IMPACTS OF CLIMATE CHANGES, LAND USE AND FIRE ON ECOSYSTEMS AND THE ATMOSPHERIC ENVIRONMENT OF THE MARITIME CONTINENT: CHALLENGE FOR IMMEDIATE ACTION AND A LONG-TERM SCIENCE AND TECHNOLOGY PLAN [1]

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1. Past and Present Fires as Expression of Climate Variability and Land Use

Past and present occurrence of fire in insular and mainland South East Asia is closely linked to climate variability, ecosystem properties, and historic and contemporary patterns of land-use systems. Radiocarbon dating of charcoal in East Kalimantan document prehistoric forest fire occurrence up to 18,000 year before present (BP). Possible sources are early land-use fires and fires caused by burning coal seams which have been dated by thermoluminescence analysis up to 20,000 yrs BP. These prehistoric fire most likely are also associated with drier climate conditions during the late Pleistocene and the Pleistocene-Holocene transition.

The present use of fire and cause of wildfires are associated with:

- Temporary conversion of primary and degraded lowland dipterocarp rain forests by traditional but rapidly expanding slash-and-burn agriculture
- Land-use change by permanent conversion of rain forests into forest plantations and other tree plantations (e.g. oil, rubber) and agricultural land use (agricultural maintenance burning and crop residual burning);
- Uncontrolled wildfires escaping from these land-use fires into surrounding natural forest, swamp and swamp forest, and forest plantations
- Uncontrolled short-return interval wildfires occuring in degraded vegetation: Alang-alang (*Imperata cylindrica*) fires

In mainland SE Asia fires are common and occur annually in the seasonally dry monsoon forests which have been adapted to fire influence since thousands of years. Fire climax forests are also found in the mountain coniferous (pine) forests all over SE Asia, such as around Lake Toba (Sumatera), in the Cordillera of the Philippines, and between Myanmar and Viet Nam on the mainland.

The most recent fire episodes in insular SE Asia were associated with the dry spells of 1982-83, 1987, 1991, 1994, and 1997 which are caused by the El Niño - Southern Oscillation (ENSO). During the 1982-83 drought more than 5 million hectares of forest and other land were affected by fire in the Indonesian and Malaysian provinces on Borneo. A post-fire inventory on 3.2 million ha burned in east Kalimantan revealed an economic damage of 8-9 billion US-Dollars.

After the smoke episode of 1994 the Indonesian Ministry of Forestry reported that a total of ca. 5.1 million hectares of land were affected by land-use fires and wildfires.

The national and region-wide damages caused by smoke, e.g. impacts on human health and economic damages, have not yet been assessed for the previous and the still

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ongoing smoke episode of 1997. The impact of the smoke produced from SE Asian land-use fres on the regional and global atmosphere have not yet been investigated in depth.

2. National Indonesian Programs

After the 1991 fire and smoke episode Indonesia, in cooperation with international partners, convened a conference in Bandung (June 1992) in which a "Long-Term Integrated Forest Fire Management Programme for Indonesia" was initiated.

Participants in the conference were national agencies involved in fire management as well as international partners who jointly designed a concerted action to initiate a plan of action by sharing expertise and resources. In implementation of the Bandung Strategy the following fire management projects were intiated:

1994: A bilateral Indonesian-German project "Integrated Forest Fire Management" (1994 - 2000)

1995: Establishment of a "National Coordination Team on Land and Forest Fire Management" at the Environmental Impact Management Agency BAPEDAL

Fire management projects in Sumatera (Jambi) and West Kalimantan supported by the Japan International Cooperation Agency (JICA)

Forest Fire Prevention Project in Sumatera (Palembang) sponsored by the European Union (EU)

The Fire Warning Project in Central Kalimantan supported by the UK Overseas Development Administration (ODA)

Support of the Ministry of Forestry (Central Level) by the Food and Agricultural Organization of the United Nations (FAO)

Fire Management Training (inter-project) provided by the United States Department of Agriculture (USDA) and US AID.

1996: Development of "National Guidelines on Protection of Forests against Fire" supported by the International Tropical Timber Organization (ITTO), to be finalized in December 1997.

3. Programs within the ASEAN Region

Regional cooperation in fire and smoke management is underway in the frame of activities under the "Transboundary Haze Pollution" agreements within ASEAN. After the workshops of 1992 (Balikpapan, Indonesia) and 1995 (Kuala Lumpur, Malaysia) the ASEAN Fire Forum at the Conference on "Transboundary Pollution and the Sustainability of Tropical Forests" (Kuala Lumpur, December 1996) delivered proposals for the development of an ASEAN-wide fire and smoke management strategy by sharing responsibilities and resources, focusing on:

- Prediction of fire hazard and fire effects on ecosystems and atmosphere;
- Detection, monitoring and evaluating fires; and
- Sharing fire suppression technologies and resources.

The "Forest Fire Management Plan of Action" for the ASEAN region is a program under preparation, to be jointly developed and implemented by the ASEAN Institute for Forest Management (AIFM) and Canada.

4. International Science Programs

The ASEAN Fire Forum also recommended and prepared the outline of a regional science program which will clarify the multiple interaction between climate variability, land use and fire in the maritime continent.

A major scientific endeavour will be the "South East Asian Fire Experiment" (SEAFIRE) which has been planned since the early 1990s. SAEFIRE intends to investigate the ecological impacts of fire in land use (fires used in forest conversion and shifting cultivation, grassland and seasonally dry [monsoon] forests), the characteristics of pyrogenic emissions, the regional and global transport and impacts of these emissions. Biogenic and marine sources of trace gases and aerosols will be included. Special emphasis will be laid on interannual climate variability (ENSO vs. non-ENSO) and the role of the "Warm Pool" in global distribution of fire products.

The South East Asian Fire Experiment (SEAFIRE) is a research activity under the scheme of the International Geoshere-Biosphere Programme (IGBP). The International Global Atmospheric Chemistry (IGAC) Project is a core project of IGBP. One of the activities of IGAC Focus 2 (Natural Variability and Anthropogenic Perturbations of the Tropical Atmospheric Chemistry) investigates the impact of biomass burning on the atmosphere and biosphere (Biomass Burning Experiment [BIBEX]). SEAFIRE will establish the fire research component within the Integrated SARCS/IGBP/IHDP/WCRP Study "Human Driving Forces of Environmental Change in Southeast Asia and the Implications for Sustainable Development".

Scientific planning workshops have been held in Samarinda (East Kalimantan, Indonesia, September 1995), at the 13th Conference on Fire and Meteorology (Lorne, Australia, October 1996), and at the Conference on "Transboundary Pollution and its Impacts on the Sustainability of Tropical Forests" organized by the ASEAN Institute for Forest Management (AIFM) (Kuala Lumpur, Malaysia, December 1996), and will further continue after this conference during the Synthesis Workshop on "Greenhouse Gas Emission, Aerosols and Land Use and Cover Change in Southeast Asia" (sponsored by Southeast Asia Regional Committee for START) in Taipei (15-18 November 1997).

The SEAFIRE program will be facilitated by the Max Planck Institute for Chemistry (Germany) which will prepare and coordinate ground-based and airborne measurements of fire and smoke effects. The chemistry of fire emissions will further be investigated by cooperative efforts of the Atmospheric Sciences Division of NASA, Langley Research Center, and the US Forest Servive Intermountain Fire Labortaory (Missoula, Montana) in conjunction with the Department of Chemistry, University of Montana and the Canadian Forest Service, Forest Fire Research, Great Lakes Forestry Center. The "Biomass Burning and Lightning Experiment" (BIBLE) designed by the University of Tokyo, in conjunction with the research conducted by the Japanese National Institute of Agro-Environmental Sciences (NIAES), will provide important atmospheric chemistry research inputs to a regional program.

This successful implementation of the program will be dependent on inputs by Indonesian agencies and research institutions, such as the work of the Agency for the Assessment and Application of Technology (BPP Teknologi), the Bureau of Meteorology (BMG), the Indonesian Space Institute (LAPAN), as well as the university capabilities, e.g. in Bogor and Samarinda.

Established partnerships, such as the cooperation between the Environmental Climatology Group of Monash University (Australia) and BMG, will be important for consolidating the research in trajectory dispersion modeling and air quality investigations (see contribution by N.Tapper, Monash University). Other example is a growing collaborative work between Japanese Group and Indonesian *Scientific Community on Atmospheric Dynamics (SCAD)*

on *Climatology of the Indonesian Maritime Continent* will also be a substantial groups to extend collaborative work since the members of the groups come from research institutes and universities in both countries. (See contributions by M.D.Yamanaka and H.Tsuruta).

Major international contributions are expected from the Joint Research Center of the European Union which has bee successfully implementing pioneering work in remote sensing of fire activities in mainland SE Asia (see contribution by J.P.Malingreau, JRC, EC). The use of sensors such as the Along Track Scanning Radiometer (ATSR) on the ERS-1 and ERS-2 satellites (and in future on ENVISAT) must be included.

The project "Studies of the Hydrology, Influence and Variability of the Asian Summer Mosoon" (SHIVA) and the further development of climate models such as the ECHAM4/OPYC3 coupled ocean-atmosphere-ice model, will provide important inputs for assessing the role of monsoon variability on drought and its consequences, such as fire and smoke occurrence and shortage of water and food supplies, etc. (see contributions by L.Dumenil and A.Timmermann, Max Planck Institute for Meteorology, Hamburg, Germany).

5. Development of new Technologies for Disaster Management

New tools for operational hazard mitigation, monitoring and contingency planning need to be devloped. Some recent activities in technology development are encouraging, e.g. the ongoing construction of the BIRD fire satellite program of the German Agency for Aeronautical and Space Research (DLR) which is a small satellite mission dedicated to the investigation of hot spots (forest fires, volcanic activities, burning oil wells or coal seams), of vegetation condition and changes and of clouds. The launch date of the BIRD satellite will be in 1999. The expected lifetime of 1 to 2 years must be fully utilized for exploring its use in the South East Asian fire and volcanic environment. The project should deserve first priority within an upcoming Indonesian-German technology cooperation program. The results of the BIRD program will have a major influence on the development and financing of a global fire satellite program.

6. Towards a National and Regional Program on Climate Variability and its Cosequences on Natural Disasters

During the 1997 drought the first fire management projects in Indonesia have been proven successful. The Integrated Forest Fire Management (IFFM) Project in East Kalimantan was able to issue fire hazard alert to the provincial government of East Kalimantan as early as 2 August 1997. Consequently the provincial government released warnings and issued burning and forest utilization restrictions and was more efficiently prepared than other provinces which do not yet have similar systems available.

However, the 1997 smoke episode in South East Asia has revealed that Indonesia is not yet ready to fully respond to climate extremes. A science and technology program and a disaster mitigation and management action plan must be developed with high priority. The proposed establishment of a center for climate prediction, crop estimation and disaster mitigation must receive the full support by the government of Indonesia and international partners.

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