Remote Sensing verification by Aerial Surveys and Ground Truth Campaigns 1997 and 1998 in Central Kalimantan, Indonesia - Peat Swamp Forest, Mega-Rice-Project and Fires

Dr. H.-D.V. Böhm[1] and Dr. F. Siegert[2]

[1]*Kalteng Consultants*
Kirchstockacher Weg 2, 85635 Höhenkirchen, Germ.
Tel.: +49-8102-774848, Fax: +49-8102-774850 Cell phone: +49-170-3161199
e-mail: viktorboehm@t-online.de http://www.rhc.at/kalteng

[2]*Kalteng Consultants and University München*
Luisenstraße14, 80333 München, Germany
Tel: +49-89-7930169, Fax: +49-89-79360713 Cell phone: +49-171-6064514
e-mail: fsiegert@zi.biologie.uni-muenchen.de
http://www.zi.biologie.uni-muenchen.de/institute/zoologie/Siegert/sat/index

Abstract

The overall aim of Kalteng Consultants' research programme, which started in 1995, is an investigation into the evolution and the economic potential of the peat swamp forest (P.S.F.) resource in Central Kalimantan by remote sensing techniques. A multispectral and multitemporal image analysis has been used to monitor the environmental importance and agricultural potential as well as wildlife conservation aspects. This report gives information about field trails to Central Kalimantan in March 1997 and in June and Nov. 1998.

Typically, the natural vegetation that is found in most tropical peatlands are rainforest trees of commercial value, e.g. Ramin. Selective harvesting is probably the most sustainable use of this resource, but when more destructive developments take place, sustainable harvesting can no longer be practised. The current status of forestry on tropical peatlands needs to be determined - especially defining the different categories of forests, e.g. production forest, conversion forest, protected forest, along with forest policies on logging and other activities.

The 1 Million ha (Mega)-Rice-Project for rice cultivation, which included transmigration schemes, started with a feasibility study and, in April 1996, with the digging of the irrigation channels into the peat swamp. The development of an area of one million hectares in Central Kalimantan, situated between the Rivers Sebangau in the west, River Kahayan, River Kapuas and River Barito in the east, and the Java Sea in the south, is planned and partly realised. The total area of impact is 1.4 million hectares for the Blocks A, B, C, D and E. The project faces problems of peat domes with a height up to 10m between the main rivers.

Satellite-images of the heavy forest fires in Autumn 1997 in Central Kalimantan has been processed. To undertake global monitoring/survey in a short time, it was essential to use LANDSAT Thematic Mapper, SPOT and ERS1/2 Radar images, linked to a programme of field checking of forest and the status of development of peatland and peat condition. Remote sensing technology was used for all survey, monitoring and planning tasks. This paper presents some of the results from LANDSAT, SPOT, ERS1 and ERS2 image processing activities, from aerial surveys on 13 and 27 June and 3 November 1998, as well as from several ground truth campaigns in 1997 and 1998 (compare with Kalteng report 1996). Between 1995 and 1998, this area of Central Kalimantan was visited 7 times.

All data will be evaluated for the preparation of a detailed peatland analysis to be stored in a Geographical Information System (GIS). This evaluation will take place in the next three years (1999 - 2001) within the framework of a European Union project with 6 international partners.

Introduction and Background

Central Kalimantan covers an area of 153,564 km², which is 28% of the total area of Kalimantan. The southern part of the province consists of lowlands and wetlands (mostly peatland), constituting a total of 36,716 km² or 24% of the total extent of the province. This area comprises 812 km² of coastal plains, 12392 km² of alluvial plains (including floodplains), 1,027 km² of tidal swamps, and 22,485 km² of peat swamps (RePPProT, 1985). The middle and northern belts of the land vary from low-altitude uplands to rolling hills with a height of up to 2,500 m (the Schwaner and Muller Mountains at the northern boundary).

According to a 1995 statistics (Biro Pusat Statistik, 1996), Central Kalimantan has a total population of 1,627,000 and a population density of 11 per km² - very little, compared to an average density of 101 per km² for the whole of Indonesia. Up to the beginning of this decade, it still had huge tracts of pristine and (secondary) logged peatland areas, which is now not the case.

A Presidential decree in June 1995 (No. 82/1995) established the conversion of the Peat Swamp Forest of Central Kalimantan into a rice production area called "Mega-Rice-Project". This project violates the government's own regulations. Firstly, reclamation of peat deeper than three metres is prohibited by Presidential decree No. 32/1990. Secondly, the environmental impact assessment (EIA) which is legally required before the implementation of any project work was not started before April 1996, which was then almost half a year after work had begun on the excavation of a huge channel system and some tracts of forests had been cleared. Drainage of the peat swamp is already affecting the entire area and damaging its ecology (Notohadiprawiro 1998).

Droughts, forest fires and famine were the logical results of such activities. In 1997, Central Kalimantan was one of the three main regions in Indonesia where forests and peatlands were burning. The "Mega-Rice-Project" had a major concentration of "hot spots" because burning for land clearance had been started at the onset of the dry season. In June 1997, months before fires and smog had become a serious health hazard to millions of people in South-East Asia, the areas upstream of the reclamation project had already suffered serious food shortages. A marked drop in the water-level of major rivers, and hence lack of water for irrigation, combined with smog-caused poor visibility which hindered food transport, made the planting of crops impossible. By September/October 1997, famines were reported for the entire area.

Purpose of the Survey and Ground Truth Campaign

The purpose of the missions was to verify the classified signatures of the satellite images in the peatland areas of Central Kalimantan and to monitor the rapid changing of the landscapes. Intensive ground truth checking is necessary for an accurate impression of the landscape, its vegetation, animal life and human inhabitants.

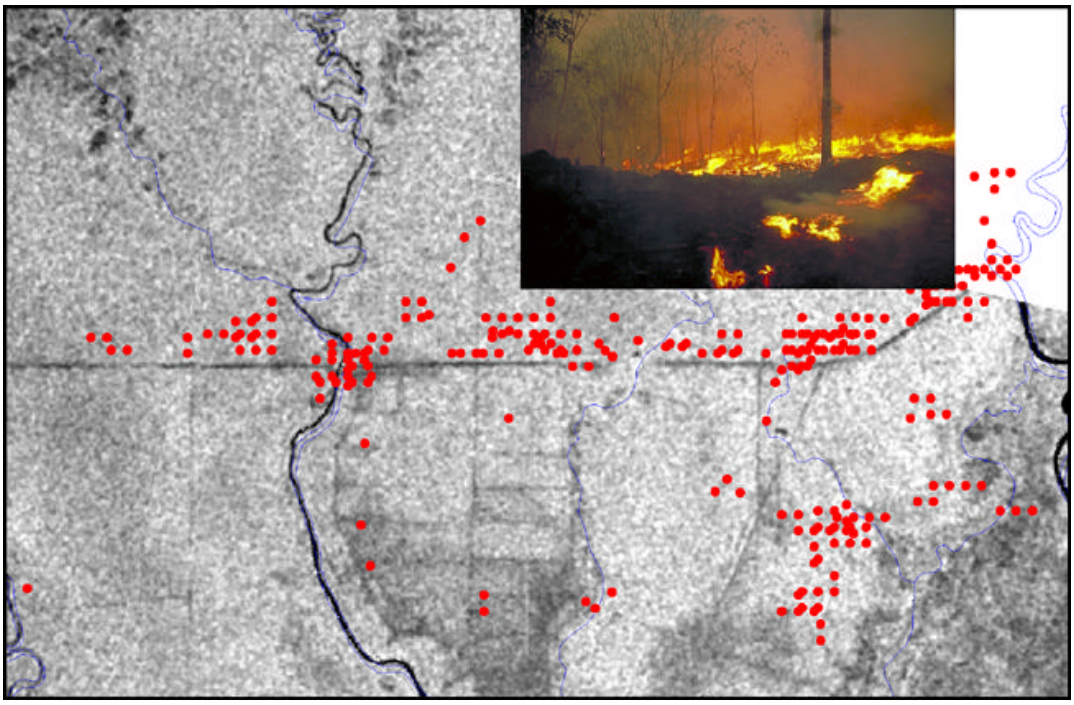

Fig. 1: ERS-image mosaic taken on 2 and 18 Sept 1997. Mega-Rice Project Area with Parent Primary Channel between Kapuas and Barito and NOAA AVHRR Hot-Spots acquired between January and April 1998 by IFFM, Samarinda

Fig. 2: Map of Kalimantan/Borneo. The red cross indicates the location of the Province Capital Palangkaraya.

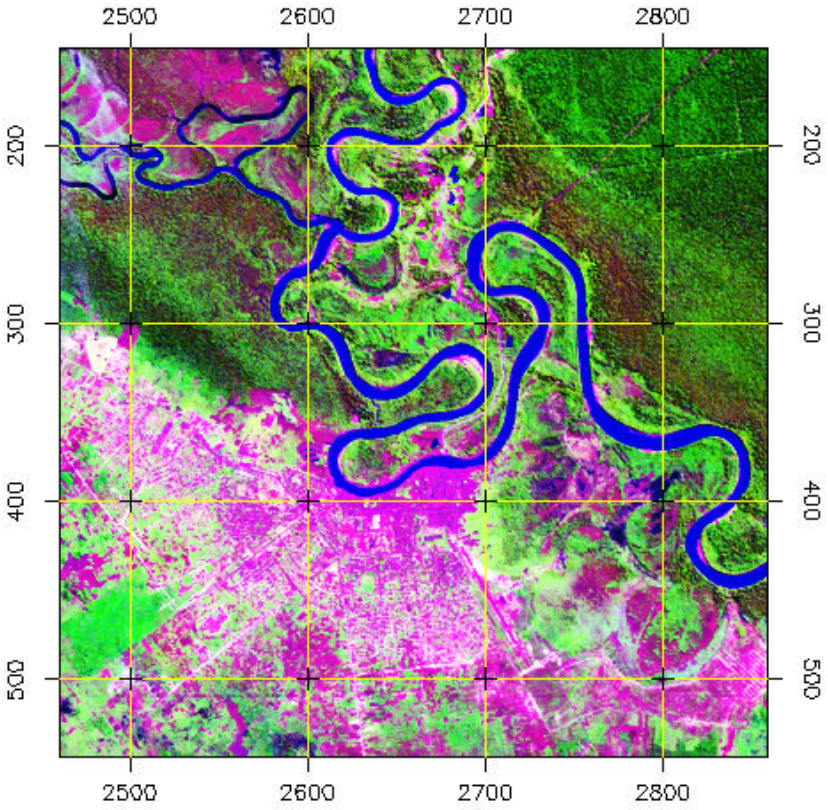

Fig. 3: Geocoded LANDSAT-TM image from 8 July 1994, RGB = 542. (12km x 12km). It shows Palangkaraya, the river Kahayan and a small part of river Rungan. Red means settlement, dark-green P.S.F. A 3km x 3km grid is superimposed.

The peatland area around the province capital Palangkaraya is largely extended and the forest type is peat swamp forest (P.S.F.). P.S.F. is grows mainly on quartz sand (podzol) from the Java Sea up to the heath forest belt in the northern area, covering a band of approx. 150km to 200km. The landscape is very flat and partly affected by coastal flood plains, in which the northward tide from the Java Sea is felt inland up to 50km – 80km. Where the soil changes and the ground becomes hilly, highland dipterocarp forests start. Along the main rivers are *ladangs* (slash and burn) built by Dayaks for rice cultivation on alluvial soil in slash and burn technique. In general, the forest is secondary logged and many areas are clear-cut. Only the northern mountain region has greater locations of unaffected primary tropical forests.

The different areas of interest can be reached by the rivers and the existing roads, some of them in very poor conditions due to rain and flooding. With a permit, the forest concession and the interior of the P.S.F. can be reached by rail-lorry. The parallel structure of these rails is visible on the satellite images. Better and easier survey is possible from a plane – a bird's view compared to a frog's view from the ground. Photographs and/or video images of the different P.S.F. types and forest quality have been stored for research work.

Another purpose of the mission was to distribute information about Central Kalimantan gathered by remote sensing from multitemporal satellite images. During the 1997 campaign, Dr. Böhm gave four RS presentations between 9 March to 9 April: for the Research Division in the Transmigration Ministry in Jakarta (14/3), during the national seminar "Scientific Implications of the Development of tropical Peatlands" in Palangkaraya (19 - 22/3), during the

National Indonesian Peat Conference in Pontianak (HGI, 24/25 March) and during the "Workshop and Seminar GIS" organised by Forestry Research Institute Samarinda, ODA, Kayu Mas and Cifor, at Wanariset Sangai in camp 48 of the Kayu Mas Concession north of Tumbang Sangai (30/3 - 5/4).

The next trip to Indonesia took place between 9 and 28 June 1998. A presentation was given at the Forest Ministry in Jakarta (INTAG department), and another at the "BIG 98" meeting in Bali. On 13th and 27th June, flights were carried out over the peatlands.

Between 26 – 29 Oct. 1998 Viktor Böhm and Florian Siegert visited Jakarta for the presentation of RS-papers**,** (Böhm 1998; Hoffman & Siegert 1998; Siegert & Kuntz 1998), during the International Conference on Data Management and Modelling Using Remote Sensing and GIS for Tropical Forest Land Inventory, Jakarta, organised by FIMP – EU/IFSSP and INTAG. A visit to Central Kalimantan followed. Several field trips with 4 wheel-drives, motor bikes and boats were undertaken. A survey flight took place on the 3rd Nov., using continuous GPS-measurements.

On 11 Nov.1998 a paper "The Fundamental role of Remote Sensing in the DARTROP and EUTROP Projects" was presented during the workshop for the EU-project at the UNI-Palangkaraya, Kalimantan (UNPAR).

Remote Sensing Methods

This large-scale survey will apply sophisticated techniques of remote sensing, using the Synthetic Aperture Radar (SAR) satellites ERS-1/2 (EU) and JERS-1 (Japan), which are able to penetrate the clouds that frequently cover this part of Kalimantan. Results obtained from remotely sensed vegetation as well as peat and land use mapping will be linked to extensive field surveys, ecological studies and laboratory analyses within the frame of the EU-project. Natural, secondary, developed and degraded peat swamp forest (P.S.F.) will be investigated. Species will be documented, compared and evaluated while peatland area, peat thickness, geochemistry, hydrology and hydrochemistry, forest sub-types and structure, tree biomass and nutrient dynamics will be determined for the purpose of understanding the ecological processes and natural resource functions of tropical peatlands and the impact of development thereon. Special emphasis will be placed upon the socio-economic values of both developed and undeveloped P.S.F. and the question of how these can be catered for within strategies for environmentally sustainable management.

Image Processing

a.) Processing of LANDSAT TM Images:

For LANDSAT TM image processing, well-established methods are used.

1. Image preparation (tape reading, file format conversion, basic enhancement)
2. Geometric correction according to BAKOSURTANAL maps (Peta Rupabumi Indonesia) and GPS measurements
3. Image enhancement, analysis of different TM band combinations
4. Identification of training areas (Sungai Sebangau)
5. Supervised classification
6. Final editing of classified images after ground truth evaluation
7. Map production

8. Plotting of maps
9. Photographic reproduction of LANDSAT image with CIRRUS Printer

b.) ERS SAR Processing:

ERS-1 SAR PRI (GEC) data were used. Data are read from Exabyte tapes or CD-ROMs using a public domain software tool provided by DLR Oberpfaffenhofen. This software allows calibration of raw data towards σ°-values directly during data input from the tapes. Image processing is done in several steps:

1. Reading Exabyte tapes or CD-ROMs of ERS-1 GEC data
2. Calibration (and Geocoding) according to BAKOSURTANAL maps (Peta Rupabumi Indonesia) and GPS measurements
3. Reduction of 16 bit data to 8-bit data for increased processing speed and data handling.
4. Mosaic of (several) adjacent ERS SAR scenes
5. Speckle reduction
6. Filtering and RGB image production
7. Principal component transform to identify temporal changes
8. Digital delineation of principal land use classes in two ERS-1 image sets (1996, 1997 and 1998)
9. Map production
10. Plotting of maps

Image Classification and Verification by Aerial Survey and Ground Truth Campaigns

a.) LANDSAT TM Images

LANDSAT TM images are interpreted by visual inspection as well as by semi-automatic classification schemes, e.g. supervised classification. Preliminary results show that a large number of vegetation types and land use classes can be distinguished in the available LANDSAT TM scenes.

1. Peat swamp forests of varying types of species composition, canopy structure, leaf colour, tree height etc.
2. Flooded swamp forest
3. Lowland *Dipterocarp* forest
4. Heath forest
5. Mangrove forest
6. Water hyacinths and floating grass
7. Alang-Alang grassland
8. Burnt forest
9. Shifting cultivation
10. Transmigrate areas
11. Bushland
12. Bare soil
13. Plantations
14. Water bodies
15. Settlements and roads
16. Selectively logged forest
17. Different intensities of logging
18. Clouds and the shadow

b.) ERS SAR Images:

The project relies on visual interpretation of optimised SAR-images, as no operational automatic classification procedure for SAR-images is known to achieve similar accuracy as skilled human interpreters. We expect to be able to classify the following vegetation types and land use classes by processed ERS SAR images:

1. Undisturbed primary forest (at least three types): Peat swamp forest on thin and thick peat layers and lowland *Dipterocarp* forest
2. Secondary forest.
3. Shifting cultivation and agriculture.
4. Alang-Alang grassland
5. Selectively logged forest.
6. Settlements and Transmigration areas.
7. Clearcuttings for plantations
8. Water bodies and irrigation channels

We anticipate that it will be possible to distinguish peat swamp forest communities according to their canopy structure and their different leaf size, leaf water content and canopy roughness. This will make an estimation of the depth of various peat layers possible. Results thus obtained can then be compared to LANDSAT classifications.

Radar backscatter is influenced by an object's geometry (roughness) and its humidity (dielectric constant). Differing surface roughness impacts on backscatter characteristics and, therefore, on image texture. Unprocessed "raw" images show topographic features and major water bodies only. Without texture analysis, even the classification of simple features such as forest/non-forest becomes difficult. In processed ERS-1/2 SAR images it is possible even to discriminate forest types due to the structure of the canopy.

Signature Analysis

A detailed signature analysis of texture features will be undertaken in SAR images, while land use and vegetation classes will be analysed by LANDSAT TM images. This analysis will demonstrate the separability of different landscape classes and the temporal stability in the ERS SAR time series. Furthermore, a quantitative comparison of the satellite images with the results of ground truth campaigns will be conducted in several training areas.

Sensor Fusion

The two data sets complement each other in spatial and spectral resolution and in availability.

1. in areas where clouds obscure LANDSAT TM images
2. in areas covered by peat swamp forest (for testing the ability of the radar sensor in distinguishing forest types)
3. for verification of change detection information detected by the radar sensor. (By overlaying ERS SAR GIS information on older LANDSAT TM images it is possible to identify former vegetation covers and land use with high accuracy).

Change Detection by Multitemporal Analysis

a.) LANDSAT images:

In areas where two LANDSAT scenes are available, supervised classifications will be compared quantitatively in order to identify changes in land use and vegetation cover.

b.) ERS SAR images:

Multitemporal RGB images will be produced by change detection techniques such as assigning the texture features of the earlier images to one channel, texture features of the last image in the time series to the second channel, and the mean of all available speckle filtered images to the last channel. From these composite images change detection maps will be produced in which all major changes in land use patterns become evident.

By applying principal component transformation to processed ERS SAR images, the change between two successive data sets will be quantified. Principle component transformation reduces the amount of data significantly and highlights major land use changes in the 6th component. These changes are mainly related to recent clearcuts and shifting cultivation.

In a third approach, the two GIS layers obtained by digital delineation of the enhanced ERS SAR images will be compared quantitatively. This gives detailed information about the changes of land use classes which occurred during the two year period of our survey.

Geographical Information System - GIS

The results of the different image processing steps and of the ground truth campaign will be stored in a GIS database (ARC-INFO/ARC-VIEW format as used by Indonesian authorities).

1. Planning and delivery of a general database for land use planning and monitoring in peat areas. This will consist of several layers:
   a. Mapping level: optical LANDSAT TM images as the basis for vegetation and land use mapping, scale 1:50 000 or 1:100 000;
   b. Monitoring level : ERS SAR images as the basis for change detection monitoring, scale 1:100 000;
   c. Geographic maps: peat depth, agricultural potential, soil types, forest types, infrastructure, settlements;
2. Storing of all available ground truth and aeroplane/helicopter information in separate layers;
3. Analysis of the different levels of this database and combination for planning purposes.

Geographic and Ecological Profile of the P.S.F. in Kalteng

Overview over the P.S.F. Area in Kalteng

Indonesia has a large amount of tropical peat (between 17 and 27 Million.ha), located mainly on three islands, Sumatra (8.2 (4.6) Mha), Kalimantan (6.8 Mha) and Irian Jaya (4.6 (8.7) Mha) (compare with Rieley and Page 1995). The age of the peat varies from several hundred years up to 10,000 years. In the last few decades, the area of the peat has been

shrinking due to land use conversion. High amounts of stored carbon were thus released into the atmosphere.

Waters draining from P.S.F. are dark-brown to blackish and acidic (pH-value 3 to 4). Peat accumulates in domes with a thickness of 12 to 15 meters and flows from watersheds to the main rivers. Peat forests have a specific ambience and many different animal sounds are heard. Large, undisturbed P.S.F. still boast strong Orang Utan populations. Temperature in the forests is moderate and under closed canopies, seldom exceeds 28°C. There is noticeable wind circulation in the afternoons. Soil and water have a constant temperature of approximately 23 - 24°C. Tree and fish species are adapted to the acid water. Special breathing roots stick out of the water to absorb oxygen.

According to the LANDSAT image from May 1996, (Fig. 4) the size of the original P.S.F. between the rivers Katingan and Barito is estimated as covering approximately 1.8 Million ha (1995). This amount has been drastically reduced within a few short years by land use conversion. The remaining, relatively untouched area is located between the rivers Katingan and Sungai Sebangau, but even there, illegal logging has caused a lot of damage.

Blocks A, B, C and D faced the biggest changes in the last 30 months by clearcuts and forest fires (see Fig. 10). Even in Block E (above the Parent Primary channel, connection between Kahayan, Kapuas and Barito), the construction of a 10km long channel has started. A recommendation that this area be protected and conserved as refuge for animals (e.g. Orang Utan) and forest products has been forwarded to the Indonesian authorities (Rijksen, et al 1998).

It is now estimated that up to one billion tons of carbon were released during the fires of July-October 1997. This equals the entire European output of one year. Burning and oxidised peat is largely responsible for these huge releases. An estimated 2 to 4 billion tons of carbon is stored between peat-layers in the "Mega-Rice-Project". Research data show that carbon sequestration and storage in the forests of Central Kalimantan is among the highest recorded sustained values anywhere in the world. The rate of accumulation in tropical peat forests in Indonesia has been found to be between 228 and 668 gC/m² year (58%C). Indications are that the erosion of peat in the "Mega-Rice-Project" will irreversibly affect the climate of the whole of Kalimantan and will influence the world carbon budget in meteorological climate models.

Mega-Rice-Project and Irrigation Channels

The development in Indonesia of wetlands for sawah rice cultivation is not new. Decades ago, coastal wetlands in Sumatra and Kalimantan were opened and settled by Bugis from South Sulawesi, Banjars from South Kalimantan and Malays from Riau, East Sumatra and West Kalimantan. They selected land along the broad, natural estuaries and avoided deep swamps and peat soils. Tidal movements in the estuaries were spread laterally by a network of simple, hand-dug channels. Using tidal movements, the indigenous people succeeded in cultivating sawah rice, albeit on a modest scale, on a 1 - 2 km wide strip alongside the estuaries. By present standards the yield was a meagre 0.8 Mg/ha harvest once a year. This Banjarese system became known as "sawah bayar".

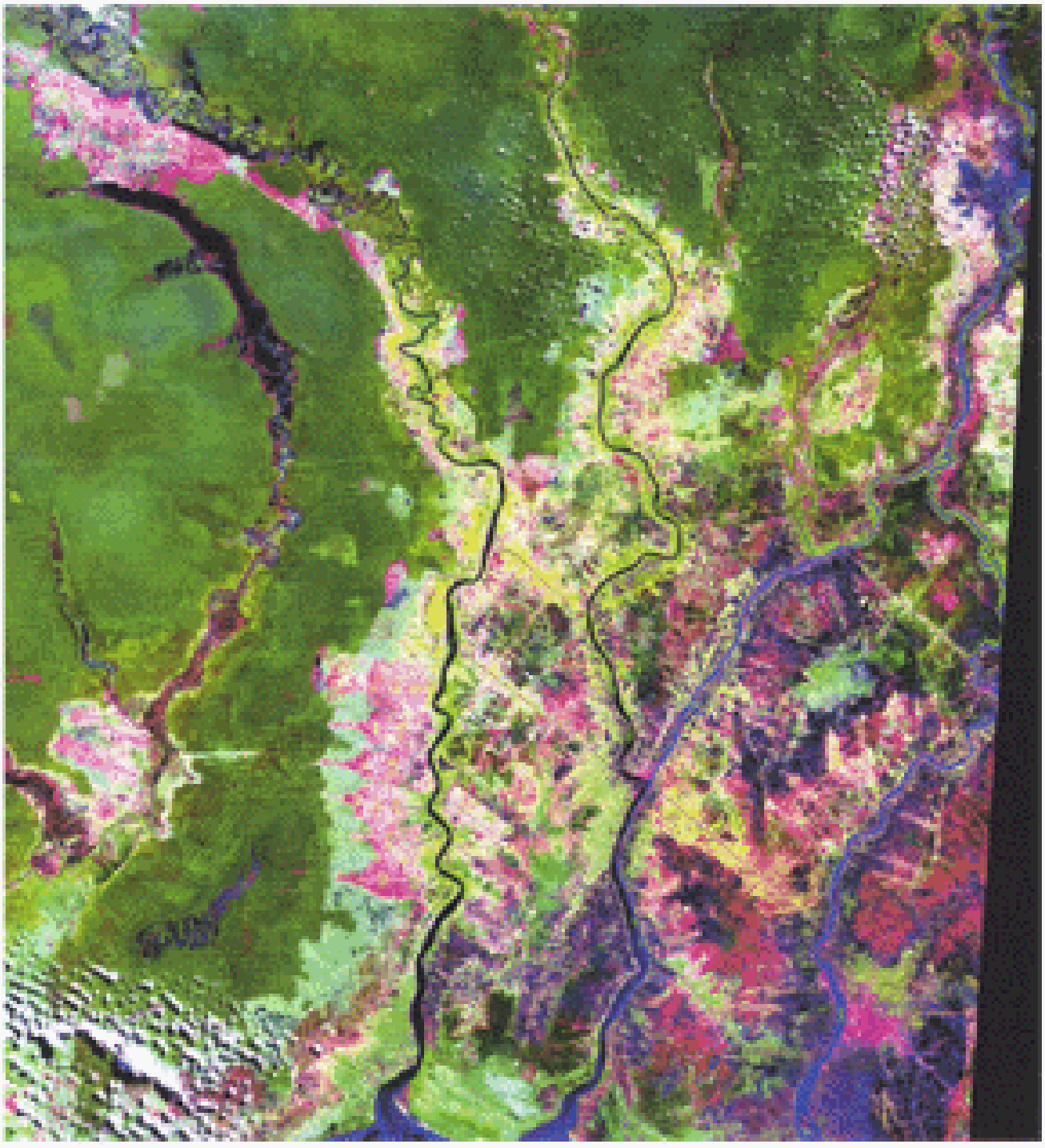

Fig. 4: LANDSAT TM image (118-62, 10 May 1996, RGB = 542, Image size 125km x 150km) showing the peat swamp forest area and the 1 Million ha rice project, the transmigration areas and the four rivers Sebangau, Kahayan, Kapuas and Barito (from left to right). This channel combination enhances agricultural land use classes. The city of Banjarmasin is located at the lower right corner of the image (pink colours). Note the irrigation channels between the rivers Kahayan, Kapuas and Barito. Small Dutch-made irrigation channels are visible near Lamunti, Dadahup and Palingkau.

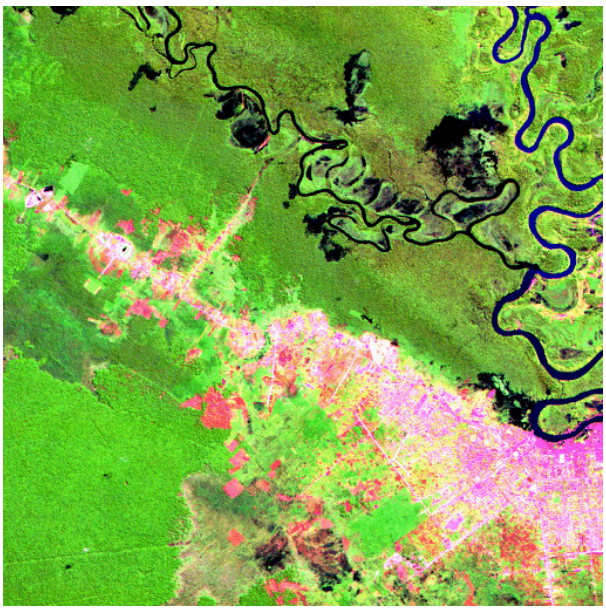

Fig. 5: LANDSAT TM image **(**24 July 1994, RGB = 542) showing the province capital Palangkaraya with the rivers Kahayan and Rungan. Green indicated P.S.F., red indicated clear cuts. (Image size 15.4km x 15.4km; File: 94_ORIG.bmp).

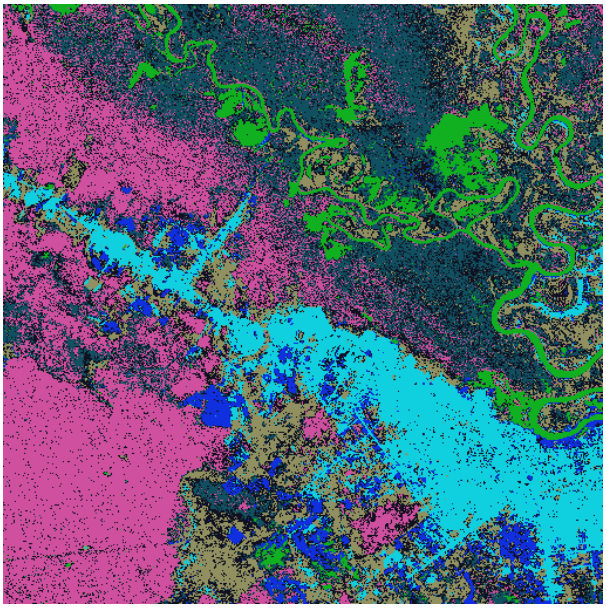

Fig. 6: Classified LANDSAT TM image (24 July 1994). Processing with a neuronal net classifier shows 6 different classes: Green = water bodies/rivers(1); pink = primary-/secondary P.S.F.(2); blue = clear cut, open ground(3); light-blue = settlements(4); grey-blue = swamp area(5), brown = bush land/ alang alang (6). (Image size 15.4km x 15.4km; File: 94_NEU.bmp).

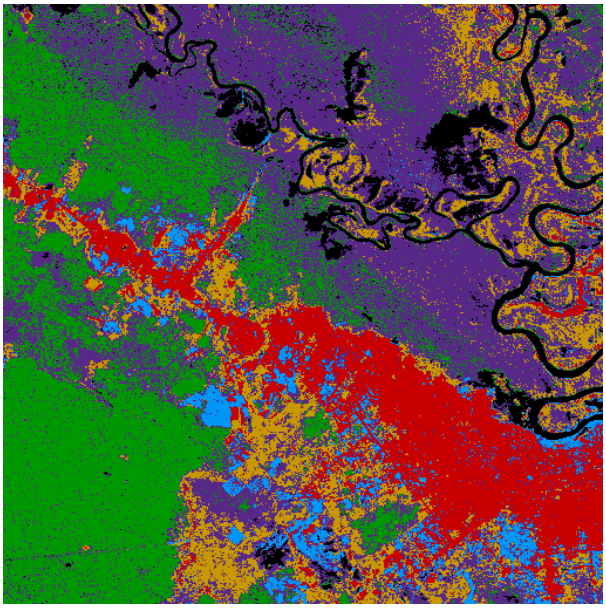

Fig. 7: Classified LANDSAT image (24 July 1994). Processing with a minimum distance classifier shows 6 different classes: Black = water bodies/rivers (1); green = primary-/secondary P.S.F. (2); light-blue = clear cut, open ground (3); red = settlements (4); violet = swamp area (5), brown = bush land/ alang alang (6). (Image size 15.4km x 15.4km; File: min-onne.bmp).

The success of this system attracted genuine interest in the Netherlands Indies government. Channels connecting big rivers such as Barito, Kapuas and Kahayan were built across their common delta plains. These channels were also meant to provide waterways and to make the area between the cities of Banjarmasin, Kuala Kapuas and Palangkaraya accessible. The first channel in Kalimantan, *Anjir Serapat* (anjir = Channel), was finished in 1890, connecting the rivers Kapuas and Barito and spanning a distance of approximately 28km . A second channel, *Anjir Basarang*, and also approximately 28km long, connects the rivers Kahayan and Kapuas.

The big scale sawah rice field "Mega-Rice-Project" was initiated in 1995 by Presidential Decree No. 82. (Development of One Million Hectares of Peatland for Food Crop Production in the Province of Central Kalimantan, Peat reclamation). It is also known as "Peat Area Project" or "Proyek Lahan Gambut – PLG". The settlement of 350,000 families into this area was planned by the Ministry of Transmigration. Up to now, approximately 13,000 families were settled in the Dadahup – Lamunti region, facing the hard conditions of clear-cut areas.

Parent, main, secondary, third and quarter level channels for irrigation and transport were built at a very fast pace from Spring 1996 to 1998. Over 4000km of channels were built in just two years, using 225 million US $ from the Indonesian reforestation fund.

Table 1: Channels of the Mega-Rice-Project

Parent Primary Channels	(PPC: 110km)	2x25m surface width, 15m bottom width, 6m deep
Main Primary Channels	(MPC: 1129km)	25m surface width, 15m bottom width, but only 5m deep
Secondary Channels	(SC: 964km)	15m surface with, 10m bottom, 3m deep
Tertiary Channels	(TC: 900km)	6m surface w., 4m bottom, 3m deep
Quaternary Channels	(QC: 1515m)	4m surface w., 4m bottom, 3m deep

Taken from Notohadiprawiro, T. (1998)

During our amphibious-plane flight on 13 June 98 we passed the following points (Figs.8, 9): from Palangkaraya eastwards along the PPC (Blocks B and A) up to the Barito, then in a southerly direction to the Dadahup Transmigration Location, to Palingkau Lima and Baru, Kuala Kapuas, then westwards along the Anjir Basarang (Block D) to Pulang Pisau (with the Catchment Sungai Sebangau on the left side) and over Block C along the MPC back to the Kahayan at Palangkaraya. Total flight time: 2h 30min and 400km flight distance.

The 110km long Parent Primary Channel (actually consisting of two parallel channels) is located exactly alongside latitude 2°15' south; only towards the Kahayan it bends south and at the Barito it bends north. There are four sluices: one where it begins at the Kahayan, two at the crossing of the Kapuas, and one where it ends at the Barito (see figs.9, 10, 15). At present, they are not equipped with water-pumps for irrigation. Where possible, channels are used for the transportation of tree trunks. The two channels were planned to have a width of 25m at the surface and 15m at the bottom, with a depth of 6m. The reality is different - see chapter 4.6. During flights and ground checking it became obvious that the PPC is not working properly. The difficult task of building channels through peatdomes of up to 10m high has not been mastered as yet. On several stages water-barriers were constructed in peat where sluices would

have been necessary. At some points the water-level of the PPC is less than 2m, as opposed to the required 6m. The crossing of the PPC with the black-water river Mentangai caused further problems. The opening of P.S.F. in this area since 1995 changed the height of the water table and the hydrology. It enabled loggers to make inroads into the remaining forest left and right of the PPC. Large parts of the forest burned during the 1997 fires, causing severe financial loss.

In dry and intermediate periods, even the combined waters of the main rivers are insufficient for irrigating the "Mega-Rice-Project"; a waterflow of between 150 - 500m³ per second would be necessary. But such waterflow would be likely to damage channels built into the peat. Furthermore, for agricultural purposes water quality would have to improve to a pH value of 5 - 6. Untouched P.S.F. has an average value of pH 3.8. During the drought of autumn 1997, waters reached an acidity of pH 2, unsuitable for drinking by humans and animals. Several people died.

Through the opening of P.S.F. and conversion into paddyfields, peatdomes shrink and release oxidised carbon gas directly into the atmosphere. Peat itself, even with ample fertilisation e.g. volcanic ash (pugas) and limestone, sustains only pineapples and some types of oil-palms. Mineral storage capacity and water-table are the most important parameters in soil quality. Only alluvial regions with peatlayers no more than 2-3m can be considered for yields of significance. Of the "Mega-Rice-Project" area, no more than 30% meet these requirements.

After the May 1998 riots and subsequent change of government, a rethinking process has taken place within the Indonesian government and World Bank (see letter to Ministry of Public Works). An advisory commission (Tim Pengarah Pengembangan Lahan Gambut) has handed over a recommendation paper to President Habibie in early Sept. 1998.

The "Mega-Rice-Project" and many other transmigration sites are now disaster areas created by incompetence or greed on a level that is difficult to fathom. Action-plans to reverse inflicted damage would attract moral and financial support of many international donors.

Table 2: Water parameters

Samples	**1.Kahayan**	**2.Rungan**	**3. P.S.F.**	**4. Rungan Sari**	limited values
pH-value	**5.6**	**3.9**	**3.3**	**5.8**	6.5 – 9.5
conductivity mS/m	2.1	2.2	6.5	2.2	?
Pb in µg/l	<10	<10	<10	<10	40
Cd in µg/l	<2	<2	<2	<2	5
Cu in µg/l	<5	<5	<5	<2	approx.2000
Ni in µg/l	<10	<10	<10	<10	50
Hg in µg/l	<0.2	<0.2	-	-	1
Zn in µg/l	10	5	9	4	2000

The pH-value was measured by Ralf Trenkle, München, on four sample plots. Water samples from: 1) Kahayan at Palangkaraya, 2) Rungan at Sei Gohong, 3) P.S.F. between Tangkiling and Palangkaraya, 4) the Nursery of Rungan Sari.

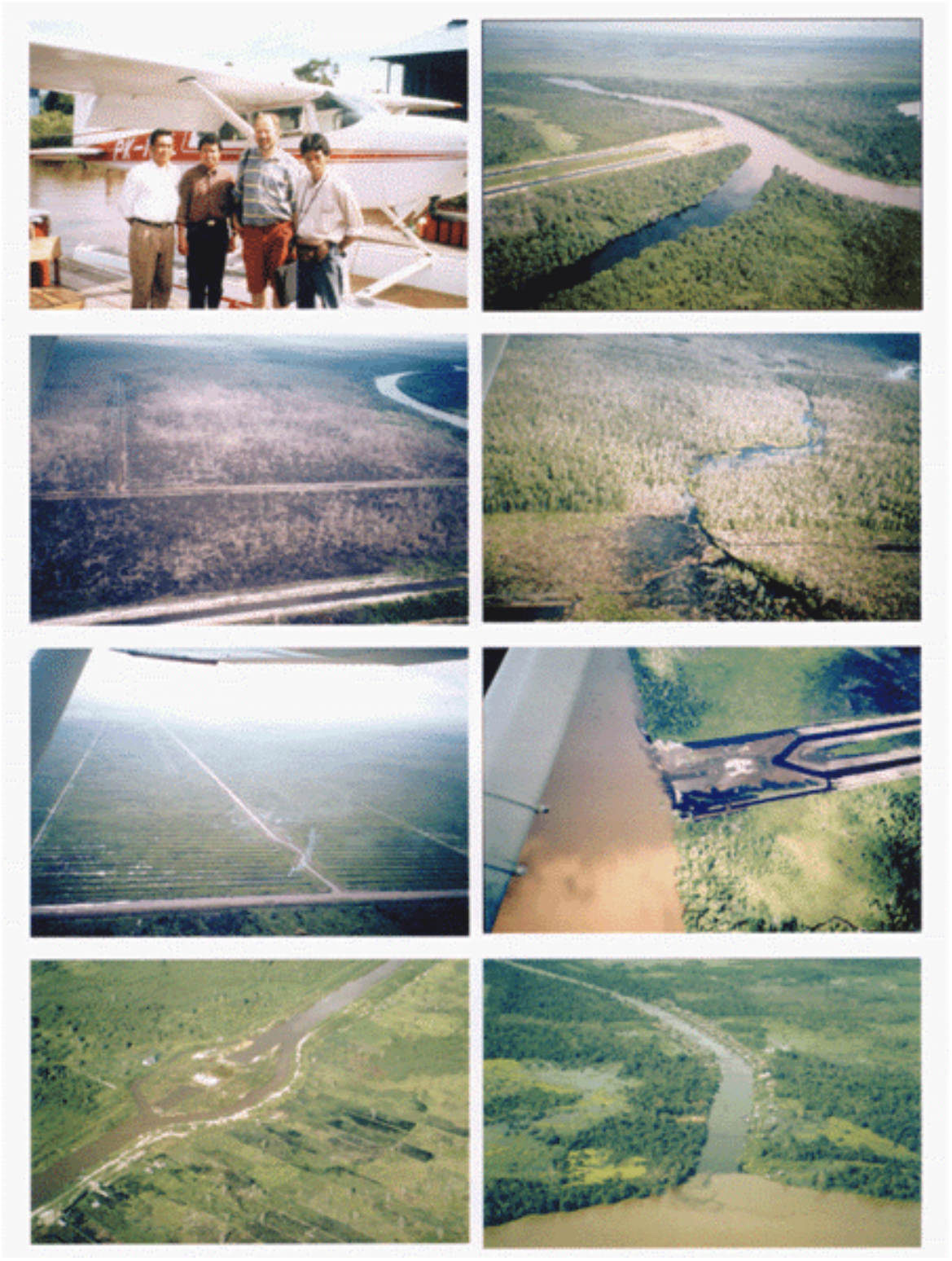

Fig. 8: Aerial Photos acquired during a flight on 13 June 1998. A: Staff from UNPAR, B: PPC sluice at Kahayan, C: PPC and burnt scars at Kapuas, D: PPC and black water river Mentangai, E: Channels and Transmigration area in the Mega-Rice-Project, F: PPC, sluice and Barito, G: Channels with sluices, H: Kapuas Murung and Mengkatip.

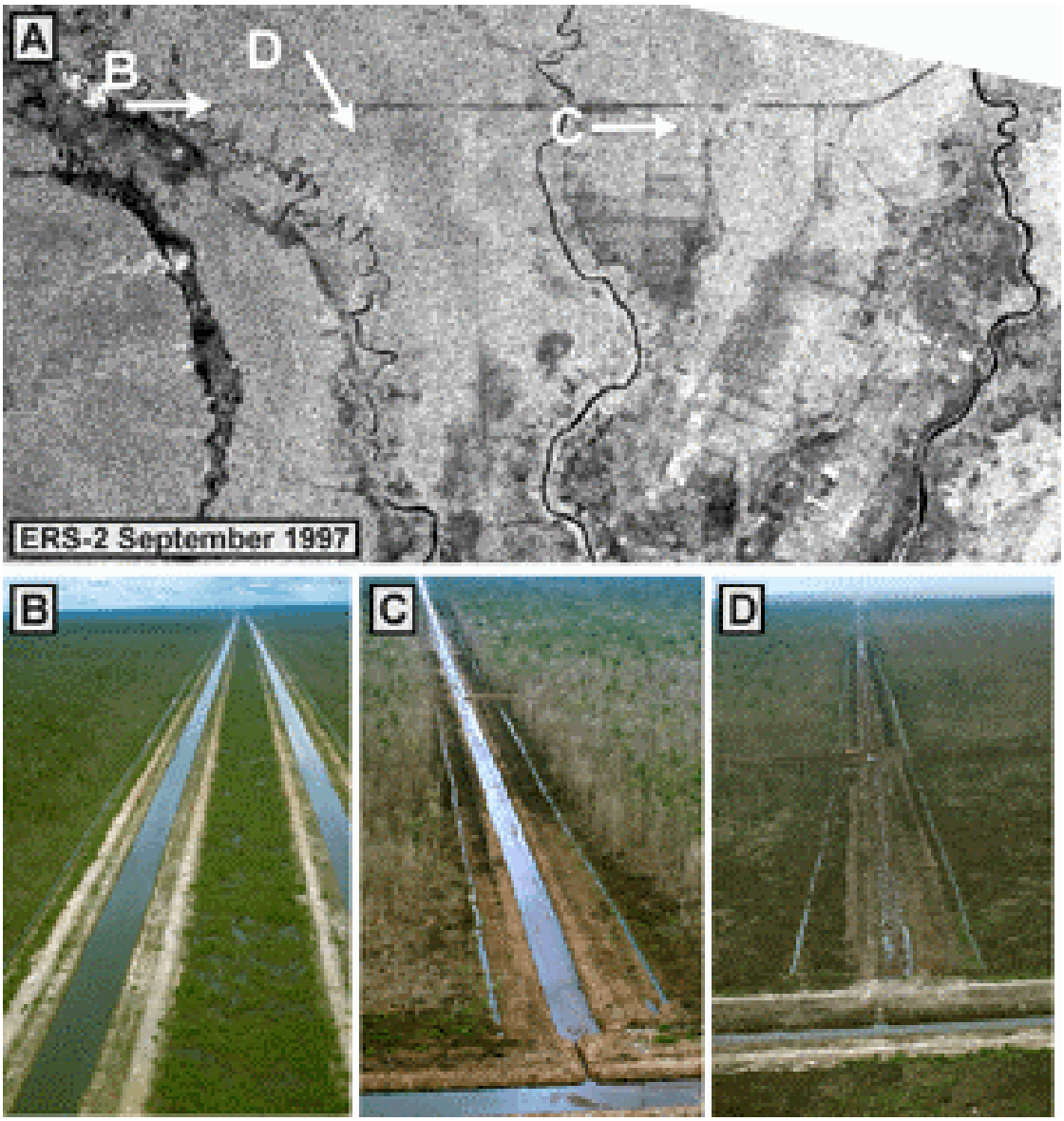

Fig. 9: Irrigation channels of the 1 Million ha rice project**. A:** Gamma map filtered ERS-image mosaic showing irrigation Channels (PPC, MPC, SC, TC) of the "Mega-Rice-Project" at the river Kapuas region. (ERS images acquired 18 Sept. 1997 and 2 Sept. 1997). **B**: Main Channel, 110 km long, **C**: Side channel filled with water near Kapuas river, **D**: Dried out side channel in the centre of the peat dome between Kahayan and Kapuas river. Burnt scars are visible along the channels.

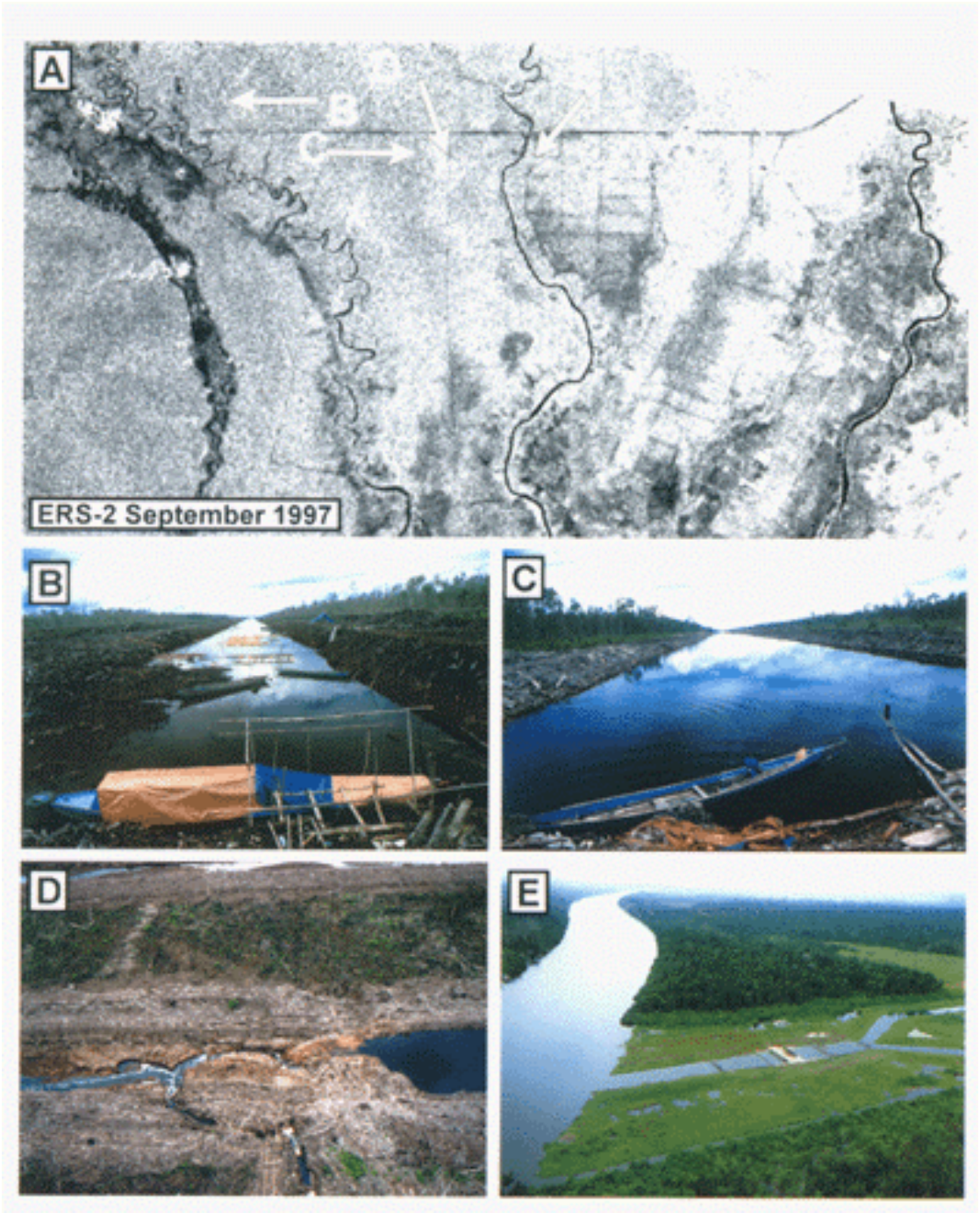

Fig. 10: Irrigation channels and peat barriers. **A**: ERS-image mosaic showing irrigation Channels (PPC, MPC, SC, TC, ERS image 18 Sept. 1997 res. 2 Sept. 1997). The arrows indicate the location of the ground photographs. **B**: Main channel viewed from a peat barrier towards the Kahayan river (approx. 15km from the river). Note the high peatdome and the low water level. **C**: The same channel viewed from the peat barrier in opposite direction towards Kapuas river. Note the high water level behind the barrier. **D**: An opened up peat barrier near Kapuas river. Without functioning barriers the centre of the peat dome dries out completely, most trees die. **E**: PPC-Sluice at Kapuas.

Notice the variation in pH-value from 5.8 at Rungan Sari (clear water) to 3.3 in P.S.F. Mercury (Hg) values are very low in the Kahayan and Rungan rivers, thus only few small scale gold miners are attracted to the area. Small amounts of Zn are present in the water.

P.S.F. in Setia Alam Jaya Concession and Sungai Sebangau

The *Setia Alam Jaya* Concession is located approx. 12km south of Palangkaraya, opposite to the village of Kereng Bengkirai on the Sebangau catchment. It is the last remaining big secondary logged P.S.F. area extending over the black-water lake Bulan to the Katingan river. Many orang-utan live there. Selective logging was officially discontinued in 1996, and unless regular repairs are undertaken, the rails will rot quickly and become useless for EU research tasks.

This region west of Sungai Sebangau is outside the "Mega-Rice-Project". But Block C, east of the Sungai Sebangau, and at the edge of the fragile P.S.F. has been opened by main and secondary channels (fig.11). We recommend that the conversion of Block C be stopped immediately and Block C be used as a buffer zone to the P.S.F. west of Catchment Sebangau.

Several P.S.F. classes can be analysed in figure 11A: Riverine Sedge Swamp (RSS), Mixed Swamp Forest (MSF), Low Pole Forest (LPF), Tall Interior Forest (TIF), Degraded P.S.F. and Clear-Cuts. The catchment Sungai Sebangau shows up black. A granite hill is seen approx. 18km south-west of the camp. Straight lines are logging rails in the P.S.F.

The area around Camp *Setia Alam Jaya* has been chosen by the EU-project as a natural laboratory. Many P.S.F. data have been collected there by Dr. Jack Rieley (University of Nottingham), Dr. Susan Page (University of Leicester), Ir. Suwido Limin (University of Palangkaraya) and their students (Böhm & Haisch 1996; Rieley, et al 1992; Rieley & Page 1993; Rieley, et al 1995, Rieley& Page 1995; Rieley, et al 1999; UNPAR 1995). An old railroad leads more than 18km into pristine peatland. A small granite hill shows many types of forest vegetation. These have been determined by ground checks and will be used for Satellite image classification on a big scale. The camp also has potential for Eco-Tourism.

Dadahup on Mengkatip and the Barito-Kapuas Murung Area

Apart from Lamunti, Dadahup is the main "Mega-Rice-Project" area to be settled by transmigrates. Irrigation channels were started early 1996 (see LANDSAT image fig.4). On the ERS image from 18 Sept. 1997, the MPC, the SC and the TC can be seen near completion. The draught of 1997 proved a good opportunity to clear the landscape for transmigration settlements by burning. The sequence of SPOT images from 6 June, 27 July and 8 Sept. 97 clearly shows the fire situation.

Aerial photos from 13 June 1998 (fig.8) included here show the many channels dug in connection with the "Mega-Rice-Project". All forest at Dadahup has been cleared and houses of transmigrants have been erected.

During the ground truth campaign on 6 November 1998 we used a boat from Dadahup to follow the Mengkatip some kilometres south. We saw Rattan left and right. Branching off into an SC necessitated a change of boat. After approx. 7km we reached the junction with the

58km long MPC. SC and MPC are separated by barriers and have slightly different water levels. Some new transmigrant villages on moderate peat layers are located along the 7km long SC. Other areas are burnt (see SPOT images Figure 12B) These clear-cuts are a big disaster from the ecological point of view and repeat the damage experienced years ago in the nearby Pulau Petak region (between Kapuas Murung and Barito).

Figure 12A shows a LANDSAT-TM image (10 May 1996) of the Dadahup area and Figure 12B shows a time series of SPOT-images of the same area acquired during the great fires in autumn 1997. The SPOT images were downloaded from the CRISP-homepage. The first image was taken on the 6 June 1997 before the fires. Areas covered with healthy vegetation (all peatland) show up in red or pink, while bare soil or sparse vegetation areas show up in various shades of green. River Barito cuts through the image at the Dadahup area from North to South (approx. 30km x 40km). West of the river (Dadahup area), irrigation channels show up as a grid of pale green lines, enclosing a large plantation. The second image was taken on the 29 July 1997. Many smoke plumes rise from burning vegetation in the plantation area. A few smoke plumes can also be seen to the east of the river, which could be fires started by small farmers or spontaneous bush fires. The third image was taken on 8 September 1997. The smoke haze has lifted on this day revealing the extent of damages. Red/pink areas in the previous images have turned to dark green indicating the results of two month of burning. The 1997 drought proved a good opportunity to clear the land for transmigration settlements. Systematic land-clearing by fire was still in progress in 1998.

Fires and Drought Hazard, Burnt Scars in 1997 and 1998

Rainforest often grows on very poor soils, which allow only 1-3 years farming every 20 years. If these forests are removed either by large scale cutting or by uncontrolled forest fires, as has happened in 1982/83, 1987, 1994, and 1997 in Kalimantan, it will take centuries until a new forest with similar species diversity grows again. In moderate climates, in contrast, a forest with similar species composition and diversity as before will regenerate within 10-30 years, even after clear felling. In many areas, exploitation and conversion of tropical rain forest proceeds uncontrolled and at an increasing rate. Up to now, mainly optical satellite images and aerial photos were evaluated to analyse changing patterns in land use. A major disadvantage of optical images for operational planning and monitoring is the frequent cloud coverage in tropical regions; the all-weather-capacity of SAR is a major advantage for land surface monitoring under these conditions.

Central Kalimantan had a heavy concentration of hot-spots in 1997 because the dry season started a frenzy of burning for land clearing. Food shortages occurred in June 1997 and the the areas upstream of the Mega-Rice-Project had already suffered serious food shortages. The drop in the water table made planting and growing crops almost impossible. In fall 1997, famines were reported for the entire area. (Compare Figs. 12 and 13, NOAA hot-spots are presented in Figure 14A).

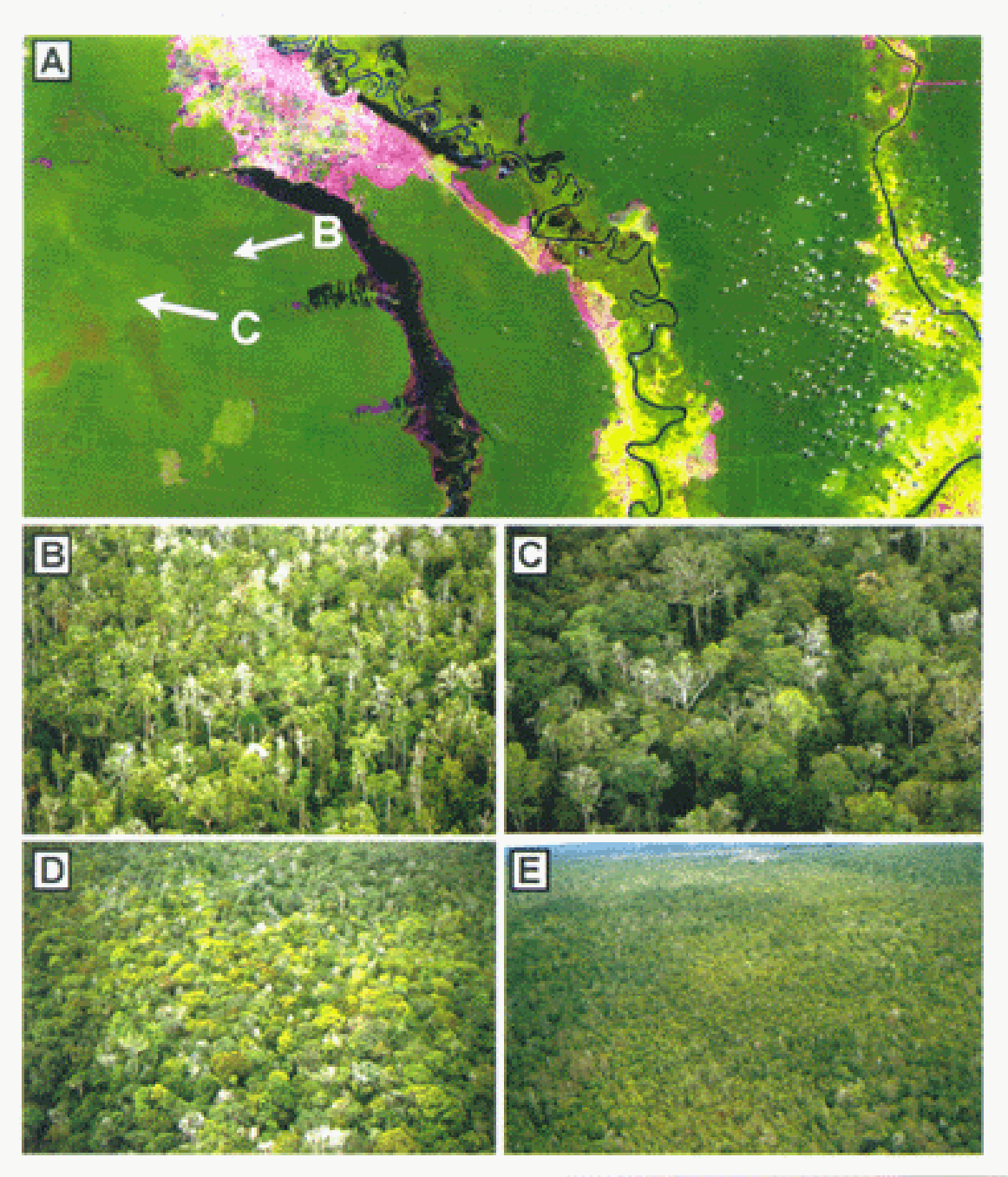

Fig. 11: Different peat swamp forest types (P.S.F.)**. A:** LANDSAT TM image (118-62, 10 May 1996, RGB = 543) showing Palangkaraya and the surrounding peat swamp forests. A close look reveals different shades of green within the peat swamp forest, which can be related to different types of forest and likely to peat thickness. The arrows designate the location of the aerial photographs. **B:** Low pole forest (~20m high) near catchment of Sungai Sebangau **C**: High peat swamp forest (~40m high) near the centre of the peat dome. **D**: Heath forest (~20-30m high). **E**: Mixture of peat swamp forest and heath forest to the north of Palangkaraya.

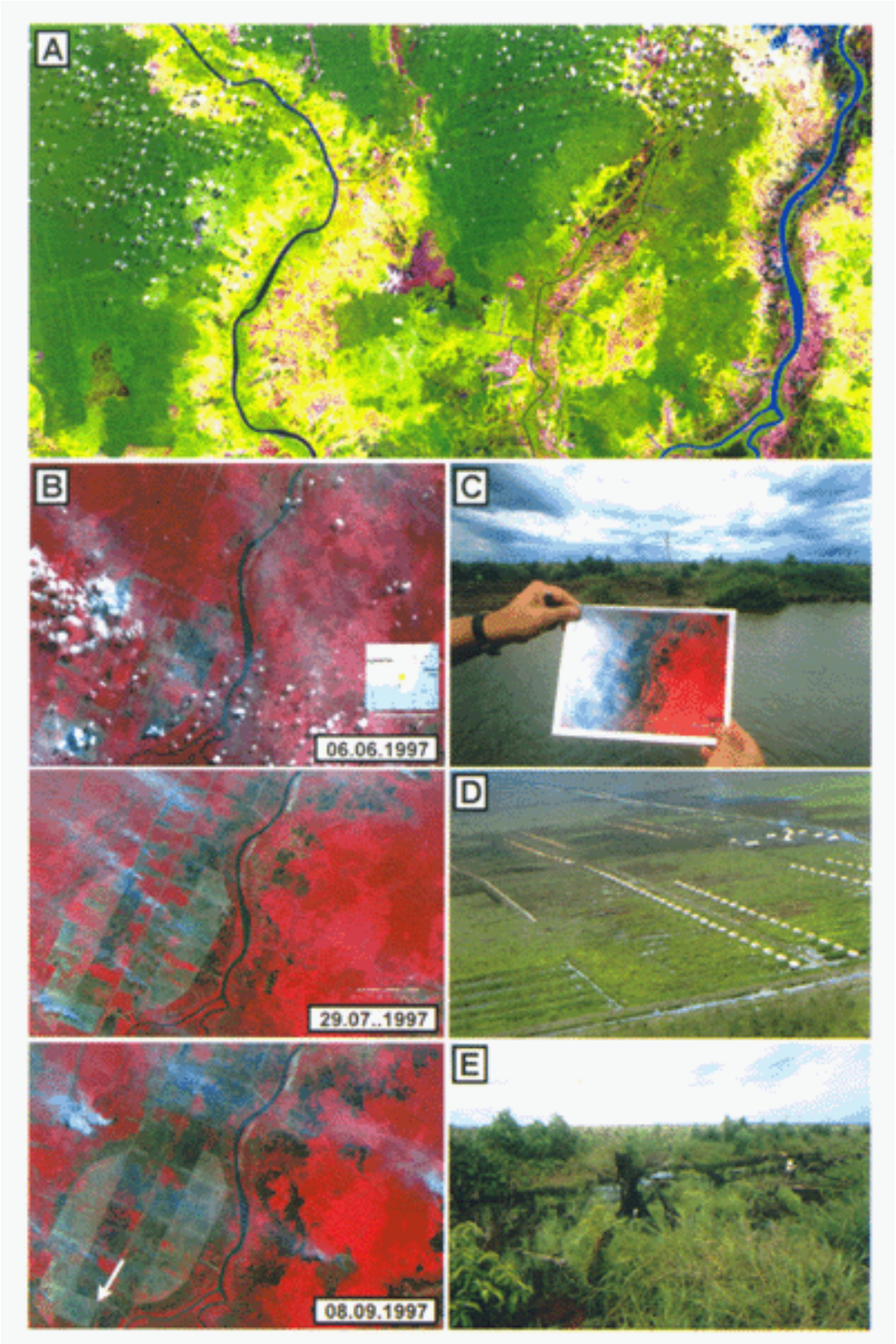

Figure 12: **A:** LANDSAT-TM image (10 May 1996) showing the Dadahup area between Barito and Kapuas river. **B**. A time series of SPOT-images (acquired by CRISP) of the Dadahup area acquired during the great fires in autumn 1997 (compare the rivers in A + B, see text). **C:** Ground survey in the Dadahup area, location indicated by arrow in B. **D:** New irrigation channels and transmigration houses in this area. **E:** One year after the fires.

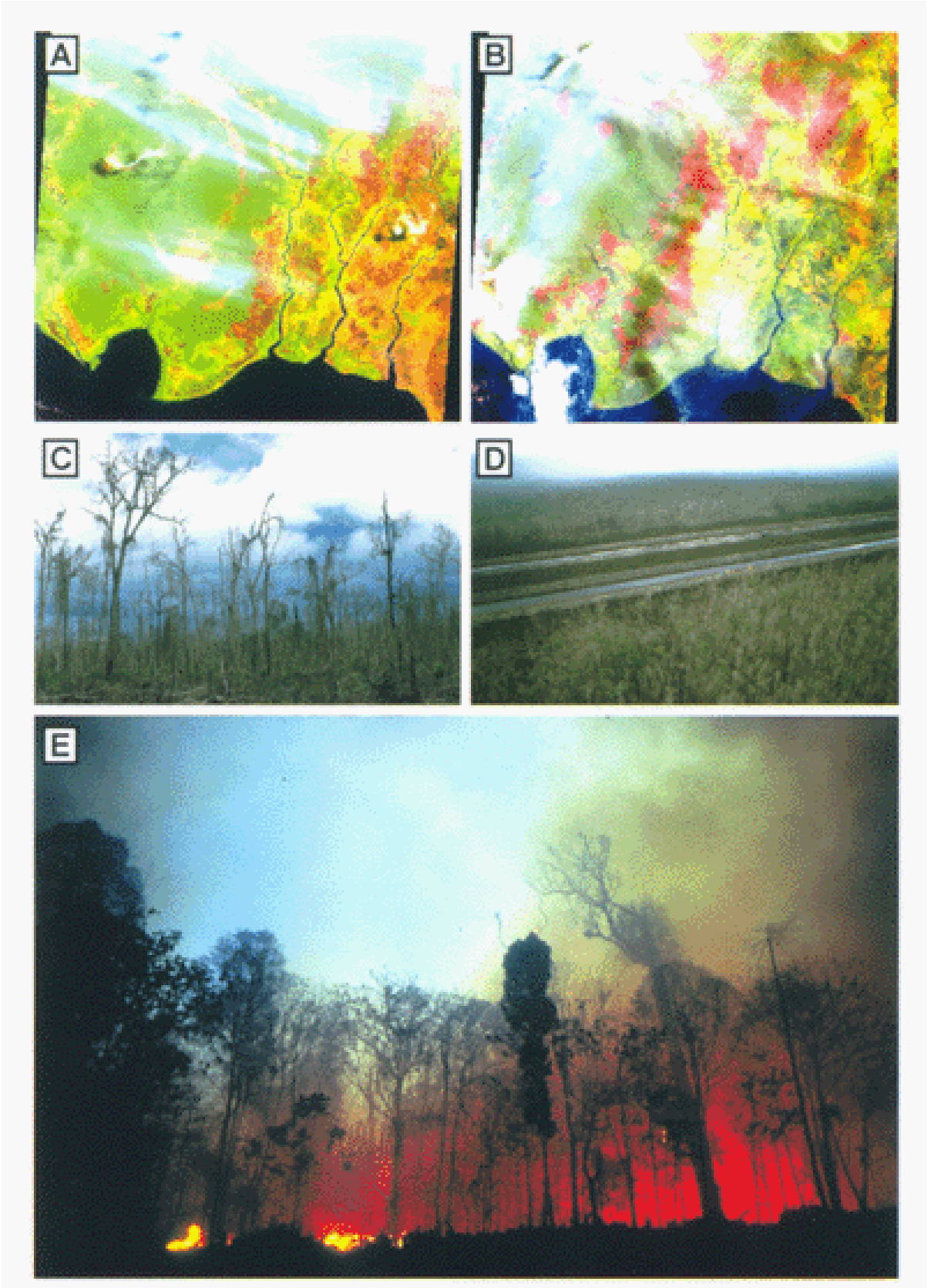

Fig. 13: **A:** LANDSAT-Quicklook acquired during the fires (2 Sept. 1997, 118-62). **B:** LANDSAT-Quicklook acquired 6 months after the fires (29 March 1998, 118-62). Red areas indicate burned P.S.F. Approx. 700,000 ha have been burned. **C:** Burnt trees along a side channel. **D:** Burned forest along the Main channel. **E:** Fire inferno in Kalimantan.

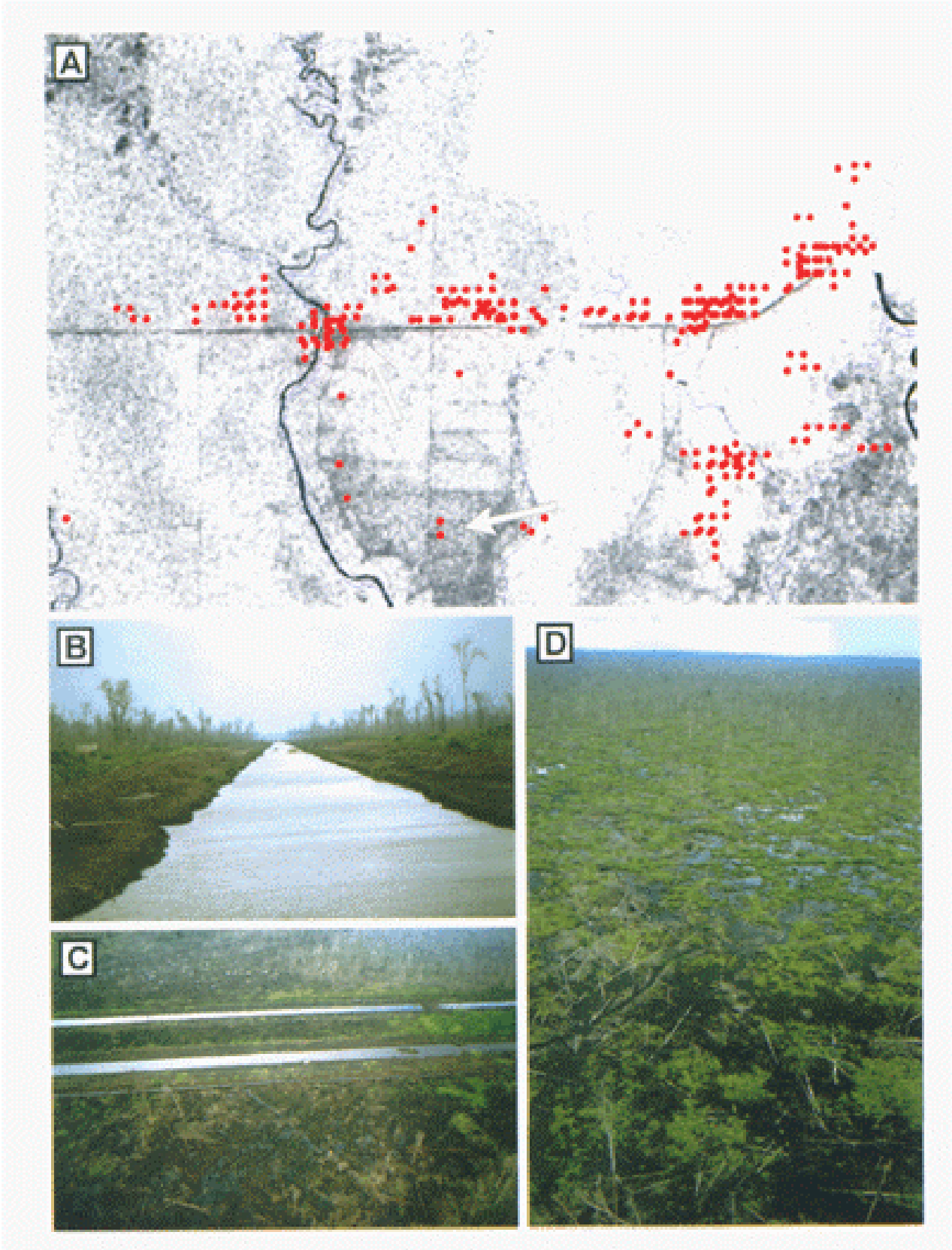

Fig. 14: A: ERS-image (18 Sept. 1997) with the Main channel and NOAA AVHRR hot-spots (red dots) acquired between January and April 1998. Received and processed by IFFM (Mrs. Anja Hoffmann) in Samarinda (Kaltim). **B:** Irrigation channel and burnt trees. **C+D:** Totally destroyed P.S.F. along the main channel, location of D indicated by arrow in A.

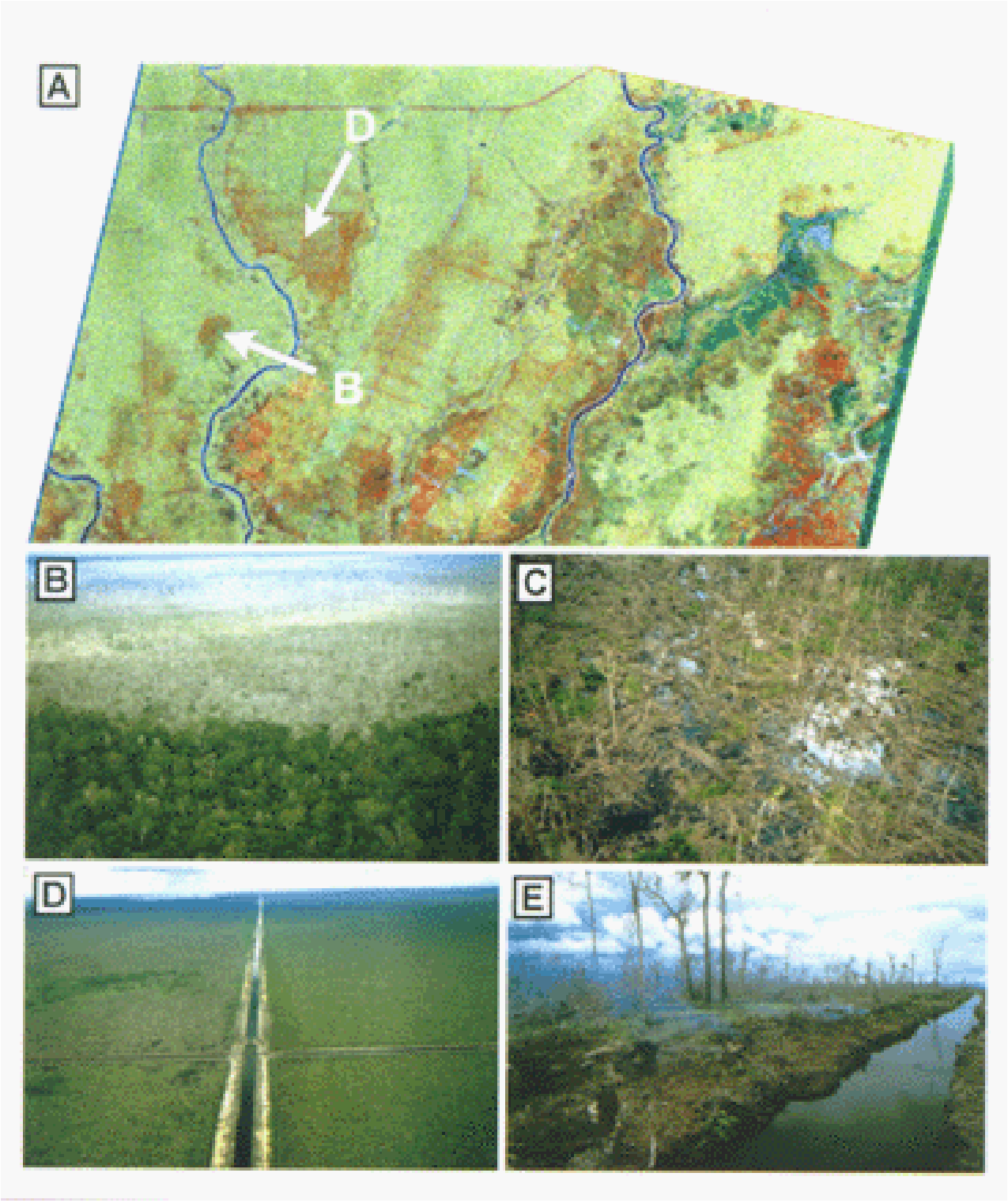

Fig. 15: A: ERS Change Detection image (7 Nov.1996 and 18 Sept. 1997) of the 1 Million. ha rice project between the rivers Kapuas and Barito. Burnt scars appear in reddish colours. Compare aerial photos as indicated by arrows. **B:** Burned scar. **C:** Totally destroyed P.S.F. **D:** MPC and SC crossing each, no trees remain. **E:** Spontaneous farming along side channels.

Economic Crisis

Since July 1997 the value of the Rupiah (Indonesian currency) has fallen from Rp. 2,450 to approximately Rp. 10,000 against the US dollar. At more than 400%, this is the steepest currency devaluation among all countries in Asia affected by the crisis. Being on the brink of economic collapse in January 1998, the Indonesian government had no choice but to accept dramatic policy changes and austere measures imposed by the International Monetary Fund (IMF) in exchange for a $43 billion bail-out package. Among these are 10 provisions that affect the forest sector directly or indirectly.

The economic crisis is changing the configuration of forest land-use. On the one hand, the timber sector is experiencing decreasing demand for its exports. This will alleviate some of the pressures on Indonesian forests from unsustainable harvest rates and poor harvesting practices in recent years. On the other hand, it is possible that this will be more than offset by increased demands for forested land conversion from outside the forest sector, due to the economic crisis.

The severity of the economic crisis forced President Suharto to step down from power on May 21, 1998 after 32 years as head of state. Suharto's successor, B.J. Habibie, has promised to support the IMF policies and to implement reforms that would, among other aims, eliminate the rampant practice of corruption, cronyism, and nepotism that characterised Suharto's New Order regime. If these reforms are implemented, they will have far-reaching consequences for the way Indonesia's forest sector is managed.

Recommendations and Findings

Peatland ecosystems are not only amongst earth's most important ecosystems, but are also well known for their extreme fragility. Their huge carbon storage is well known. Local communities have traditionally cultivated rice in that part of Central Kalimantan for many years, but on shallow peatland and on a very limited scale and without significantly affecting the environment.

As a result of investigations and consultations conducted over a two-year period with indigenous people and a large number of Indonesian and international agricultural, soil and ecological scientists, it was concluded that:

1. Draining peat swamp will change the local climate and hydrology of the province in an undesirable way (e.g. periods of prolonged drought and flash floods).
2. The burning of peatland will release unacceptable amounts of carbon dioxide into the atmosphere.
3. Last year's peatland and forest fires in this part of Kalimantan are the logical result of the drying-out of the area due to draining the deep peat (between 2 and 20 metres thick) and the use of fire as the cheapest method of land clearance.
4. The risk of similar fires - with the severe consequences for people's health, economic activity and the environment - will increase in years to come.
5. The soil, hydrological, ecological and social conditions of the region make it highly unlikely that the planned production capacity of the area can ever be attained.
6. Rice cultivation will require massive inputs of limestone, fertilisers and soil supplements to counteract the acid, infertile soils.

7. The ability of farmers to pay for the large amounts of pesticides and other agrochemicals required is highly questionable.
8. The ill-planned drainage scheme makes the conservation of unique areas of peat-swamp forest and their biological diversity impossible.
9. Reclamation work on this scale requires more thorough planning and sophisticated management to deal with inherent ecological constraints and to minimise environmental and socio-economic risks than was hitherto applied.
10. For the conservation of the environment in Central Kalimantan it is best to fill in the parent primary channel (PPC) and establish a protected area in Block E. A buffer zone in Block C should be established to protect the P.S.F. area in the west of Sungai Sebangau. The Setia Alam Jaya area should be conserved as P.S.F. eco-system. The building of additional channels should be stopped.

Conclusions

Satellite images from 1997 compared to those from 1996, 1994, 1993 and 1991 show quick conversion of Peat Swamp Forest areas into land use regions, some of which are left uncultivated. Roads and a system of irrigation channels with a total length of more than 4000km give loggers unprecedented access to cut every tree. After commercially viable trees have been cut, smaller ones of a diameter of 10 – 20 cm are not spared. Selective logging, although required by government law, is hardly observed. Countless floats transport timber over black-water lakes and along channels and rivers. Huge areas of ecologically damaged peat-landscape are visible from the air.

Drought and/or low water-tables cause trees to die. Frequent fires give forests no time to recover and the tropical climate causes quick overgrowth by ferns and alang-alang, and etc. Most of the Kalteng fires in 1997/1998 were man-made. Huge amounts of stored carbon were released into the atmosphere. Peatland destruction is an irreversible process.

The soil of the proposed "Mega-Rice-Project" is largely unsuitable for the plantation of rice fields due to the big peatlayers found there. The normal peat pH value is between 3 and 4. The huge peatdomes between the main rivers Kahayan, Kapuas, Barito and Sebangau pose massive problems for the hydrology. The region is drying out, the water table is low, problems of water-management remain unsolved. The big PPC between Kahayan, Kapuas and Barito (KaKaB) provides no irrigation and only has a draining effect.

Since the 1960s, experiences in Kalimantan have shown the difficulty of creating agriculture on thick peat soil, especially without the acid-reducing influence of the tide, e.g. in the following areas: Pulau Petak, Pangkoh 1-9, Berengbengkel, Marang, more recently Transsambadep, Palingkau baru and km 38 at Tangkiling.

The eco-sociological aspects caused by large-scale transmigration are unsolved. Most transmigrants lack skills and experience with peatland. Furthermore, they are poor. They work under hard conditions and have no possibility to return to their origins. The "Mega-Rice-Project" destroyed the habitat of many small and large animals. Planning was done by bureaucrats with disastrous results. 225 Million US$ of the Central Government's reforestation fund were spent on the "Mega-Rice-Project". The winners were the forest industry and channel construction companies. After the Indonesian economic crisis of 1997/98 the financial situation became worse. Other public work projects, such as road construction between Kuala Kapuas and Palangkaraya, have been neglected. River crossings by ferries and car damage caused by potholes cost time and money, even though bridges have been constructed over the Kapuas Murung, Kapuas and Kahayan rivers.

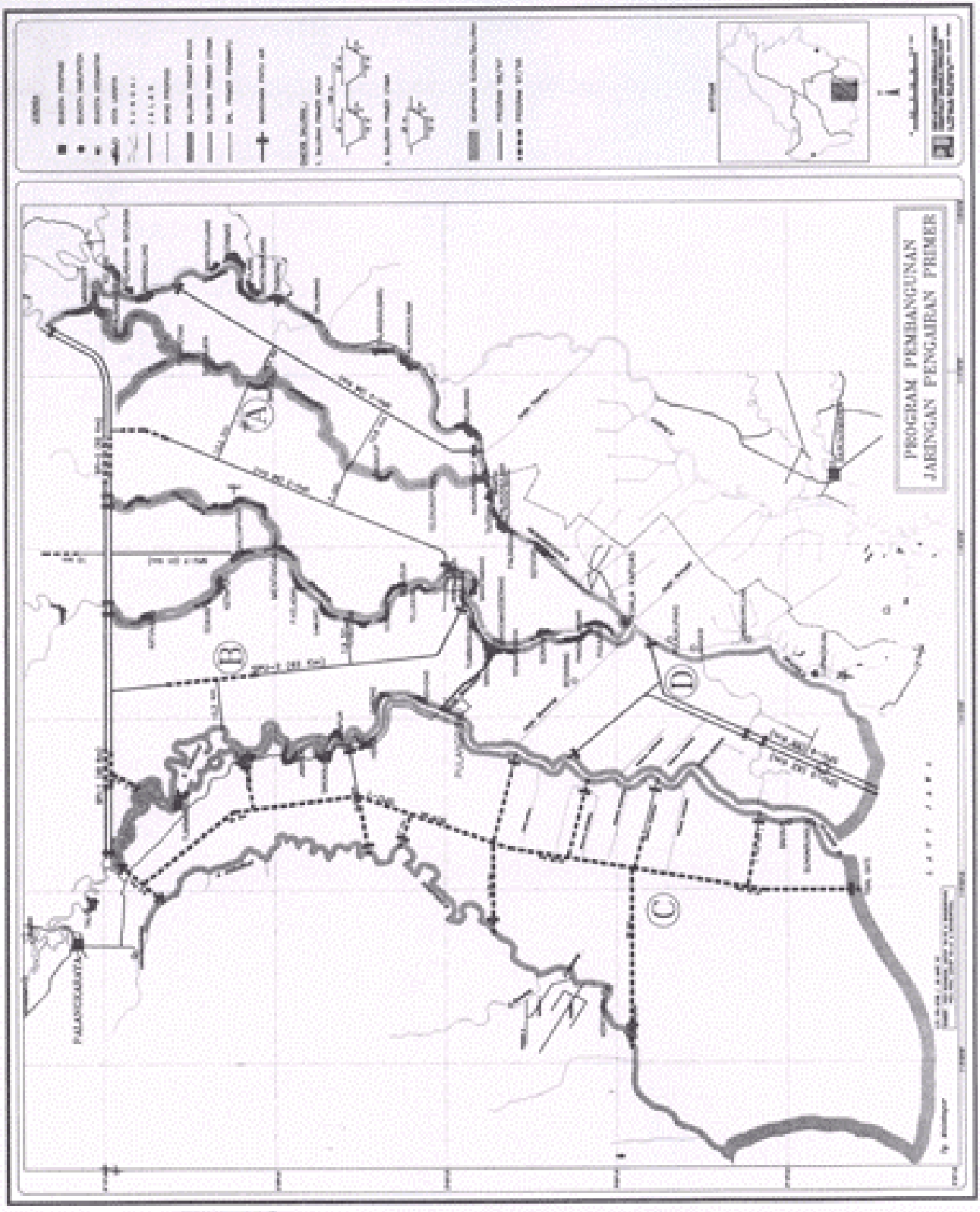

Fig. 16: Construction Map from Public Works (28 March 1997) of the Mega-Rice-Project to convert 1 Million hectares of peatland in the Blocks A, B, C and D.

Abbreviations

AVHRR	Advanced Very High Resolution Radiometer
CIMTROP	Centre for International Co-Operation in Management of Tropical Peatland
CIFOR	Centre for International Forestry Research
CRISP	Center for Remote Imaging, Sensing & Processing
DARTROP	Darwin project of Tropical Peatland
DLR	Deutsche Luft- und Raumfahrt-Gesellschaft
EIA	Environmental Impact Assessment
ENVI	The Environment for Visualizing Images
ERS	European Remote Sensing Satellite
ESA	European Space Agency
EU	European Union
EUTROP	European Project of Tropical Peatland
FIMP	Forest Inventory and Monitoring Project
GIS	Geographical Information System
GPS	Global Positioning System
GTZ	Gesellschaft für Technische Zusammenarbeit
HGI	Himpunan Gambut Indonesia
HTI	Hutan Tanaman Industri (forest crop industrial)
IDL	Interactive Data Language
IFFM	Integrated Forest Fire Management
IFM	International Monetary Fund
IFRIS	Integrated Forest Resource Information System
INTAG	Inventarisasi dan tata guna hutan
JERS	Japan Radar Satellite
JRC	Joint Research Centre
KaKaB	Kahayan, Kapuas and Barito
Kalbar	Kalimantan Barat
Kalsel	Kalimantan Selatan
Kalteng	Kalimantan Tengah
Kaltim	Kalimantan Timor
LPF	Low Pool forest
MPC	Main Primary Channel
MoF	Ministry of Forestry
MSF	Mixed Swamp Forest
NOAA	National Oceanographic and Atmospheric Administration
ODA	Overseas Development Administration, now DFID
ORSTOM	Office de la Recherché Scien-tifique et Technique Outre-Mer
PLG	Proyek Lahan Gambut
PPC	Parent Primary Channel
PSF	Peat Swamp Forest
QC	Quaternary Channel
RGB	Red Green Blue
RS	Remote Sensing
RSS	Riverine Sedge Swamp
SAR	Synthetic Aperture Radar
SC	Secondary Channel
SPOT	French electro-optical Satellite
SW	Soft-Ware
TC	Tertiary Channel
TIF	Tall Interior Forest
TM	Thematic Mapper (LANDSAT)
TREES	Tropical Ecosystem Environment observation by Satellite
UNPAR	University Palangkaraya
UPT	Unit Pemukiman Transmigrasi (Transmigration settlement unit)
4WD	Four Wheel Drive

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Remark: Kalteng Consultants uses the ENVI-IDL, Erdas IMAGINE and ArcView SW-Programmes

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