *Luciocephalus pulcher*, *Hemirhamphodon* sp., *Pristolepis grooti*, *Mystus micracanthus*, and one crab.

Keywords: **tropical peatland, blackwater fish, sampling techniques**

INTRODUCTION

According to Mackinnon *et al.* (1996) 872,000 ha of Central Kalimantan area is covered by peat swamp forest. It has unique characteristics i.e. the water source is only from rainfall, extreme deficiency of mineral nutrients and strongly acid condition (Riswan, 1998). Peat swamp forest, even though it is an extreme habitat, is capable of supporting people in the surrounding by the fish yields obtained from it. Mansor (2001) reported that 66 species from 21 families of fishes were found living in peat swamp ecosystem in Perak, Malaysia. Although peat swamp forest provides fish yields for this region the fish themselves have not been studied in detail. The purpose of this present study was to prepare an inventory of freshwater fish in tropical peatland of Central Kalimantan.

STUDY SITE AND METHODS

The study was performed on 11 - 12 August 2005 and 19 August 2005 in Block C of ex-Mega Rice Project area. Data was collected by two methods i.e. interviewing local people who live around of the sampling area, and catching of fishes directly used fishing gears i.e. Trap (*Kabam*), Stage trap (*Tampirai*), Fike (*Pangilar*), Push net (*Tangguk*) and Gill net (*Rengge*). The fish was identified by Kottelat (1993).

RESULTS AND DISCUSSION

In this present study, 17 species of freshwater fish from 10 families were identified by trapping and interviewing local fishermen Figure 1). The fish number was dominated by members of the anabantoid group, especially the families Belontiidae, Anabantidae and Luciocephalidae while the greatest diversity occurred in the Cyprinid group Figure 2). According to Kotellat (1993), Cyprinidae is a large of family with a wide distribution and Belontiidae is the largest group, which have a special respiratory organ (labyrinth). Commonly, the fish families found in this area have this special respiratory adaptation either labyrinth or arborescent, which enables them to survive in conditions of low of dissolved oxygen (DO) concentration.

CONCLUSIONS

17 fish species were identified from Block C Kalampangan of the ex-Mega Rice Project area, belonging to 10 families. These are dominated by members of the anabantoid group (Belontiidae, Anabantidae, Luciocephalidae) in terms of individual number, while diversity was highest in the cyprinid group.

ACKNOWLEDGEMENTS

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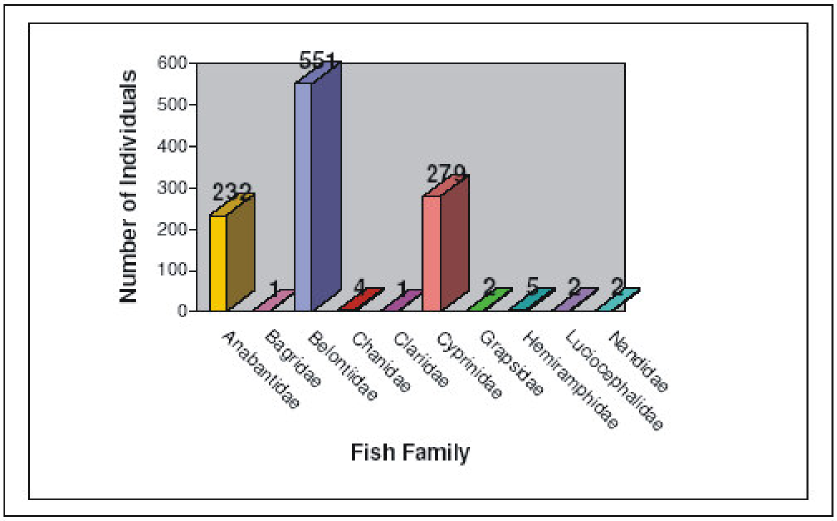

Figure 1: The number of fish species in each family identified from peat swamp near Kalampangan in Block C of the former Mega Rice Project in Central Kalimantan, Indonesia

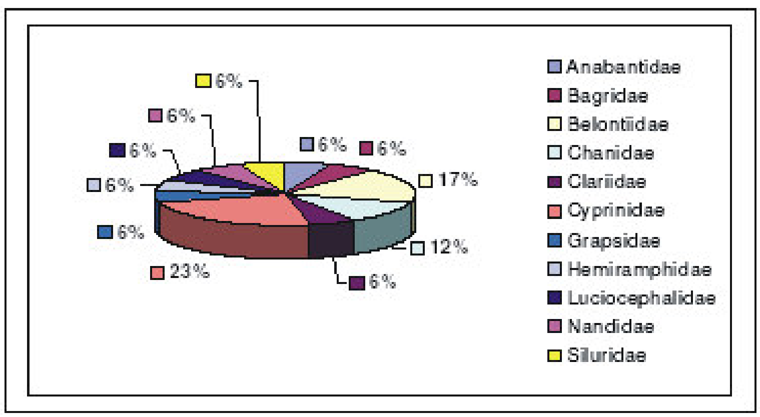

Figure 2: The composition of fish families in peat swamp near Kalampangan in Block C of the former Mega Rice Project in Central Kalimantan, Indonesia

THE COMPOSITION OF MACROZOOBENTHOS IN TROPICAL PEATLAND IN CENTRAL KALIMANTAN, INDONESIA

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SUMMARY

The composition of macrozoobenthos was studied at three stations in a canal constructed for the ex Mega Rice Project in Block C at Kalampangan. The purpose of the present study was to evaluate the composition of macrozoobenthos in tropical peatland including number of species, abundance, diversity and dominance. Macrozoobenthos data and environmental information were collected monthly from April – July 2005. Three replicates of Macrozoobenthos samples at each sampling station were taken with an Ekman-birge grab (225 cm2), and the sediments were washed through a nylon net (mesh size 0.3 mm). The benthic organisms were preserved in 10% formalin solution. 25 taxa of macrozoobenthos were recorded from this site, consisting of 21 taxa from Diptera, 2 taxa from Odonata, 1 taxa from Trichoptera and 1 taxa from Nematoda. The composition of macrozoobenthos show that Diptera have the highest number of species and abundance in these sites, making up approximately 93% of total organisms. The dominant and most abundant individual found in three stations of canal is Chironomus sp. from Chironomidae family of Diptera.

Key words: **tropical peatland, macrozoobenthos, Diptera, Odonata, Trichoptera, Nematoda**

INTRODUCTION

Benthic animals are a food source for fish. Compared to other habitats of blackwater ecosystems, little information is known about benthic animals of peat swamp forests. Research carried out on benthic communities of oxbow humic lakes in Central Kalimantan have shown that the dominant animals were insect larvae in lake Tundai (Yulintine, 2001) and oligochaetes in lakes Hurung (Wulandari, et al., 2003; 2006) and Takapan (Yulintine, 2004). The purpose of this study was to evaluate the composition of macrozoobenthos including number of species, abundance, diversity and dominance in tropical peatland.

STUDY SITES AND METHODS

The study was carried out at three locations in Block C of The Mega Rice Project area near to Kalampangan (02^o 20'31.4" S, 114^{o}02'12.0" E). Macrozoobenthos samples and environmental data were collected monthly from April to July 2005. Macrozoobenthos samples were taken with an Ekman-birge grab (225 cm^2), and the sediments were washed through a nylon net (mesh size 0.3 mm). The benthic organisms were preserved in 10% formalin solution and identified according to Pennak (1953), Wiederholm (1983), Merritt and Cummins (1996) and McAlpine, *et al*., (1981). Diversity was evaluated by the Shannon-Wiener diversity index on the basis of the logarithm in terms of 2 (Krebs, 1989). Physical and chemical parameters such as transparency, depth, temperature and dissolved oxygen and pH were measured in situ using secchi disk, depth sounder Hondex PS-7, DO meter YSI model 55 and pH meter Horiba D-24, respectively.

RESULTS AND DISCUSSION

25 taxa of macrozoobenthos were identified from the canal in Block C at Kalampangan and these consisted of 21 taxa of Diptera, 2 taxa of Odonata and 1 taxum each of Trichoptera and Nematoda. The results of the research showed a great abundance of insects occupy this habitat. This is supported by Thorp and Covich (1991) who stated that insects occupy every freshwater habitat in tremendous densities and diversity.

Diptera exhibited the highest number of species and abundance at the three locations, making up approximately 93% of the total number of organisms. In contrast, Trichoptera comprised of approximately 5% and Odonata and unidentified insect larva contributed 1% each. There were a higher number of members of the Chironomidae family both of taxa and in abundance than either Chaoboridae or Ceratopogonidae. In the Chironomidae family, the highest number of taxa and abundance was represented by Chironomini such as *Chironomus* sp., *Cryptochironomus* sp., *Cyphomella* sp., *Dicrotendipes* sp., *Endochironomus* sp., *Microchironomus* sp., *Parachironomus* sp., *Phaenopsectra* sp., *Polypedilum* sp., *Stenochironomus* sp. and *Xenochironomus* sp.. The dominant species with greatest abundance was *Chironomus* sp from Chironomidae family of Diptera. This is supported by Wetzel, (2001) who stated that the dipterans are commonly dominant components of benthic invertebrate communities in many standing and running water, and that chironomid larva are ubiquitous. This group appears to be least affected by environmental change and can rapidly re-colonize waters following disturbance (Pires *et al*.**,** 2000).

The abundance of macrozoobenthos fluctuates every month. The highest abundance was recorded in April with an average of 2060 ind/m^2 and the lowest in July with 242 ind/m^2. Moreover, the abundance of macrozoobenthos in location 2 was lower than in locations 1 and 3 possibly because the water level in location 2 was deeper than in the other two. The highest abundance of macrozoobenthos was in June in station 3 probably because the water was very shallow then and may have caused the macrozoobenthos be concentrate where there was still enough water to support their life.

The macrozoobenthos diversity, evenness and dominance indices range from 1.522 – 2.546, 0.505 – 0.933 and 0.190 – 0.444, respectively. It seems that the habitat has moderate species variation, tends to have uniform individual composition but relatively few species are dominant (Figure 1). The environmental parameters measured are shown in Table 1. Moreover, the Pearson correlation between environmental factors and macrozoobenthos abundance, and diversity show significant positive correlation between dissolved oxygen (DO) and diversity with value of $r = 0.979$. This value indicates that the macrozoobenthos diversity in the Kalampangan site is influenced by DO concentration. This is supported by the findings of Wulandari, *et al*. (2003) that benthic organism were absent from the centre of Lake Batu owing to the very low DO concentration (<1 mg/l) and by Efriana (2003) who found many *Chironomus* sp. in the littoral zone of the same lake where DO concentration were > 4 mg/l.

CONCLUSIONS

The highest number of species and abundance of macrozoobenthos in the Kalampangan site was represented by Diptera, constituting approximately 93% of the total organisms, with C*hironomus* sp as the most abundant species. The Pearson correlation between dissolved oxygen (DO) and diversity showed significant positive correlation (r=0.979), indicating that the diversity of macrozoobenthos in this blackwater site was influenced by DO concentration.

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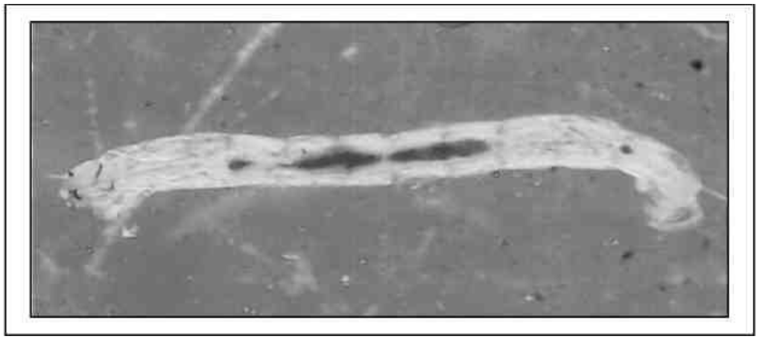
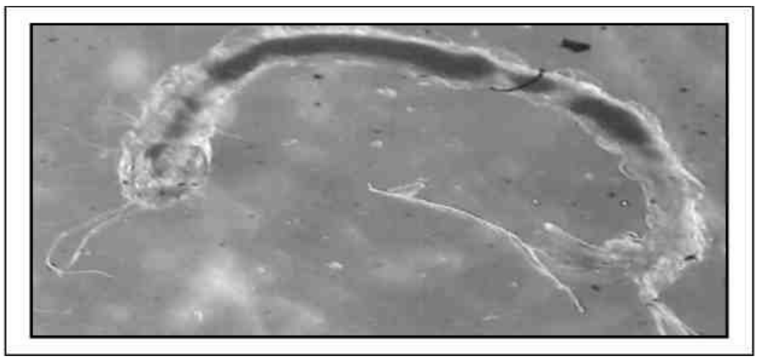
Table 1. The average of Water quality value and Pearson Correlation between environmental factors and abundance, and diversity of macrozoobenthos

Parameter	The Water quality value	T he Pearson Correlation	
		Abundance	Diversity
Physical			
Temperature (^{o}C)	29.66	0.272	0.535
Transparency (cm)	33.99	-0.939	0.336
Depth (m)	0.76	0.076	0.746
Chemical			
pH	4.84	-0.579	0.862
DO (mg/l)	2.89	-0.421	0.975*



Chironomus sp



Stenochironomus sp

Stenochironomus

Figure 1. The dominant species of Chironomidae family in Block C Kalampangan of ex Mega Rice Project

THE SEASONAL DYNAMICS OF PLANKTON COMMUNITIESIN TROPICAL PEATLAND ECOSYSTEM OF CENTRAL KALIMANTAN

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SUMMARY

The seasonal dynamics of phytoplankton and zooplankton communities were investigated in a tertiary canal in Block C of the ex-Mega Rice Project in Kalampangan area near Palangka Raya, Central Kalimantan. Plankton samples were collected monthly during April-July 2005. The densities of phytoplankton and zooplankton fluctuated. The density of zooplankton communities was dominated by protozoa groups while the number of taxa was dominated by the rotifera group. However, Chlorophyta group dominated the density and number of phytoplankton taxa communities. The seasonal dynamics of phyto- and zooplankton were correlated with physical and chemical parameters of the water.

Keywords: **phytoplankton, zooplankton, seasonal dynamic.**

INTRODUCTION

A vast area of Central Kalimantan is covered by tropical peatland. This tropical peatland is a unique ecosystem with high biodiversity, even though under strong acid condition and low nutrient concentration (Rieley *et al.*, 1998; Simbolon & Mirmanto, 2000; Page, 2001).

In the fishery sector, this tropical peatland has an important role for local people because it is the habitat for various freshwater fishes (MacKinnon, 1996) that are a source of protein and income for them.

Plankton (phyto- and zooplankton) are a major diet for fish and play an important role in supporting fish yield in the tropical peatland ecosystem. In the meanwhile, there is a lack of phyto- and zooplankton information from tropical peatland in this region.

In this present study, we investigated the seasonal dynamics of phyto- and zooplankton comunities in the tropical peatland ecosystem and correlated these with physical and chemical parameters of the water.

STUDY SITE AND METHODS

The study was carried out at an area of tertiary canal in Block C of the ex-Mega Rice Project area (02^{o}20'31.4''S, 114^{o}02'12.0''E) in Kalampangan near Palangka Raya the capital city of Central Kalimantan province. The study was conducted monthly over a 4 month period for zooplankton study (from April to July 2005) and a 3 months period for phytoplankton study (from May to July 2005).

In the field, samples of phyto- and zooplankton were collected by using a 20 cm plankton net diameter 20 µm mesh opening, except in April when zooplankton were collected using a 20 cm plankton net diameter with mesh size 30 µm. The filtration of plankton samples was carried out by a vertical hauling method where the net was lowed into the bottom of waters and then pulled up to the surface with a speed of 1 ms^{-1}. Samples were then preserved with 1% concentration of lugol solution for laboratory analysis.

In the laboratory, three 1-ml sub samples were counted in a 1-mm grid-marked counting chamber under a compound microscope at 100 x magnification. Phytoplankton samples were identified to genus or species level according to Mizuno (1979), Prescott (1970) and Akiyama *et al*. (1991). Zooplankton samples were identified to genus or species level according to Pennak (1978), Koste (1978), Mizuno (1979), Koste and Shiel (1986, 1987), Nogrady *et al.* (1995), Segars (1995), De Smet (1996), Smirnov (1996), De Smet and Pourriot (1997). Phyto- and zooplankton diversity was expressed by the Shannon-Wiener's diversity index (H'), described by Krebs (1989).

During the study, we measured physical and chemical parameters of the water. The water depth was measured by using a Hondex PS-7 Lcd Digital Sounder. The transparency was measured by secchi disk (20-cm black and white disk diameter). Water temperature and Dissolved Oxygen (DO) were measured by using an oxygen probe (model 55, Yellow Springs Instruments) at the surface. The values of pH were measured using a HORIBA Water Quality Monitor, Type U-22.

For Chlorophyll-*a* (Chl-*a*) analysis, water samples were filtered through a filter (Whatman GF/F) until saturation. After filtration, the filtrate was removed and stored in a 15-ml screw-capped polypropylene centrifuge bottle with 5-ml ethanol. Before analysis, the tube was centrifuged using a manual centrifuge and the absorbance of the supernatant was measured with a spectrophotometer (spectronic 20+) at wavelengths of 630, 645, 663 and 750 nm. Chl-*a* concentrations were calculated according to the following formula described by Yutaka and Osamu (1997).

$$\text{Chl-}a\ (\text{mg chl-}a.\text{m}^{-3}) = (11.64E_{663} - 2.16E_{645} + 0.10E_{630}) \times (a/(V \times L))$$

Where:
E_{663} = Abs 663 – Abs 750; E_{645} = Abs 645 – Abs 750; E_{630} = Abs 630 – Abs 750;
a = Volume of ethanol; V = Volume of water filtered and L = Cuvet Length (1 cm)

RESULTS AND DISCUSSION

Phytoplankton Community

The study revealed 14 species belonging to 7 families of phytoplankton in the canal. The density and species number of phytoplankton species were dominated by members of the chlorophyta group such as *Spirogyra* sp. and *Mougeotia* sp. This finding is supported by Ormed and Wade (1990) *in* Mason (2002), namely that green algae (chlorophyta) appear most frequently at low pH. The density of phytoplankton increased continuously from May to June with the highest value of 114 ind/l. Compared to a study of phytoplankton from several lakes in Central Kalimantan, made by Sulastri (1998) and Ardianor & Veronica (2002), the density of phytoplankton in this study was relatively lower. In the meanwhile, the Shannon-Wiener's diversity index (H') of phytoplankton community showed low values. This finding coincides with those of Keskitalo & Eloranta (1999) that the most humic water bodies have the lowest species richness of the phytoplankton community.

The change of some environmental factor has affected the phytoplankton community. It was shown by negative correlation of stepwise regression between pH and phytoplankton density and between transparency, chl-*a* and phytoplankton diversity.

Zooplankton Community

There were 38 species belonging to 21 families. The density of zooplankton was very fluctuation with the domination of protozoa group, *Euglena* spp. According to V. Ilmavirta (1983, 1984, 1988) *in* Keskitalo and Eloranta (1999) this group has a special advantage in the difficult environmental condition prevailing in humic waters.

The diversity of zooplankton was dominated by rotifera group such as *Anuraeopsis* spp and *Trichocerca longiseta*. This finding is in line with the reports by Gumiri (2002) and Yantrinata (2002), who reported that rotifers as small-size zooplankton dominated zooplankton community in terms of the number of genera in several fresh water bodies of Central Kalimantan.

Statistically, the stepwise regression shows the density of zooplankton was affected by DO, temperature and Chl-*a*., while the changing of environmental factors did not affect zooplankton density.

CONCLUSIONS

Based on this present study, the plankton appear to be dynamic from time to time. The phytoplankton community was dominated by chlorophyta especially *Spirogyra* sp. and *Mougeotia* sp. The abundance of zooplankton contained a high number of protozoan (*Euglena* spp.), but the diversity of zooplankton was dominated by rotifers such as *Anuraeopsis* spp and *Trichocerca longiseta*.

The pH influenced the density of phytoplankton, while the transparency and chl-a influenced the diversity of phytoplankton. The changing of environmental factors e.g. DO, temperature and Chl-*a* only affected the zooplankton diversity.

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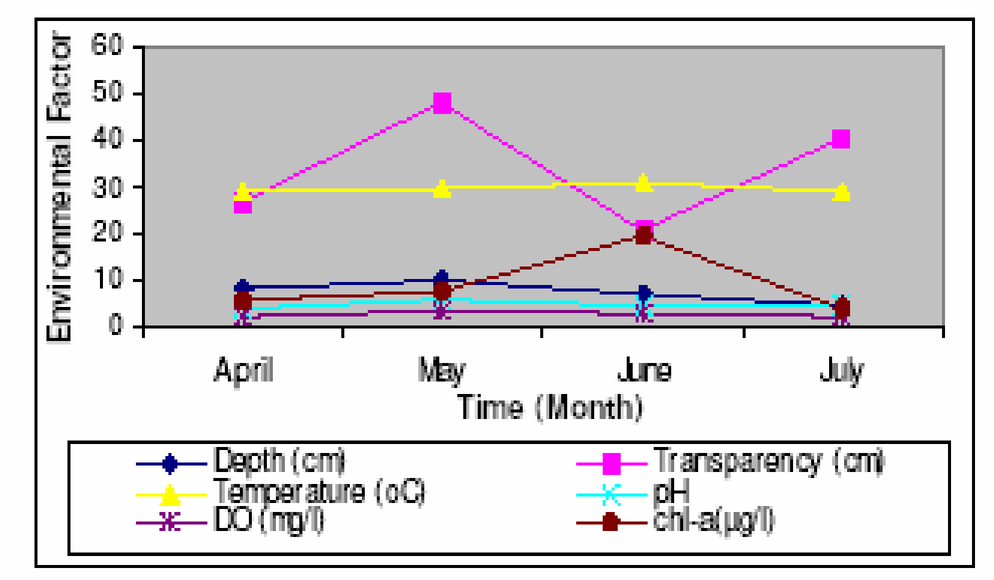

Figure 1: The Seasonal Changes of Environmental Factors and Chl-a Concentration

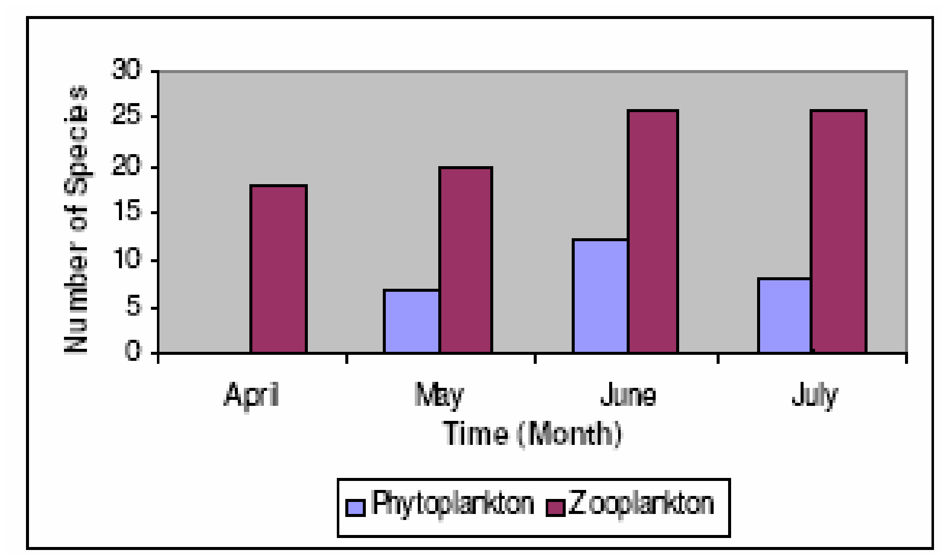

Figure 2: The Seasonal Changes of Species Number of Phyto-Zooplankton plankton

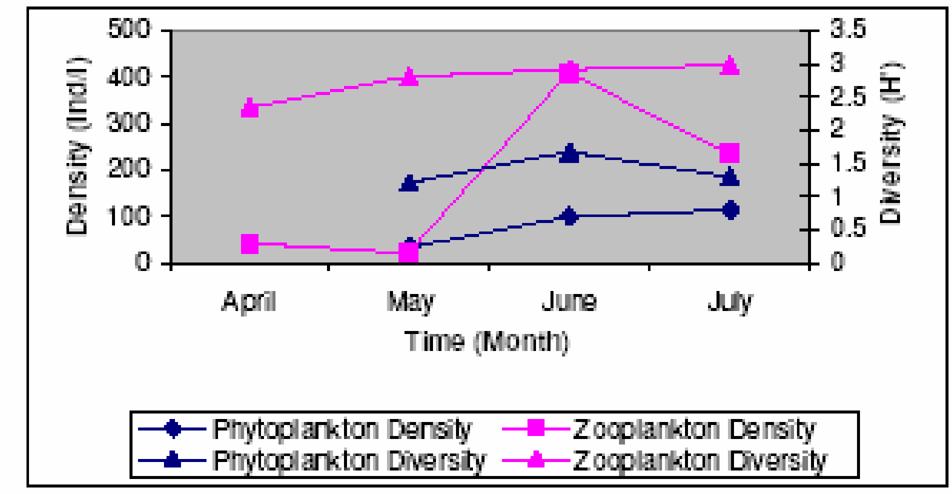

Figure 3: The Seasonal Changes of Phyto-Zooplankton Density and Diversity (H')

RELATIONS BETWEEN ORGANIC MATTER DYNAMICS AND PLANT SPECIES COEXISTENCE IN A TROPICAL PEAT SWAMP FOREST

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SUMMARY

Although carbon storage in ecosystems and biological diversity have been central issues of environmental and ecological sciences for a decade, a reciprocal relationship between diversity and productivity of ecosystems is still unknown. To reveal such reciprocal relationship, we developed a model describing local peat accumulation, and a simulation was conducted using published data for flows and stocks of organic matters in soils in the form of litter, peat and roots under three different microtopographic conditions, namely, gaps, mounds and non-mounds. The results suggest that heterogeneity of peat accumulation rate results in an undulating peat surface. Such undulating peat surface contributes to habitat differentiation of tree species, because subtle difference in peat surface elevation determines the degree of flooding, which affects survival rates of plants differently according to species. We conclude that the relationship between diversity maintaining and carbon storing functions of the tropical peatland ecosystem is closely correlated and reciprocal.

Keywords: **Sumatra, organic matter dynamics, elevation dynamics, species coexistence, heterogeneity, tropical peatland**

I

INTRODUCTION

Biological diversity and ecosystem function of carbon storage have attracted considerable interest in relation to global environmental issues. Higher species and/or functional diversity of plants cause higher productivity (Hector et al ., 1999; Tilman et al ., 2001; Reich et al ., 2004). Recently, some studies have pointed out that other factors such as history of community assemblage (Fukami & Morin, 2003) and facilitative interactions among plant species (Mulder et al., 2001) influence diversity-productivity relationships. The facilitative interactions often include the carbon assimilation process. Through the carbon assimilation process, some influential plant species develop dominant land coverage. As a result, many species of smaller plants are protected from direct sunlight, wind, moving sand, waves or predation (Pugnaire et al., 1996; Bruno & Kennedy 2000; Forseth et al., 2001; Quested et al., 2003; Tirado & Pugnaire 2003). In addition, growth of other plant species is enhanced through cycling of nutrient rich leaf material (Quested et. al., 2003). However, the diversity-productivity relationships have been treated as one-sided effects; diversity is the causing factor, while productivity is the resulting factor. In this paper, we introduce the concept of reciprocal relations between biodiversity and productivity determining carbon storage abilities in a tropical peat swamp forest. Tropical peat swamp forests contain important biodiversity (Dennis & Aldhous, 2004) and have an important function of carbon storage (Brady, 1997; Page et al., 1999; Page et al., 2002).

In tropical peat swamp forests, the peat surface is characterized by considerable topographic heterogeneity at various scales, ranging from tens of centimeters to several metres (Brady, 1997; Page *et al.*, 1999). The large buttressed trees have a large amount of roots supporting the aboveground organs. The root architecture raises the peat surface around the buttresses and forms mounds (Shimamura & Momose, 2005; Figure 1). Some species have numerous pneumatophores that enable root respiration to continue during flooding. Such species are found in non-mounds, while juveniles of other species are found on mounds (Figure 1).

Tropical peat swamp forests are appropriate ecosystems for studying the relation between diversity and carbon storage for three reasons. Firstly, plant activities regulate conditions on the peat surface (mound or non-mound) at the small scale. Peat that supports the terrestrial ecosystem originated from plant material. The surface peat materials have deposited during the modern age (post 1950 AD) (Maloney & McCormac, 1995; Brady, 1997), and peat surface properties are vulnerable to organic matter input and decomposition. Then, organic matter dynamics at small scales (2-20 m) determines conditions of peat surfaces, i.e. mounds and non-mounds. Where production exceeds decomposition, peat surfaces rise and mounds are created. Where the rate of decomposition exceeds the production, peat surfaces sink. Production at small scales are greatly affected by large individuals of some tree species. Thus, their distribution determines conditions of peat surfaces (mound or non-mound) at small scales. Here one can assume there is spatial association between specific microtopography and large individuals of specific trees. For example, huge buttressed trees create mounded sites around them, while individuals without buttresses do not. Such difference in microtopography is due to the difference in the regime of production and decomposition.

Secondly, in wetlands, the relative position of the soil surface and the water table strongly regulates the distribution of plants (Keddy, 1983; Huenneke & Sharitz, 1986; Denneler *et al.*, 1999; Castelli *et al.*, 2000), seedling survival (Budelsky & Galatowitsch, 2000) and seedling germination (Seabloom *et al.*, 1998; Smith *et al.*, 1995). Similarly, humus depth affects the spatial distribution of plant species at small scales in tropical heath forests (Miyamoto *et al.*, 2003).

Therefore, established individuals associated with specific microtopography in tropical peat swa mp forests affect survival of younger individuals through modifying the conditions of peat surfaces.

Thirdly, effects of facilitative interactions through environmental modification have been documented often in harsh sites (Callaway, 1994; Forseth *et al*., 2001; Quested *et al*., 2003) and leads to increased productivity (Mulder *et al.*, 2001), because such effects are more important for plants as environmental stresses increase (Pugnaire & Luque, 2001). Tropical peat is characterized by low nutrient content and high acidity, and the peat surface is seasonally inundated for long periods. Thus, locally mounded sites, where the frequency of flooding decreases, can be regarded as examples of modified habitats, in which facilitative interactions are observed.

Here we hypothesize an important diversity-productivity relationship. The heterogeneity of peat surfaces enhances the diversity of plant species that can coexist, and also the plant species diversity increases heterogeneity in productivity that leads to heterogeneity in conditions of peat surfaces. In this study, we present a reciprocal relationship between plant species diversity and carbon storage process in a tropical peat swamp forest. For this objective, the study shows how plant activities of different functional groups regulate peat surface condition and how the resulting conditions of peat surfaces affects regeneration of plants and, further, how such feedback between plant and peat surface contributes to species coexistence in a tropical peat swamp forest. We conducted theoretical studies on microtopographic heterogeneity and on organic matter dynamics, i.e. litter fall, root input and decomposition processes on different types of microtopography.

THE MODEL

To evaluate carbon accumulating processes at small scale, we applied models. Details of the models are described in Shimamura & Momose (2005). In the model tropical peat soils consist of three layers. The litter layer consists of undecomposed leaves and small woody debris above the peat layer. Similar to boreal and temperate peat, tropical peat is characterized by two horizons: the surface aerobic acrotelm and the deeper anaerobic catotelm. Differences in acrotelm thickness contribute strongly to differences in elevation. On the other hand, because the depth of the catotelm layer is defined by the height of the water table and the bottom of the peat, there is no heterogeneity in depth of catotelm within a relatively short distance. Thus, the net accumulating peat is reflected by the mass of the acrotelm layer. In the model the mass of the acrotelm (m_A) is expressed as follows:

$$m_A = A\exp(p_A / b - k_A)t + sk_L(p_L / k_L - m_{L0})\exp(-k_Lt) / (k_L + (p_A / b - k_A)) - (sp_L - m_Ck_C) / (p_A / b - k_A)$$

where *A* is an integral constant, p_A is root production per unit depth, *b* is bulk density of the acrotelm, *s* is the portion of fragmented litter not lost from the peat by respiration or leaching, k_L is Olson's decomposition constant (Olson, 1963) for the litter layer, m_{L0} is the initial mass of the acrotelm, p_L is mass of litter fall, m_C is mass of the catotelm, and *kC* is Olson's decomposition constant for the catotelm.

SIMULATION

Based on the model, we simulated the change of acrotelm mass in three types of habitats, gap, mounds, and non-mounds using the data provided by Brady (1997) and Shimamura & Momose (2005). We also examined the effects of shifting habitats on the peat surface. We simulated shifts in habitat by exchanging variables. For example, to determine the effect of disturbance on mounds, we changed five variables, pL, kL, pA, kA and s for those of gaps. In this way, we simulated four types of shifting habitats; from non-mound to mound, from gap to non-mound, from non-mound to gap and from mound to gap.

According to the model, the thickness of the acrotelm layer will increase at mounds, non-mounds and gaps. The rank in degree of surface rising was mounds > non-mounds > gaps in descendant order and peat accumulation after 5 years was 56.8, 28.5 and 3.57 ton ha-1 (Figure 2) equivalent to 5.46, 2.35 and 0.300 cm increment of peat surface (Shimamura and Momose 2005), respectively. The result of simulation indicates creation of non-mound forming trees on gaps with an increment of 22.6 ton ha-1 in AmA after 5 years. Similarly, establishment of mound-forming trees leads to an increase of 15.2 ton ha-1 in AmA. On the other hand death of mound and non-mound forming trees cause a decrease of 54.7 and 22.7 ton ha-1 in AmA, respectively (Figure 2).

DISCUSSION

The establishment and death of huge buttressed trees causes the rise and fall of the peat surface, respectively, and results in an undulating peat surface. Mounds formed around huge buttressed trees are suitable habitats for flood-intolerant species to regenerate. After established and buttressed trees are dead, mounds become lower and finally disappear (Figure 2). As a result, habitats suitable for flood-tolerant species appear. Thus, plant species coexistence in the present forest can be explained by mosaic-like dynamics of mounds and non-mounds although we do not know whether this forest is in kinetic equilibrium or not in a long time scale. This process was named by Shimamura & Momose as "elevation dynamics". Even if this forest is not in kinetic equilibrium, species composition of forests fluctuates through the following mosaic-like dynamics.

We propose a dynamic model that allows us to explain the coexistence of tree species in tropical peat swamp forests (Figure 3). The model is based on the following assumptions: (i) mounds are created around buttressed trees as they grow; (ii) after huge buttressed trees die, the surrounding mounds sink; (iii) there are flooding-tolerant and flooding-intolerant tree species; and (iv) there are shade-tolerant and shade–intolerant trees. Examples of these species are listed in the main paper and the electronic appendix to Shimamura & Momose (2005).

Peat swamp forests are composed of areas categorized by one of four phases based on conditions of canopy coverage and microtopography; mounds under canopy: MU-phase; non-mounds under canopy: NU-phase; mounds in gaps: MG-phase; and non-mounds in gaps: NG-phase. In the NG-phase, individuals of flooding-tolerant and shade-intolerant tree species dominate. Canopy gaps in tropical moist forests return to the pre-gap phase within 5 years in tropical moist forest (Fraver *et al.*, 1988; van der Meer, 1997). This time scale is less than establishment of huge buttressed trees that form mounds. Thus, whether regenerating tree species are mound-forming or non-mound-forming, the NG-phase is replaced by the NU-phase. In the NU-phase, individuals of flooding-intolerant and shade-tolerant species dominate. If a disturbance occurs the NU-phase is replaced by the NG-phase. *Shorea teysmanniana* is one of the mound-forming tree species that can inhabit in non-mounds. Once a huge individual of mound-forming tree species like *S. teysmanniana* is established, this phase is replaced by the MU-phase. In the MU-phase, individuals of flooding-intolerant and shade-tolerant species regenerate successfully. If a disturbance occurs in the MU-phase, this phase is replaced by the MG-phase. In the MG-phase, the mound sinks because above- and below-ground production decrease. Thus, this phase is replaced by the MU-phase. When the MU-phase is created by canopy closure in the MG-phase, the phase shift is determined by the tree function that dominates in this MU-phase. If a mound-forming tree establishes, the MU-phase continues. Unless establishment of a mound-forming tree occurs, the phase is replaced by the NU-phase.

The model suggests that plant species coexistence in tropical peat swamp forests is facilitated by plant interaction via soil processes, and effects of facilitation of large trees are important. The model also clearly shows that the relation between diversity maintaining and carbon storing functions of the ecosystem is closely correlated and reciprocal.

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FIGURE LEGENDS

Figure 1. Changes in ground surface elevation with distances from living established, buttressed trees (40 cm > dbh) (solid line), dead established, buttressed trees (broken line), established *Madhuca motley ana* trees (15 cm > dbh) (dotted line) and established *Stemonurus secundiflorus* trees (15 cm > dbh) (broken-dotted line). This figure is reproduced from data in Shimamura & Momose (2005).

Figure 2. Changes in peat deposition in acrotelm within 10 years as simulated by the model. The solid, broken and dotted lines in *(a)* indicate values for mounds, non-mounds and gaps, respectively. In *(b),* shifts in habitat from non-mound to mound, from gap to non-mound, from non-mound to gap and from mound to gap are indicated by the solid line, broken line, dotted line and dotted-broken line, respectively.

Figure 3. Diagram of proposed four phase dynamics used to explain plant species coexistence in tropical peat swamp forests.

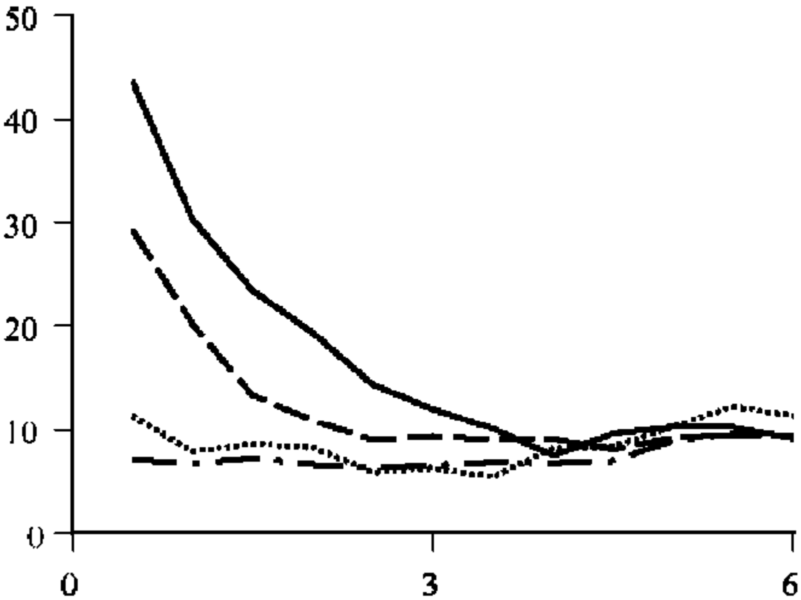

Figure 1

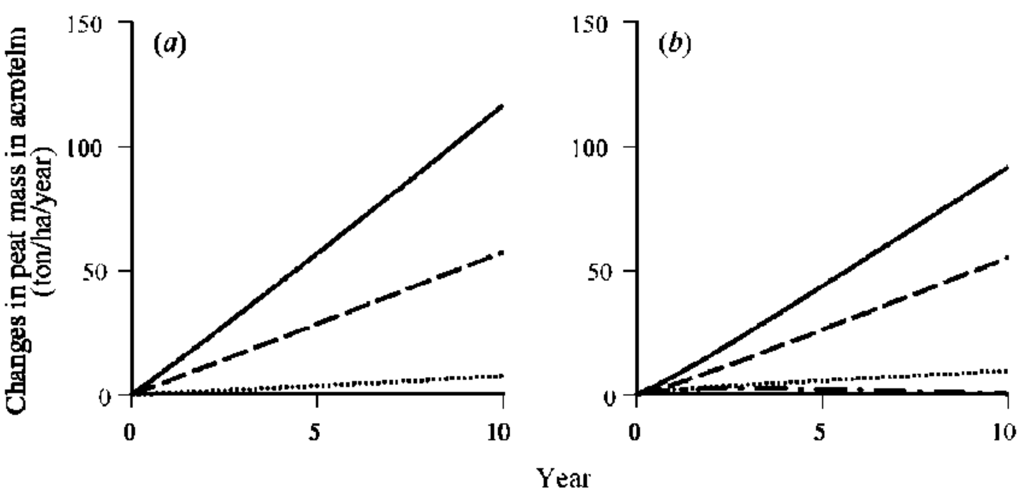

Figure 2

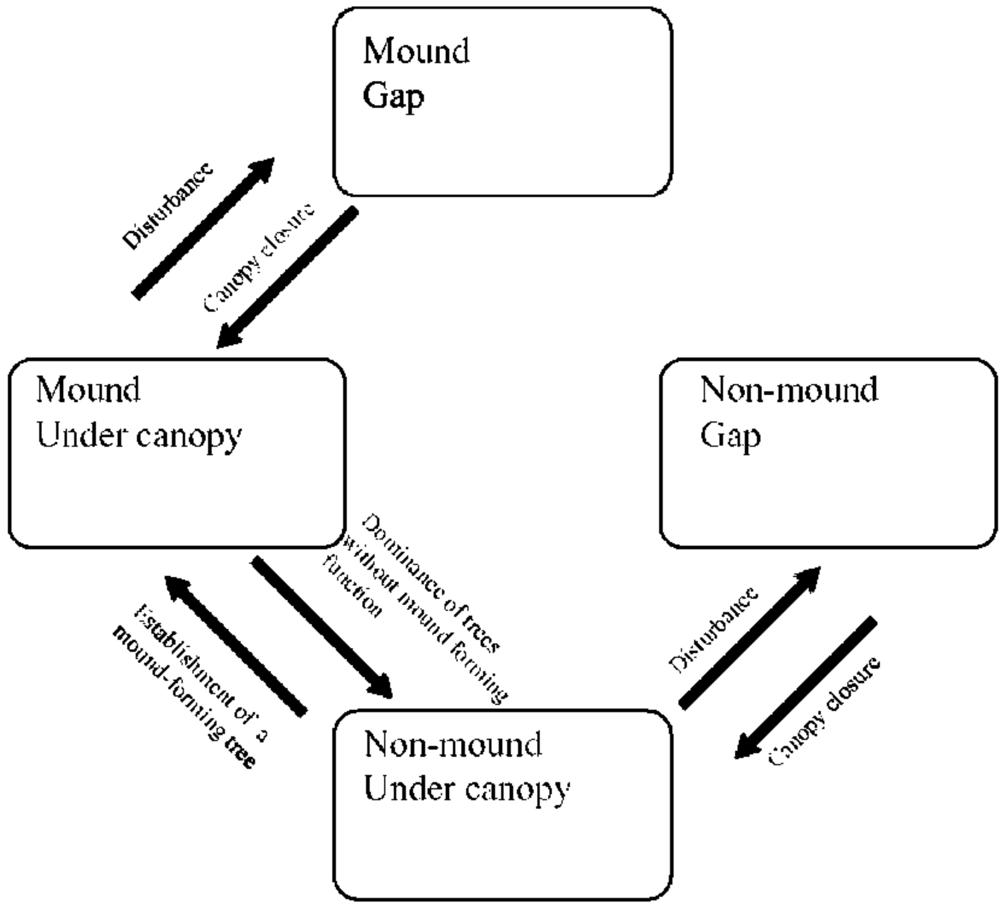
Mound
Gap
Disturbance
Canopy closure
Mound
Under canopy
Non-mound
Gap
Dominance of trees without mound forming function
Establishment of a mound-forming tree
Disturbance
Canopy closure
Non-mound
Under canopy

Figure 3

REMOTE SENSING FOR MONITORING VEGETATION AND HYDROLOGY OF TROPICAL PEAT SWAMP FORESTS: THE RELATIONSHIP BETWEEN RADAR BACKSCATTER AND PRECIPITATION

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SUMMARY

Water is a decisive factor in the formation and maintenance of peat soils. Knowledge of its spatio-temporal distribution is not only essential for understanding life processes in mires, but also for their "wise use". In inaccessible tropical peat swamp forests, ground measurements to retrieve this information are not feasible. Satellite remote sensing, which uses optical and short wavelength radar, has been successfully used to survey land cover and vegetation surface, but does not provide information about the moisture conditions of the forest floor. By analyzing a time series of L-band radar, it was possible to identify soil moisture fluctuation under forest cover. The results confirm previous ground observations. They are essential for a zonation of the peat dome, with regards to water movement. Furthermore, they provide inputs for a more detailed vegetation classification, and can aid in the strategic distribution of ground observation plots.

Keywords: **tropical peat swamp forests, precipitation, flooding**

INTRODUCTION

In the formation and sustenance of tropical peatlands, water plays a decisive role. By creating an anaerobic environment in the soil, it prevents the decomposition of plant residues and thus influences not only quality, but also quantity of organic matter accumulation. Furthermore, there are large differences between plant species with regards to tolerance of waterlogging, so that intensity and duration of flooding also affects the distribution of plant communities. Thus, knowledge of the spatio-temporal distribution of water and its flows are a prerequisite for any management which aims at restoring degraded peatlands or at their "wise use". The vast expanses of tropical peatlands and their relative inaccessibility have so far prevented any detailed ground sampling, and traditionally used optical satellite sensors have been found unsuitable to detect soil hydrological conditions under a tropical peat swamp forest canopy. However, it has been observed (Ormsby *et al*. 1985, Imhoff *et al*. 1986, Hess *et al*. 1990) that, under certain conditions, standing water under a vegetation canopy can cause an extraordinarily bright radar echo.

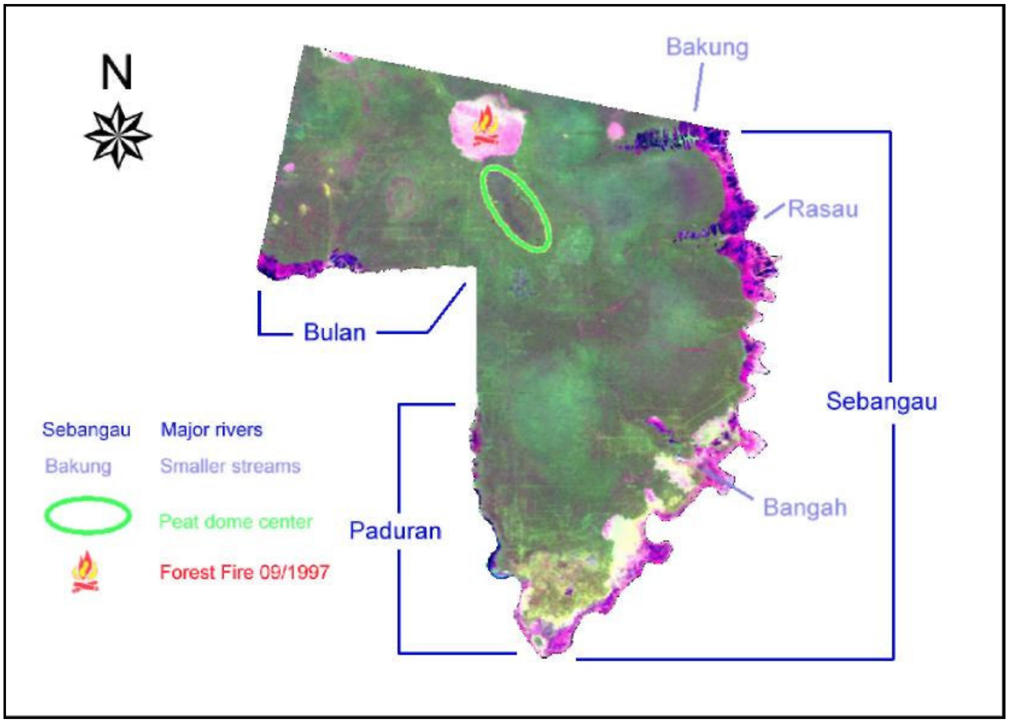

Figure 1: Map of the study area and its boundaries

LOCATION AND METHODS

The objective of this study was to determine the possibility of employing remote sensing and GIS technology, in order to detect surface water in the peat swamp forests of Central Kalimantan, Indonesia. For this purpose, it was necessary to investigate the correlation of radar backscatter and precipitation – the only source of water in an ombrotrophoic mire, and to investigate other factors that might influence the microwave reflectance.

This study was carried out in the Indonesian province of Central Kalimantan, on the island of Borneo. The area chosen, between the rivers Kasongan and Sebangau (more than 6000 km^2), is to a great extent covered by a large peat dome; however, only the portion which is covered by the available satellite images, 1800 km^2, was included in this analysis.

Three sets of data were used: (1) a time series of 14 JERS-1 radar images, covering the period from 09/1994 to 08/1998 that were pre-processed according to standard procedures (co-registration, speckle reduction); (2) three LandSat TM / ETM+ optical images taken in 1991, 1997 and 2000 were used for a visual interpretation of the land cover; and (3) meteorological data that originated from three different stations, located at a distance of two and 30 km from the area of investigation.

The 14 backscatter intensity images (n=14) were correlated to the total amount of rainfall for varying periods, in 3-day intervals from 3 to to 30 days before the images were taken. The correlation was also computed for a subset of the radar images, excluding the last three scenes that were taken after fire destroyed 100 km^2 of vegetation in the area of investigation in September 1997 (n=11).

RESULTS

31% of the area of investigation showed a significant positive correlation that did not vary between n = 11 and n = 14. For n = 14, however, only 4 % reached a high correlation of $r^2 > 0.75$, compared to 12 % for n = 11. Zones of significant correlation extend along all rivers, but only at the southern reaches of the Sebangau does the correlation exceed r^2 of 0.75%. Another large contiguous zone of high correlation was found to the east and south-east of the peat dome centre (Figure 2).

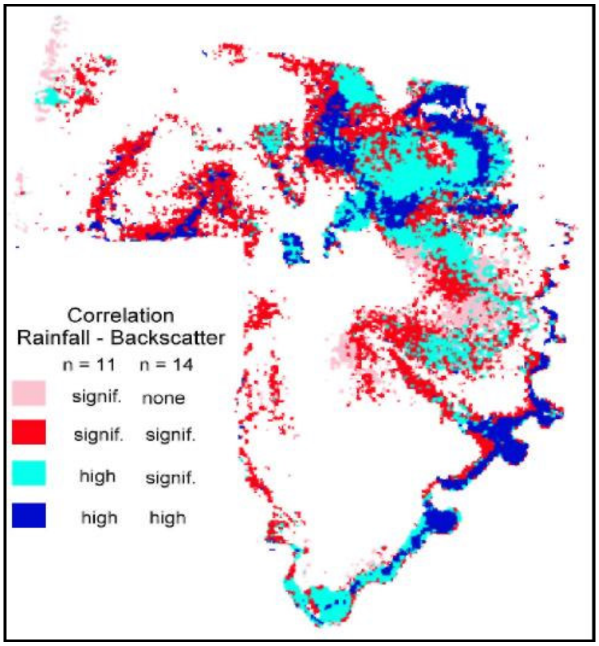

Figure 2: Zones where correlation of rainfall and backscatter change was observed

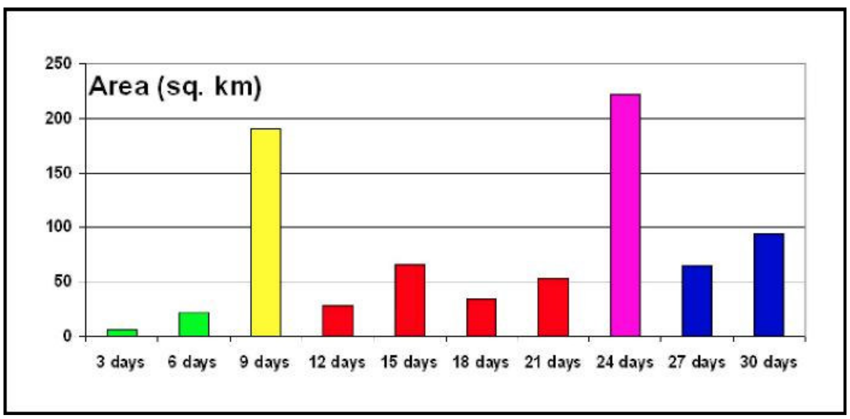

Figure 3: Area that shows a rainfall – backscatter correlation, for different rainfall intervals

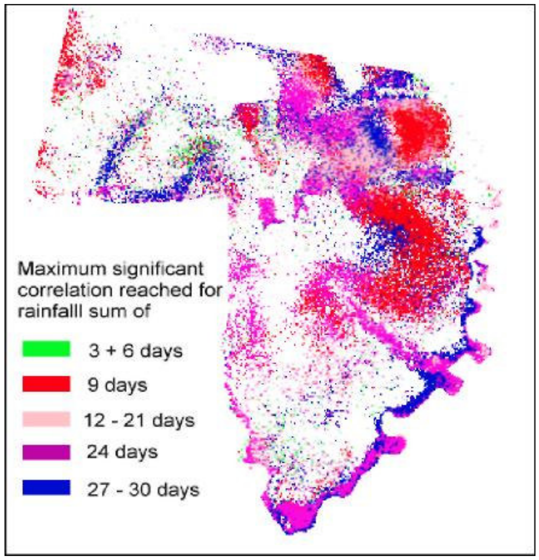

Figure 4: Zones that show a rainfall – backscatter correlation, for different rainfall intervals

The length of the period for which the rainfall is correlated with the radar backscatter greatly influences the correlation: until 6 days before the images were taken, the extent of significantly correlated area is negligible, but for 9 and 27 days, it shows distinct peaks (Figure 3). In general, the 9-day correlation is predominantly found in peat swamp forest areas east and south-east of the dome centre while, after 24 days, correlation mostly shows in zones alongside rivers in the area of investigation (Figure 4).

CONCLUSIONS

Seasonal backscatter variation and precipitation show a significant positive correlation for some zones in the area of investigation, which suggests that surface flooding causes this bright radar echo confirming the observations of Ormsby *et al*. (1985), Imhoff *et al*. (1986), Hess *et al*. (1995).

Distinctive peaks after observation periods of different lengths indicate the presence of factors that cause an accumulation or surface flooding of water after 9 and 24 days. Further research is necessary, however, to evaluate this possibility of water flow and accumulation, and to explain the absence of correlation in 2/3 of the project area. Ground observations during dry and wet seasons could be very helpful in explaining the spatio-temporal reflectance patterns observed. Also, the coincidence of flooding pattern and vegetation types requires further investigation, since an association of specific forest types with peat of a particular depth and surface structure has been observed by Page *et al*. (1999). This current study will be useful for a strategic distribution of observation plots, i.e. in the various forest types, at those locations where a significant correlation between backscatter and rainfall was observed in order to further confirm the assumed correlation between duration of flooding, soil type and forest type.

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LEACHING IMPACTS ON CHEMICAL PROPERTIES OF DIFFERENT RECLAMATION STAGE OF OMBROGENOUS PEAT

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SUMMARY

Most of the peatlands in Indonesia are of the ombrogenous type, located mainly in Kalimantan, Sumatra, and Irian Jaya. Intensive agricultural activity in these peatlands initiated by construction of drainage canals (reclamation) in order to provide better aeration and water circulation has resulted in changes to the properties of the peat. A series of experiments were carried out on peat characterization were initiated in the laboratory and glasshouse ending in field trials. The objective was to evaluate the changes in the chemical properties of peat soil as a result of the agriculture actions employed in various types of peat development (based on duration of peat reclamation). In particular, effect of leaching (by fresh water) on the release of toxic substances, acidity, and latest nutrient status of the leached peat were studies. The ultimate goal was to determine the amounts of ameliorants required to improve peat chemical properties. Results show that the peat used can be subdivided based on thickness, decomposition degree, mineral/ash content, and period of reclamation of the peatland. Laboratory experiments showed that fresh water leaching of peat soil could lead to (1) decrease in soluble acidity (H^+, Al^{+3} and Fe^{+3}); (2) improvement in some peat properties such as pH, electrical conductivity (EC) and (3) decrease in exchangeable acidity. Some negative impacts were also noticed such as removal of dissolved nutrients, leading to decline in total-N, available-P, exchangeable-K and Mg.

Keywords: **tropical peat, peat chemistry, amelioration, drainage, agriculture**

INTRODUCTION

As much as 1.5 million hectares of tidal swamp land has been reclaimed in the past 25 years (1968 – 1993) by the Government of the Republic of Indonesia (GORI) as part of a programme to resettle about one million families of transmigrants from Java and Bali to Kalimantan, Sumatra and West Papua. Another one million hectares of tidal swamps has been developed traditionally by local communities (Ditjen Rawa, 1992). About 0.6 million hectares of this reclaimed tidal swamp land are estimated to consist of peat. Recently, GORI restricted further new developments on reclaimed swampy land owing to capability and financial constraints, its high cost and local socio-culture issues. In fact, by the time that swamp land has been reclaimed and cleared the yield of the first crops has already started to decline. If the production cost is higher then the yield income, the land will not be cultivated anymore and it becomes fallow land (Bongkor). The main constraint is increase in acidity as a result of enhanced peat decay (peaty soil) and pyrite oxidation (acid sulphate soil) because of inappropriate water management.

Reclamation of the tidal swamp land surrounding the Kahayan River (C zone of Mega Rice project) in Kapuas district commenced in 1980. For the last 10 years, about 60-70% of the cultivated land has become Bonkor owing to poor planning and mismanagement (Maas *et al.,* 2001). Other fallow land can be observed in Unit Belawang, Batola district (Sutikno *et al.,* 1998), Sugihan and Rimau area in South Sumatra (Ananto *et al,* 2000)

In order to reuse the fallow land, studies need to be carried to determine techniques for removing the main constraints to crop growth, including acidity removal, soil amelioration, and proper water management. The research goals were to study (a) characterization of peat soil (b) the effect of leaching on the solution of toxic substances (H^{+}, Al^{+3} and Fe^{+2} or Fe^{+3}), (c) decrease of soil acidity and (d) improvement of peat chemical properties;

METHODS

Characterization of peat soil

Four peat samples were taken from several areas in the Transmigration Resettlement Unit (TRU) Pangkoh, which is located to the west of the Kahayan River and TRU Dadahup II in Kapuas district. Site selection was based on duration of reclamation and actual field condition, i.e. (G1) TRU Pangkoh X, 15 years reclaimed, good water regulation (WR); (G2) TRU Pangkoh VI, 20 years reclaimed with poor WR; (G3) TRU Dadahup II Block A5, 5 years land reclaimed, poor WR; and (GO) natural peat with secondary forest at Jl. A. Jani Km 18, Banjar district.

Peat was sampled at 0-30 cm depth. Laboratory analyses were carried out in hydrophilic condition, and focused on chemical and physical properties. Peat soil was grouped based on thickness and decomposition degree (PSSL-UGM, 2000). Chemical characterizations were (a) pH (H_2O), pH ($CaCl_2$), CEC, exch-H and Al, OC, N, avl-P, K, and Fe, (b) water parameters pH, EC, Al^{+3}, H^{+} and Fe^{+2}. Analyses of physical characteristic included water content, BD, fibre content (Lynn *et al.,* 1974).

Effect of leaching on soil acidity and nutrient status

Greenhouse experiments were conducted in the Department of Soil Science, UGM, Yogyakarta. Surface layers of peat (0 - 30 cm) were taken from Kalimantan. Each peat sample was kept moist (hydrophilic) and sieved (**0** 5 mm), then placed in a paralon column (**0** 22 cm, and 40 cm of thick).

A factorial experiment was designed with Completely Radom Design (CRD) in four replications. First factor (development of peat) was: (G1), (G2), (G3), and (GO) as described above. Second factor (leaching systems) was: watering as much as 157 mm (averages of rain intensity in 9 years at TRU Pangkoh = 1,885 mm/years) successively, leached out every two days (L1). Water was conserved in 5 cm inundation (Lo). Observations were carried out for up to 8 weeks. Observed parameters were: (a) Quality of leached water such as: water-pH and EC, toxic ions such as H^{+}, Al^{+3} and Fe^{+3} for 2 - 8 weeks; (b) chemical properties of peat soil before and after the experiment, such as: soil pH, exch-Al and H, org-C, tot-N, avl-P, exch-K and Mg were observed.

RESULTS AND DISCUSSION

Characterization of peat

Field description

TRU Pangkoh X Blok A.

The area was affected by tidal movement (type B), mainly as traditional paddy field (local rice varieties), harvested once yearly (IP 50). Peat thickness was about 40 cm, the land was intensive ploughed. Water circulation was controlled at tertiary canals using inappropriate wooden gates.

TRU Pangkoh VI, tertiery canal 6 - 9 (Gerantung Village)

Tidal movement can be observed only in secondary canals, no water inundation in the field (Type C). No water control (gate construction) at the tertiary canals, resulted in intensive leaching (over drained) of peat soil (recently only 15 – 20 cm thick), water table fluctuated 50 – 70 cm. Previously the land was used for traditional rice cultivation (IP 100), since land degradation was going on continuously, the farmer was not able to get sufficient yield. Part of the land then became bare, especially in Gerantung, tertiary canals 6 – 9. Tertiary canals 2 – 3 with 45 cm peat thickness, situated closed to the river and the highest tide was able to inundate the field. With good water circulation, the farmer plants the field continuously and obtains a reasonable yield.

Dadahup II blok A5

Tidal swamp area with C type, no gate construction present in tertiary canals. The land was traditionally used for paddy field. Peat thickness was about 55 cm. It was suggested that the natural "*subsidence*" was caused by the use of a heavy machine during land clearing and fire used in land preparation (vegetation clearance). The ground water table reached 60–70 cm.

Natural peat

Site location was situated in the secondary forest of Gambut subdistrict. This peat (250 cm thick) has never been used for agriculture. This land was inundated periodically and in the dry season it was subjected to fire. The main vegetation is bushes with some young/small gelam trees.

Laboratory anal yses

Table 1: Chemical characteristics of selected peat samples

Characters	Peat Type			
	Go	G1	G2	G3
pH H_2O (1 : 5)	3,42	3,90	3,96	3,77
pH $CaCl_2$ (1: 5)	3,14	3,58	3,63	3,36
EC ($dS.m^{-1}$)	0,20	0,49	0,22	0,48
Ash content (%)	3,71	14,53	19,54	21,85
Org- content (%)	53,50	40,20	40,92	48,90
Total N (%)	0,38	1,42	1,30	1,15
Total-P (%)	0,13	0,16	0,15	0,16
Avl-P (ppm)	5,25	10,20	8,35	7,25
CEC ($cmol^{(+)}$ kg^{-1})	40,90	57,90	49,40	45,80
Exch-K ($cmol^{(+)}$ kg^{-1})	0,17	0,20	0,15	0,14
Exch-Ca($cmol^{(+)}$ kg^{-1})	0,42	0,56	0,50	0,52
Exch-Mg ($cmol^{(+)}$ kg^{-1})	0,32	0,50	0,45	0,43
Exch-Na ($cmol^{(+)}$ kg^{-1})	0,02	0,02	0,00	0,00
BS (%)	1,85	3,05	1,38	2,00
Exch-Al ($cmol^{(+)}$ kg^{-1})	1,25	3,72	3,68	1,60
Exch-H ($cmol^{(+)}$ kg^{-1})	6,40	2,60	3,28	2,54
Avl-Fe (mg kg^{-1})	1,40	2,50	2,65	2,60
Moisture (%)	271,10	157,20	167,20	143,00
Fiber (%) - total -	80,00	40,00	40,00	42,00
rubbed	40,00	30,00	30,00	33,00
Decomp. degree	Fibric	Sapric	Sapric	sapric

Remarks: Go = Fibric (natural peat); G1 = sapric, good WR 15 year reclaimed; G2 & G3 = sapric, 20 and 5 years reclaimed, improper WR.

Table 1 shows that:

a. pH of the peat is very acid, especially for fibric natural peat, even with frequent burning in the dry season. Sapric peat has higher pH than fibric peat; outside inputs such as ameliorant and fertilizer also increase the pH (Andriesse, 1988; Widjaja Adhi, 1988; Siradj, 1991; Suryanto 1997). Low pH also expressed in high acidity, organic acid (H^+) was dominant in low ash content peat. Ash level is not an indication of high nutrient content out of the organic materials, but it was an indication of clay mineral present in the peat materials. Clay minerals decomposed by organic acids may result in high exch-Al.

b. EC values are very low, indicating that there is no brackish water intrusion (also shown by very low exch-Na), or decomposition rate of the peat was very slow.

c. Nutrients status is low, high organic matter content with medium to low total-N can be used for indication of low availability of nitrogen (C/N ratio > 40). Availabilities of P, Ca, K, and Mg are also low, reaching values below the critical limit for normal plant growth. P is lower in fibric peat compared to sapric, as also had been found by Andriesse (1988) and Widjaja Adhi (1988).

Table 2: Some physical characteristics of selected peat samples

Physical Characteristics (values)	Peat Type			
	Go	G1	G2	G3
Field moisture (%)	510,70	370,80	320,50	295,60
Moisture content (%)	271,10	157,20	167,20	143,00
BD (g.cm-3)	0,13	0,30	0,18	0,21
SD (g.cm-3)	1,07	1,57	1,60	1,62
TP (%)	88,00	82,60	81,50	80,70

Remarks: Go = Fibric; G1 = sapric, good WR 15 year reclaimed;
G2 & G3 = sapric, 20 and 5 years reclaimed, improper WR.

Table 2 shows that:

a. The field water content in fibric peat is much higher than in sapric peat, while moist hydrophilic peat condition shows the same trend, as also has been found by other researchers such as: Andriesse, 1988; Nugroho & Widodo, 2001; Maas, 2003. Higher water content in the fibric peat may be related to lower bulk density (BD), and higher phenolic-OH has also has been described by Valat *et al.,* 1991; Tan, 1994). Valat *et al.* (1991) and Sabiham (2000) mentioned that the higher cellulose and hemicellulose contents (hydrophilic substances) in fibric peat are also reasons for stronger water retension.

b. Bulk density of peat depends on peat decomposition stage; higher bulk density is found in riper peat with a higher degree of decomposition (Andriesse, 1988; Lambert, 1995). Fibric peat has bulk density lower than sapric peat.

Impact of leaching on the improvement of soil acidity and nutrient status of selected peats.

<u>pH and EC values of the leachates</u>

The pH leachates in continuous flooded peat are lower than the leaching and tend to increase with time. This fact gives an indication of acidity release during leaching, as also can be observed in EC values. Continuous flooded tends to inhibit the decomposition rate owing to lack of oxygen supply for microbial activity. Increasing the EC values may be the result of addition of fresh water replacing water lost through evaporation. Intermittent leaching releases decomposition products (especially acidity) resulting in a slight increase of pH and lower EC values.

Table 3: pH and EC of the leachates aftere 2 and 8 weeks

Treatments Code	pH		EC	
	2 WAL	8 WAL	2 WAL	8 WAL
LoGo	3,94 e	3,82 cd	0,16 cd	0,13 cd
LoG1	4,93 bc	4,78 b	0,19 bc	0,16 bc
LoG2	4,82 c	4,68 b	0,17 c	0,15 c
LoG3	5,01 a	4,86 b	0,23 a	0.19 a
Lo avrg	*4,67*	*4,53*	*0,19*	*0,16*
L1Go	3,99 de	4,20 b	0,14 d	0,11 d
L1G1	5,00 ab	5,16 a	0,16 cd	0,14 cd
L1G2	4,87 bc	5,02 ab	0,15 cd	0,13 cd
L1G3	5,05 a	5,20 a	0,21 ab	0,17 abc
L1 avrg	*4,72*	*4,90*	*0,16*	*0,14*

Remarks: L1 – Leached; Lo = Flooded 5 cm thick. Go – natural peat.
G1, G2 & G3 – development levels of peat 15, 20 & 5 years after reclaimation.

The highest ionic composition of the leachates is mainly soluble organic-H, followed by organic-Fe and the smallest as organic-Al. These soluble compounds and some other nutrients are coming from decay products of peat, according to the statement of Tate (1987). Keeping the inundated water will promote reduction of nitrate, manganese and iron oxides and create higher pH. Ponnamperuma, 1977 reported that submerged acid soil is able to increase soil pH, caused by reduction of nitrate, Mn^{+3} to Mn^{+2} and Ferric to Ferrous ions. Removing (leaching) decomposition products of peat and the addition of fresh water (aeration) for the next inundation period may induce further peat decomposition. Accumulatively, the amount of soluble leached acidic ions is higher than in continuously flooded peat.

Table 4: Total dissolved-H^+, Al^{+3}, and Fe^{2+} after 8 weeks

Treatment codes	Dissolved ion ($cmol^{(+)}kg^{-1}$)			
	H^+	Al^{+3}	Fe^{2+}	Total
LoGo	1,72	0,40	1,07	3,19
LoG1	0,88	0,55	1,80	3,21
LoG2	1,08	0,49	2,09	3,68
LoG3	0,72	0,46	1,78	2,98
Lo avrg	*1,10*	*0,48*	*1,68*	*3,26*
L1Go	2,20	0,52	1,20	3,92
L1G1	1,03	0,58	1,92	3,53
L1G2	1,31	0,90	*2,25*	4,41
L1G3	0,90	0,54	1,91	3,35
L1 avrg	*1,36*	*0,63*	*1,82*	*3,81*

Remarks: L1 – Leached; Lo = Flooded 5 cm thick. Go – natural peat.
G1, G2 & G3 – development levels of peat 15, 20 & 5 years after reclaimation.

Fresh water leaching can increase soil pH (water-pH and $CaCL_2$-pH) by 11.33% and 12.33% over flooding (Table 5). This shows that leaching increases soil pH because decomposition of peat releases organic acids. Maas *et al*. (1997), Sudarman (2002) and Masganti (2003) reported that pH_{CaCl2} was observed lower than pH_{H2O} showing that there is much ionic acid in the exchangeable complex.

Table 5: Effect of leaching on peat pH (H_2O), pH ($CaCl_2$), and exch acidity

Treatments	pH(H_2O)	pH($CaCl_2$)	Exch-Al ($cmol^{(+)}kg^{-1}$)	Exch-H ($cmol^{(+)}kg^{-1}$)	TCA ($cmol^{(+)}kg^{-1}$)
Flooded	4,41 b	3,42 b	2,08 a	1,91 a	3,99
Fresh water leaching	4,91 a	3,84 a	1,94 b	1,79 b	3,65
Avrg	4,66	3,64	2.56	1,90	3,82

Note: values followed by same letters in a column no different at $DMRT_{0,05}$

Fresh water leaching (FWL) increased available-P and K compared to flooding. Decrease of t, available P and –K were 22.16% and 35% lower than flooding (Table 6).

FWL on sapric 15 years after reclaimation shows that it is able to decrease total-N content significantly compared to others peats with total-N and decreased by 40.00% (from 0.89% to 0.56%) lower than flooding treatment. This assumed that nitrate and ammonium is carried away by water leachate. This result is supported by Chaerani (1997) who used sapric peat from Pangkoh III (Desa Mulyasari) Kapuas district and sapric peat from Berengbengkel, Palangkaraya (Masganti, 2003). Total-N decreased in fibric peats by 43.0% or decreased from 0.28% to 0.16% on FWL condition (Table 6). This could be explained by FWL able to change reduction to oxidation so that microorganism activity was activated. Reduced peat decomposition resulted in changes in N nutrient such as NH_4 (flooding) or NO_3 in aerobic condition. The difference in total-N soil contents resulted in decrease in total-N of 40 percent in sapric peat (G1). Peats five years after reclaimation had 8.0% less N than flooding treatments. These, assumed that C/N in G1 peat is lower than peats five years after reclamation (G3) as a result nitrogen decomposed faster than peat of G1. G3.

Soil avail-P content could decrease as a result of FWL as occurred on peat 15 years after reclamation (G1) and peat 5 years after being reclaimed (G3) compared to flooding treatment. Reduction of available-P probably occurred by solution of P-leachate. Decreasing of soil avilable-P content on (G1) of 20 percent or decrease from 10.90 to 8.65 ppm.(Table 6). This result agrees with findings of Suryanto (1994) and Chaerani (1997). The Increase in dissolved-P is a result of FWL and supported by an increase of pH (H_2O) in G1 and G3. (Table 12).

Soil available-K content decreased as results show significant different of FWL compared to flooding. The decrease of available-K differs and depends on peat decomposition levels. Reclaimed sapric peat (G1,G2) shows available-K to be 38.0% to 50.0% lower than flooding. While in decomposed fibric peat available-K is 34% lower than in flooding areas.(Table 6). These suggest that ash content in sapric is higher than in fibric peat (Table 1). Peat ash is the source of mineral content K-sources in unburned peat. In burned, reclaimed peatland K increases in the surface peat. Probably potassium, which is a monovalent cation mobilizes (because it is un-bonded and not-covalent) by organic matter. Thompson and Troeh (1978) reported that monovalent cations such as K and Na from organic matter are more easily decomposed by leaching because they are un-bonded in covalent linkages with organic matter.

Cation exchangeable capacity (CEC) is increasingly affected by FWL with increasing averages of CEC of 5.0% over flooding or increase from 44.26 to 46.66 $cmol^{(+)}kg^{-1}$ (Table 6). CEC of sapric peat 15 years after reclamation (G1) increased by 7.0% compared to flooding. These assumed that organic matter long-chains decomposed to smaller chain molecules with a high negative charge.

FWL increased Mg by an average of 10.0% compared to lower flooding treatment with exch-Mg 0,38 $cmol^{(+)}kg^{-1}$ (Table 6). Sapric exch-Mg content decreased by FWL of 10.0% lower flooded treatment or decreased to 0.46 $cmol^{(+)}kg^{-1}$ to 0.40 $cmol^{(+)}kg^{-1}$ (Table 6). This confirms that peats are dominated by acid cations such as (H^+ and Al^{+3}) compared to basic cation. High acid-cation domination of peat soil causes low base saturation and is related to low mineral content.

Table 6: N, avl-P, axch-K and CEC and soil exch-Mg status of four peat samples as resulted in fresh water leaching.

Treatment codes	Some chemical properties of peat soils					
	EC (mS)	Total-N (%)	Avl-P (ppm)	Avl-K (me %)	CEC ($cmol^{(+)} kg^1$)	Exch-Mg ($cmol^{(+)}kg^{-1}$)
LoGo	0,04 d	0,28 f	4,15 de	0,15 bc	36,45 ef	0,29 e
LoG1	0,04 d	0,89 d	10,90 a	0,18a	53,50 b	0,46 a
LoG2	0,04 d	0,98 cd	6,85 bc	0,13 bc	44,50 cd	0,40 bc
LoG3	0,04 d	1,15 a	6,20 cd	0,12bcd	42,60 de	0,37 cd
Lo avrg	0,04 p	0,82p	7,02p	0,14p	44,26p	0,38p
L1Go	0,04 d	0,16 g	3,90 ef	0,10de	38,60 de	0,27 ef
L1G1	0,06 c	0,56 e	8,65 b	0,14bc	57,30 a	0,40 bc
L1G2	0,07 b	0,90 cd	6,05 c	0,08 f	46,50 cd	0,37 cd
L1G3	0,08 a	1,06 b	4,90 e	0,06 f	44,25 cd	0,33 de
L1 avrg	0,06 q	0,67q	5,88 q	0,09 q	46,66	0,34 q

Remarks: L1 – Leached; Lo = Flooded 5 cm thick. Go – natural peat.
G1, G2 & G3 – development levels of peat 15, 20 and 5 years after reclaimed.

CONCLUSIONS

This characterization study shows that peat can be sub divided based on thickness, decomposition degree, mineral/ash content of peat and period of time since reclamation of the peatland. These peat sample were then selected, i.e. (G1) sapric decomposition degree with 30% rubbed fibre content, 40 cm thickness and 14.53% ash content, 15 years after being reclaimed (G2), sapric decomposition degree with 33% fibre content, 40 cm thickness and 19.54% ash content, 20 years after reclaimed (G2), sapric decomposition degree with 30% fibre content, 55 cm thickness and 21.85% ash content, 5 years after reclamation (G3). Natural peat was also taken from a secondary forest area subject to periodic flooding throughout the year; characterized by fibric decomposition degree, 250 cm thickness, 80% fibre content and 3.71 % ash content.

Laboratory experiments showed that fresh water leaching of peat soil could (1) decrease soluble acidity (H^+, Al^{+3} and soluble Fe^{+3}), (2) improve some peat properties such as soil pH, electrical conductivity and decrease exchangeable acidity. However, negative effects were also noticed such as removal of dissolved nutrients, resulting in declining N, available-P, exch-K nutrients and soil exch-Mg content

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The authors acknowledge the assistance of Professor Jack Rieley and Ir. Suwido Limin, Co-Directors of the Kalimantan Tropical Peat Swamp Forest Research Programme for financial support to present this paper in The International Symposium and Workshop Restoration and Wise Use of Tropical Peatland: “Problem of Biodiversity, Fire, Poverty and Water Management” held in Palangka, Indonesia at September 21 – 24, 2005.

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GENETIC PARAMETER ESTIMATION ON RICE AGRONOMIC CHARACTERS THROUGH DI-ALLELE ANALYSIS

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ABSTRACT

A half di-allele analysis was performed among seven rice genotypes with different genetical backgrounds, i.e. Situgintung, Jatiluhur, Gajah Mungkur, B8503E-TB-9-0-3, Krowal, CT6510-24-1-3, IR 64, and its 21 progenies. This experimental material was arranged in a complete block design with 4 replications. Observed characters had highly significant genotypic differences. The genetic parameters were estimated following the Hayman method. The simple model of additive-dominance was sufficiently detected through the absence of non-allelic interaction. Productive tillers exhibited partial dominance. Heritability in a narrow sense was high. There was a positive correlation between grain yield and the number of productive tillers.

THE ROLE OF THE DARTROP HERBARIUM IN RESTORATION OF PEATLAND IN CENTRAL KALIMANTAN

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ABSTRACT

Restoration may offer the best option for retrieving natural functions, uses, and attributes of peatland in Central Kalimantan. The subject of the DARTROP herbarium in restoration is the vegetation cover in burnt and forested areas. Furthermore, what we can expect are the raw data to reconstruct the spatial distributions of plant species. The relation of plants to land surface features on forested peatland, is a fascinating study. It might seem at first consideration that the way to study this relationship is simply to go into the field and apply the best technology available. That this is necessary will not receive the slightest suggestion to the contrary but the limitation imposed by direct examination restricts the outcome unless the resources of the DARTROP herbarium are brought into play. Firstly, the herbarium has a fair representation of the plants of the peatland. Secondly, the herbarium provides the basis for the accurate determination of the species involved. There are those who feel that the task of providing correct names for plants is wholly within the province of botanists associated with the herbarium. It is certainly true that a botanist familiar with a good herbarium and well versed in the literature of taxonomy is in a favourable position to provide correct identification.

IMPACTS OF LAND USE CHANGE AND FIRE ON BIODIVERSITY AND CARBON BALANCE OF TROPICAL PEATLAND

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ABSTRACT

Tropical peatlands are unique ecosystems: they are both peat-forming wetlands and tropical rainforests. As forests, these ecosystems are an important habitat for endemic tree species and contain rare and threatened species of animals, including orang utan. Apart from its significant role in biodiversity conservation, which aims at maintaining environmental quality, peat swamp forests are a substantial source of a range of timber and non-timber products. As peatlands, important functions include carbon storage (which counteract global warming), water retention (preventing floods) and water supply (maintaining human populations), and thus offer valuable services to society - locally, regionally and globally. A good understanding of this ecosystem will help to make it sustainable for longer-term uses. A number of recent studies have, beyond identifying the services that intact tropical peatlands can provide for society, tried to quantify their functions. However, owing to needs for development, tropical peat swamp forests have been and are being converted to other land uses, often with serious economic and ecological consequences. In recent years, tropical peatlands in Southeast Asia have been impacted severely as a result of inappropriate or mismanaged land development projects, illegal logging and fire. This presentation will focus on the extent of damage to peatlands in Central Kalimantan, Indonesia and show the amount of carbon lost from the peat store as a result of land use change and fire.

RECENT TRENDS OF TROPICAL FOREST AND PEAT FIRE IN INDONESIA

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ABSTRACT

To understand tropical forest fire and peat fire situation in Indonesia, recent peat fire trend is extracted from NOAA hot spot data. Analytical results show that:

1. Forest fires in Indonesia occurred mainly in peatland areas of Kalimantan and Sumatra.
2. Fire in Kalimantan peatland is responsible for more than 50% of fire in Indonesia.
3. Recent consecutive active fires from 2001 to 2004 in Central and West Kalimantan Provinces imply that peat fires occur mainly in El Niño years. Recent trends of fires in Indonesia may be due to so-called global climate change.

INTERNATIONAL SYMPOSIUM AND WORKSHOP ON TROPICAL PEATLAND PALANGKA RAYA, 20- 24 SEPTEMBER 2006

“Restoration and Wise Use of Tropical Peatland: Problems of Biodiversity, Fire, Poverty and Water Management”

ORGANISING COMMITTEE REPORT IN CLOSING CEREMONY

Excellency Mr Rector University of Palangka Raya, Local Government of Central Kalimantan, All Informal Leaders, All Participants of Symposium and Guests.

For the five days since 20 September 2005 the symposium participants have been involved in a field excursion, presentations and discussions in order to formulate Wise Use of Tropical Peatlands. In this symposium the participants visited two field sites, namely the Natural Laboratory for Peat Swamp Forest (NLPSF) near Kereng Bangkirai on the Sabangau River and Kalampangan Zone (Block C of the ex Mega Rice Project (MRP). I believe all of the participants felt satisfied and funny, because all of your faces have been covered by peat dust, that made it more difficult to know who you are. This second excursion was a tremendous challenge logistically for the organisers,because more than one hundred motor bikes were needed to drive you for the 14 km return journey from the nearest road.

This symposium and associated workshop have produced very important conclusions and recommendations on the utilization of tropical peatland, especially in Central Kalimantan. These conclusions and the statement that was endorsed at the final plenary session to provide guidance for peat restoration and utilisation were the product of intensive collaborative research carried out by many scientific experts who were involved in the STRAPEAT Project supported by the European Commission.

As Organising Committee, I thank the Governor of Central Kalimantan who has given a high spirit of inspiration to all of the participants, so that they did not feel too tired to follow this scientific event until the closing ceremony today. I also wish to show our appreciation to the Rector of the University of Palangka Raya who entrusted the Organising Committee to organise this important event.

Ladies and gentleman, according to the Governor of Central Kalimantan’s statement that “do not just talk, but do action”, let us work together to follow up the results of this symposium. My suggestion and hope go in direction to the users, in order that their wants and consequence to implement development programmes in peatland based on peat characteristics, feasibility related with the other sectors, and feasibility that considers and embraces local knowledge.

I am specially grateful to all participants from outside of Indonesia (listed 15 countries including Indonesia) by your real contributions to give input for us who stay in Central Kalimantan where we have been living under threat of environmental degradation. I had mentioned in the Indonesian Peat Society seminar on 20 September 2005 as part of this symposium, high possibility for communities in Central Kalimantan could become mass unconscious or mass sick or mass die caused by accumulated toxic substances from the thick smoke that they have absorbed for one to four months every year in the dry season. Now we are still fresh and healthy, but we do not know what will happen in the next five to twenty years. Some scientists have stated the small particles can enter the deepest part of the lung.

I want to spread a special message for everybody in the world through all of you because, recently, many of my guests from various countries came and asked me as follows*: "where can we find orang-utan, because we want to make their movie"*. By this question, sometimes I felt that "Orang-utan are more popular than Orang Dayak *(Dayaknese)*". Therefore, in the cover page of the symposium abstracts volume, I show you one photograph of Dayaknese taking a lunch with a limited menu. They have to cook together in one pan or kettle fish, frog and mouse deer without enough flavour. In other case, at the Centre for Orang-utan Rehabilitation in Nyaru Menteng Tangkiling Central Kalimantan, the orang-utan is given an over supply of foods, e.g. fruits, milk, etc. As you know, I and my family have been eating some fruits when we went to party. We could not prepare some fruits everyday. Also provided by them, there is a School for Baby of Orangutan in Nyaru Menteng, Tangkiling, but, unfortunately, many villages in Central Kalimantan are without Play Group or Kindergarten. Therefore on this opportunity, I must state that there is two orangs in Central Kalimantan, that are *Orang-human and Orang-utan*. Therefore, please do more to support the Orang-human, in order that humans can help the animals surrounding them. Why? Because human is human, and animal is animal. This statement is with full support, because we have learned by the Lord "You shall love your neighbour as yourself". I have never heard about *"You shall love your animal as yourself"*. For this view, I need your support how to realize *"Stop treating orang-utan like a human"*

On behalf all of Organizing Committee, I do apologize by our lack of experience and mistakes when we organized this symposium. For the last word, I shall invite the Rector of the University of Palangka Raya to give his comments and closing message, and direction to close this symposium. Thank you.

Palangka Raya, 24 September 2005 The Chair of OC

SUWIDO H. LIMIN

INTERNATIONAL SYMPOSIUM AND WORKSHOP ON TROPICAL PEATLAND PALANGKA RAYA, 20-24 SEPTEMBER 2005

ADDRESS BY PROFESSOR JACK RIELEY, UNIVERSITY OF NOTTINGHAM, UK.

Excellency the Governor of Central Kalimantan Province, Rektor of the University of Palangka Raya, Deputy Minister of Research and Technology of the Government of Indonesia, Director of CIMTROP/UNPAR, distinguished guests and fellow participants, it is an honour to give this closing address on behalf of the European Union RESTORPEAT Partnership, the organisers of this international symposium and workshop.

We have spent the last four days informing, debating and discussing problems of restoring degraded and impacted tropical peatland in Central Kalimantan to a sustainable condition appropriate for environmental enhancement and maintenance, linked to improvement of the livelihood of local people. We knew before we started our meetings that the problems were immense, but now we have a better understanding of them and a vision, with an action plan of how to proceed in order to rectify the situation.

We commenced our deliberations with an excellent field excursion to examine, at first hand, the problems confronting peatland restoration in this Indonesian Province. The logistics of this, owing to the large number of people involved, were formidable but, true to form, Suwido Limin made this happen effectively and efficiently by arranging for the motor cycle ‘cavalcade’ to Kalampangan and the speedboat trip to the Natural Laboratory. We breathed the haze, swallowed peat dust, saw the devastation caused by deforestation, drainage and fire and consoled ourselves in the relative peace and beauty of the natural peat swamp forest.

At the International Symposium we were presented with detailed state of the art accounts of the problems of biodiversity, fire, poverty and water management of peatland by 14 international experts in these issues and we discussed the relevance of this information to tropical peatland in Central Kalimantan. At the International Workshop we received a further 20 contributions that focussed on the four major issues affecting restoration and wise use of tropical peatland. This was followed by breakout sessions in which the participants joined the group most relevant to their expertise and interests, to identify action points and formulate recommendations that could be provided to the Governor of Central Kalimantan and to other Indonesian and International Government Agencies, authorities, NGOs, the private sector, local communities and others for information and guidance.

This resulted in the ‘Palangka Raya Statement 2005’ that was adopted unanimously at the final Plenary Session and which will become a major catalyst for all future restoration and wise use activities on tropical peatland. You have all contributed to this major effort and benchmark document. You have done a good job of which you can be justly proud.

Many thanks, good luck and safe journey home.

INTERNATIONAL SYMPOSIUM AND WORKSHOP ON TROPICAL PEATLAND PALANGKA RAYA, 20-24 SEPTEMBER 2005

CLOSING ADDRESSES

(Rector of The University of Palangka Raya)

My Honourable:

1. Governor of Central Kalimantan
2. All elements of the top rank government of Central Kalimantan
3. Professor Jack Rieley
4. Mayor of Palangka Raya City
5. All important figures of the community
6. All speakers and participants
7. All invited guests

Good afternoon ladies and gentlemen. I am very happy to see all of you who are still participating actively in this Symposium and Workshop until the closing ceremony.

As stated by the Governor at the opening ceremony of this Symposium and Workshop this scientific meeting would give a profitable contribution for the acceleration of development in this province in its relation to the restoration and wise use of tropical peatland. At the beginning, the head of the committee frankly stated that we still have not got any manuals for the management of peatland; I do hope that this important meeting could discuss and conclude an important outcome for wise management of peatland.

In this International Symposium and Workshop we have already been told that we will get a manual for (WISE USE OF TROPICAL PEATLAND: Focus on Borneo). This manual is a collection of research done since 1993/1994 sponsored by STRAPEAT (Strategy for Implementing Sustainable Management of Peatlands in Borneo).

As Rector of the University of Palangka Raya, I am so proud for the presence and cooperation between Nottingham University, Leicester University, Wageningen University, Munich University, Hokkaido University, UGM, UNSRI, and a number of Universities in Malaysia who have already supported Basic Scientific Model (Pola Ilmiah Pokok-PIP) of the University of Palangka Raya which focuses on Wetland and Peatland.

In his report, the head of the committee stated that the International Symposium and Workshop has made an important STATEMENT as an OUTCOME of this scientific meeting. I hope that this STATEMENT could be implemented now and in the future. My high expectation is forward to the provincial government of Central Kalimantan as well as the central government in Jakarta as the users. The university only has the right to do research and to give recommendation to the users (government).

I would like to underline the governor's statement: “Do not talk only, but do it in action”. This statement is useful for all of us, because in some cases of our experiences, a lot of ideas, thoughts, and suggestions of scientists are ignored by users in taking important decision related to peatland management. As proof is the mismanagement of the one million hectares of peatland project in Central Kalimantan (PLG Project). I know that local researchers have always forwarded their protest on the design plan of PLG Project. Through the International Symposium on Tropical Peatland organised by in UNPAR on September 4-8, 1995, the government was reminded then that: “The government must be very wise in managing peatland for agriculture”.

My honourable the participants and speakers,

My endless gratitude is addressed to Professor Jack Rieley who has organised a number of peatland scientists from all over the world, and his strong and serious effort to look for financial support for this international symposium and workshop. To all speakers and participants, once again I would like to express my thanks. My thousand thanks are also forwarded to Mr Ambassador of Finland; VAPO OY – Finland and US Fish and Wildlife Service for their financial support for this meeting and development of Central Kalimantan. The support of all of you will be very important for the development of Human Resources of staff of the University of Palangka Raya.

By the closing ceremony of this International Symposium and Workshop I would like to pray to all of you for safe return home: “May the Almighty God Be with you and all of you will arrive home safely and be among your family happily.” Besides, I also hope that our cooperation will be extended in future because without your strong and serious support I believe our institution could not exist like other developed institutions abroad.

As you know that our institution does need your endless support in order that the University of Palangka Raya could create qualified Human Resources. The same expectation is that the provincial government of Central Kalimantan could become a good model in wise management of peatland. This is a test case for the government of Central Kalimantan. If the government is successful in managing peatland, it will give positive contribution not only in Indonesia but also abroad. Therefore I strongly support the STATEMENT made in this International Symposium and Workshop initiated by the Deputy of Minister of Research and Technology (President of the Indonesian Peatland Association) that: “The Peatland Project (PLG) which was inaugurated by a Presidential Decree, must be managed by Presidential Decree”. It means that the management of peatland cannot be handled separately by regencies but must be integrated because the ecosystems of peatland are uniform all over the regencies of Central Kalimantan. I think we must be proud of the statement of the Deputy of Minister for Research and Technology that UNPAR is one of the assets in the sector of peatland through the existence of CIMTROP of UNPAR as a place to integrate all peatland scientists from all over the world. For this reason I hope the management of peatland in Central Kalimantan can be coordinated by CIMTROP because CIMTROP has many qualified national and international scientists associated with it. I think we all agree that we must avoid repeating the same mistakes of the past, such as the failure of PLG.
Last but not least, once again I say good bye to all of you, May God be with you all and that you will arrive home safely, and hope that will meet again in the same place, but different occasion.

By the blessing of the Almighty God, this International Symposium and Workshop is formally closed. Thank you very much.

University of Palangka Raya
Rector,

HENRY SINGARASA

INTERNATIONAL SYMPOSIUM AND WORKSHOP ON TROPICAL PEATLAND
PALANGKA RAYA, 20-24 SEPTEMBER 2005

REPORT OF THE INTERNATIONAL STEERING AND MONITORING COMMITTEE

Problems of restoration of tropical peatland following inappropriate land use change, illegal logging and fire were addressed at this important international Symposium and Workshop. These meetings were attended by over 200 peatland scientists, land managers, representatives of national and local government, NGOs and community groups, and the private sector from Indonesia and 14 other countries. The symposium focused on measures needed urgently for biodiversity maintenance, fire control and water management linked to sustainable livelihoods of local people in order to alleviate poverty and reduce natural resources and environmental degradation. The workshop participants assessed specific problems of peatland restoration in the former Mega Rice Project and the Sebangau catchment areas of Central Kalimantan, and incorporated the views of specialists and stakeholders into a holistic approach to identify solutions using the "Wise Use" approach. The importance of peatlands to national and regional economies and the environment was stressed in opening statements by the Governor of Central Kalimantan and the Indonesian Deputy Minister for Research and Technology. The Governor expressed his concern over the current situation and made a strong commitment to support positively, initiatives to solve the problems of fire and water management through sound science and wise use. He invited the participants to submit to him their conclusions and recommendations.

The International Steering and Monitoring Committee (ISMC) met before and during the meetings in Palangka Raya and have examined the final statement of accounts that has been prepared by the Organising Committee. They are of the opinion that the symposium and workshop were organised and executed to a high scientific and technical standard and that they were a success of major importance contributing to the ongoing debate on tropical peatlands by their focus on 'Restoration and Wise Use'. The ISMC notes that all of the presentations and posters and meeting statement are available on the EU RESTORPEAT Project Web Site at www.restorpeat.alterra.nl and that a Proceedings document is being prepared with text versions of presentations.

The financial statement has been scrutinised by the ISMC, which is of the opinion it is a true reflection of the complexity and magnitude of the organisation of these meetings and field excursion that spanned 6 days. The large proportion of the budget used to contribute towards the travel and subsistence of key speakers from Indonesia and other countries enabled this event to have a higher profile than would otherwise have been possible.

It is the opinion of the ISMC that the amounts spent are compatible with the expectations and requirements of the funding sponsors and verify that accounting procedures were carried out in a professional and transparent manner with payments made against invoices or signatures and with the issuing of receipts.

We thank the various funding sponsors, especially Embassy of Finland, Jakarta, The Netherlands Embassy, Jakarta, Great Ape Conservation Fund, USA and Vapo Oy, Finland for their generous support and confirm that this money was well spent.

Professor Jack Rieley
On behalf of the International Steering and Monitoring Committee.