Interim Report of Aerial Surveys and Ground Truth Campaigns in 1997 and 1998 in Central Kalimantan, Indonesia - Peat Swamp Forest, Mega-Rice-Project and Fires

for the EEC INCO Project

NATURAL RESOURCE FUNCTIONS, BIODIVERSITY AND SUSTAINABLE MANAGEMENT OF TROPICAL PEATLANDS

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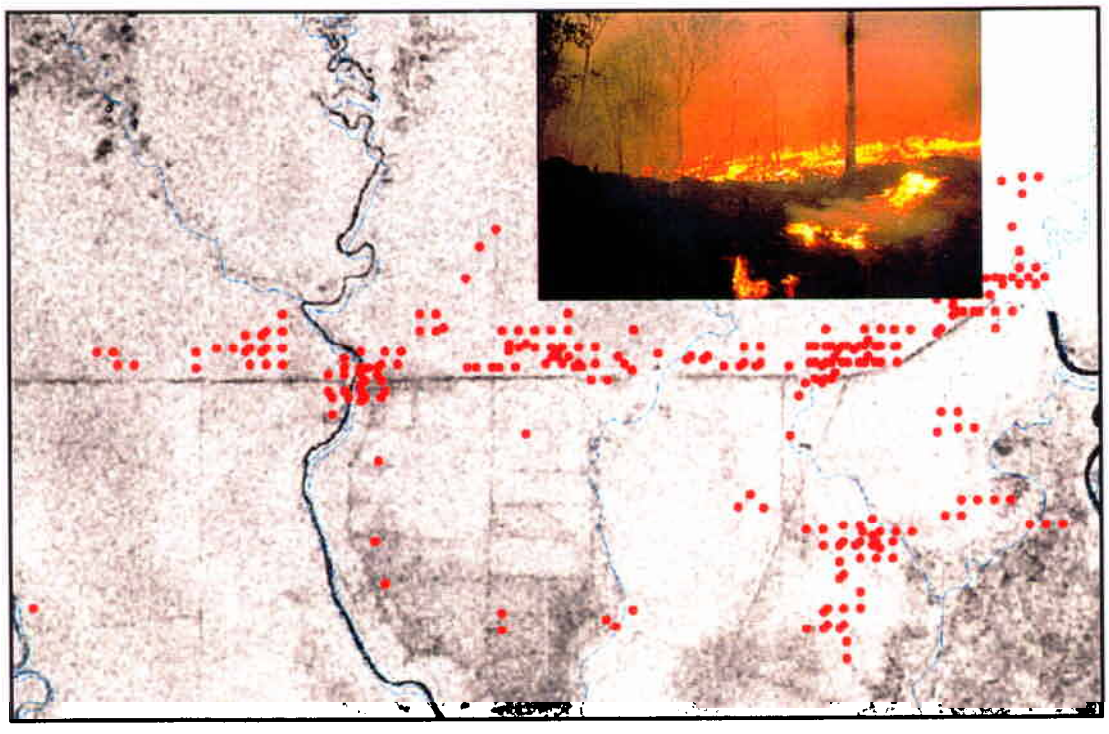

Figure 1: ERS-image mosaic taken on 2 and 18 Sept 1997. Mega-Rice Project Area with Parent Primary Channel between Kapuas and Barito and NOAA AVHRR Hot-Spots from acquired between January and April 1998 by IFFM, Samarinda

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Content

Abstract

The overall aim of this **Kalteng Consultants** research programme (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's about field trails to Central Kalimantan in March 1997 and in June and Nov. 1998.

The natural vegetation of most tropical peatland is **rain forest** containing trees of commercial value, e.g. Ramin. Selective forestry is probably the most sustainable use of this resource, but it is also the principal loser when more destructive developments take place. The current status of forestry on tropical peatland needs to be determined, especially the different categories of designation, e.g. production forest, conversion forest, protection forest together with the policies which govern these and control logging and other activities.

A land-use conversion **1 Million ha (Mega)-Rice-Project for rice cultivation** including transmigration was started by the Indonesian government 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 too.

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, peatland development 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 ref. 2 Kalteng report from 1996). Between 1995 and 1998 this area of Kalteng 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:

Natural Resource Functions, Biodiversity and Sustainable Management of Tropical Peatlands.

1. 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, 1885). 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 total of Indonesia. Up to the beginning of this decade it had huge pristine and (secondary) logged peatland areas which are changing quickly.

A Presidential degree 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 governments own regulations. Firstly, reclamation of peat deeper than three metres is prohibited by Presidential decree No. 32/1990, secondly, the environmental impact assessment (EIA) legally required before implementation of any project work was not started before April 1996, almost half a year after the excavation of a huge channel system had begun and forests were being cleared. Drainage is already affecting the entire area and damaging its ecology (ref.18).

Droughts, forest fires and famine were logical results. In 1997, Central Kalimantan was one of three main regions in Indonesia where forests and peatlands were on fire. The "Mega-Rice-Project" was a major location 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 already suffered serious food shortages. A marked drop in the water-level of major rivers, combined with poor visibility due to smog hindered food transport, and lack of water for irrigation made the planting of crops impossible. By September/October 1997, famines were reported in the entire area.

Several other aspects of the peatland in Kalteng will be discussed in this report.

2. Purpose of the Survey and Ground Truth Campaign

The purpose of the missions was to verify the classified signatures of the satellite images in 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.

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 positioned mainly on quartz

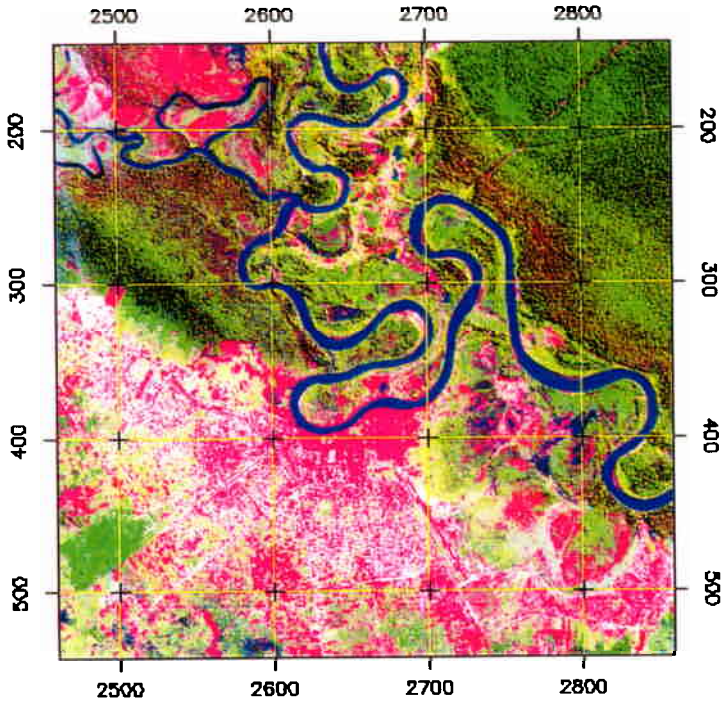

Figure 2+3: Map of Kalimantan/Borneo. The red cross indicates the location of the Province Capital Palangkaraya. Geocoded LANDSAT-TM image from 8 July 1994, RGB = 542. (12km x 12km). It shows Palangkaraya, the river Kahayan and a small part of river Rungan. Red mean settlement, dark-green P.S.F. A 3km x 3km grid is superimposed (File: Gif1.gif and 11862_4.tif).

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 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 streets, some of them in very poor condition due to rain and flood. With a permit, the forest concession and the interior of the P.S.F. types can be reached by rail-lorry. The parallel structure of these rails are visible on the satellite images. Better and easier survey is possible from a plane - birds view compared to frog 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 13 and 27 June flights were carried out over the Kalteng peatlands.

Between 26 – 29 Oct. 1998 Viktor Böhm and his partner Florian Siegert visited Jakarta for the presentation of RS-papers, refs.5, 12, and 33, 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 Jeeps, 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).

3. Remote Sensing Methods and Workpackages of the EU-Project

This large scale survey will apply sophisticated techniques of remote sensing, including the new Synthetic Aperture Radar (SAR) satellites ERS-1/2 (EU) and JERS-1 (Japan), able to penetrate the clouds which 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 peatland 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.

The different workpages used by the remote sensing part in the **EU-project** are described below.

3.1 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 (see figures in report)
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

3.2 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 backscatters are 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.

3.3 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.

3.4 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).

3.5 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.

3.6 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.

4. Geographic and Ecological Profile of the P.S.F. in Kalteng, Aerial Observation and Ground Truth Campaigns

4.1 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 the three islands Sumatra (8.2 (4.6) Mha), Kalimantan (6.8 Mha) and Irian Jaya (4.6 (8.7) Mha) (compare ref. 25). Peat age varies from several hundred years up to 10,000 years. In the last decades the size of the peat area has been shrinking continually due to conversion into land use. High amounts of stored carbon were thus released into the atmosphere.

Peat water is 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 water sheds to the main rivers. Peat forests have a specific atmosphere and many different animal sounds are heard. Large, undisturbed P.S.F. still boast strong Orang Utan populations. Temperature inside 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 approx. 23 - 24°C. Tree types and fish species adapt to the acid water. Special roots stick out of the water to absorb oxygen.

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

Figure 4: Overview of part of the peat swamp forest area in Kalimantan Tengah. LANDSAT-TM image mosaic of two scenes covering an area of approx. 180km x 360km (118-61 and 118-62, 30 June 1991, RGB = 542). This channel combination shows different forest types and land use. Light green colours in the upper quarter of the image designate *Dipterocarp* forests, brownish green colours designate heath forests and dark green colours in the lower part of the image designate peat swamp forests (PSF). The 1 Million ha rice project is located in the centre of the image. The city of Palangkaraya is visible in pink colours in the image centre.

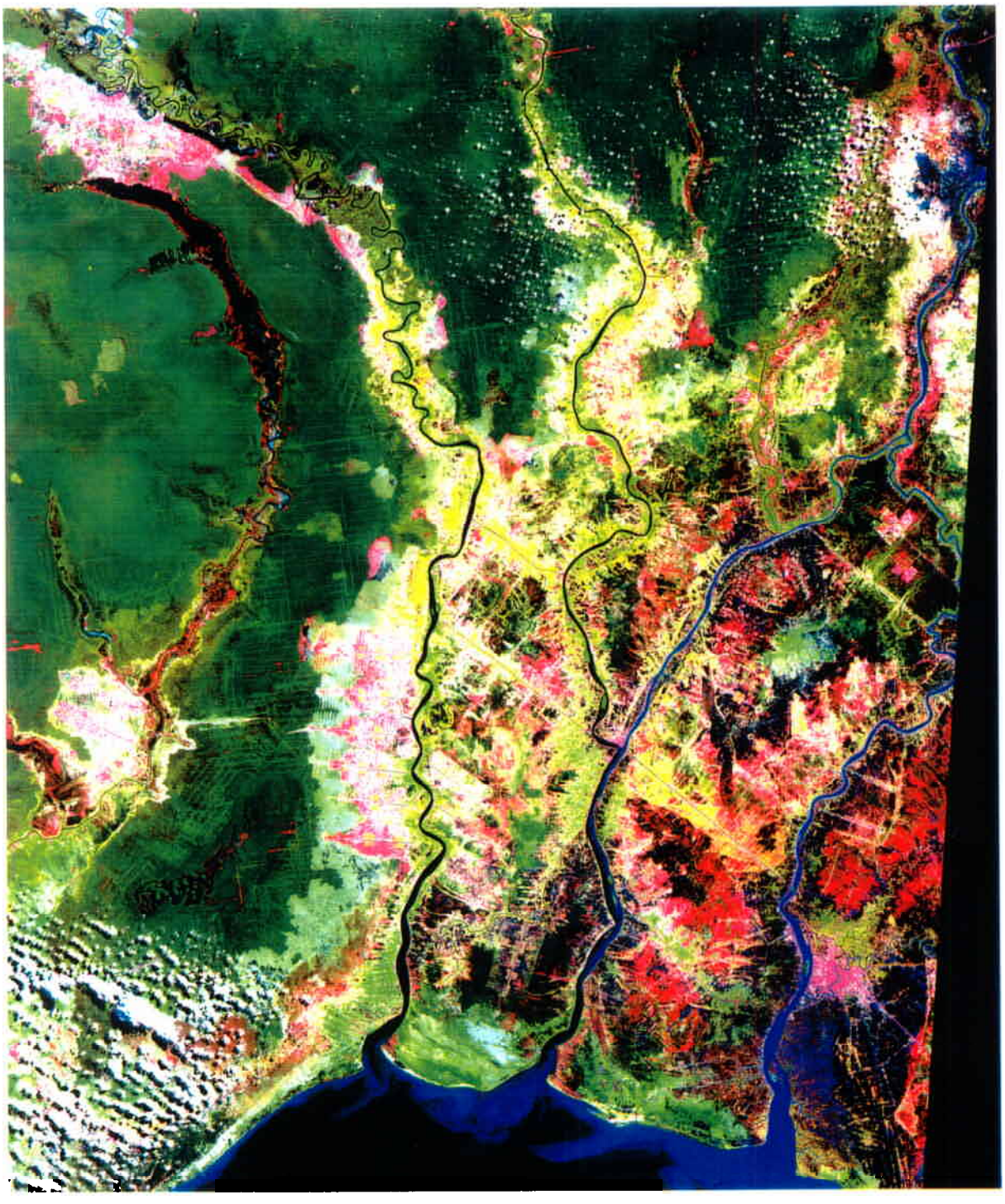

Figure 5: LANDSAT TM image (118-62, 10 May 1996, RGB = 542, Image size 125km x 150km) showing the peat swamp forest area and the 1 Million ha rice project, the transmigration areas and the four rivers Sebangau, Kahayan, Kapuas and Barito (from left to right). This channel combination enhances agricultural 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.

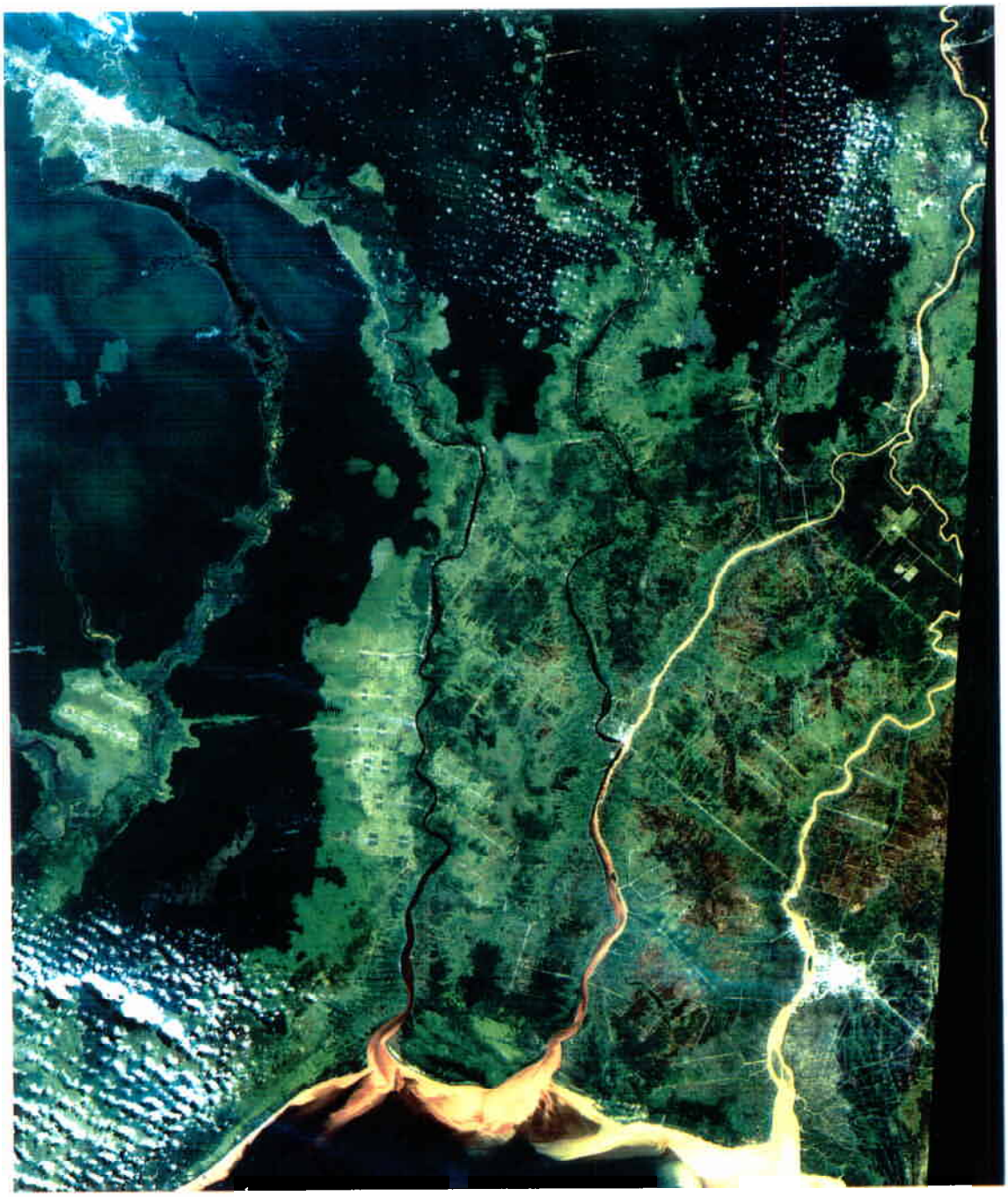

Figure 6: The same LANDSAT TM image (118-62, 10 May 1996, RGB = 321, Image size 125km x 150km) as in Figure 5, however displaying a different spectral band combination. Dark green areas indicates intact peat swamp forest, light green areas show forests that have been opened up by selective logging and clear cutting. Sediment content of the rivers is visible in brownish colouring. Note the low sediment content of the Sebangau and Kahayan (to the left), which both drain predominately peat swamp forests. The Kapuas and Barito have a much higher sediment load since they both drain the central mountain area..

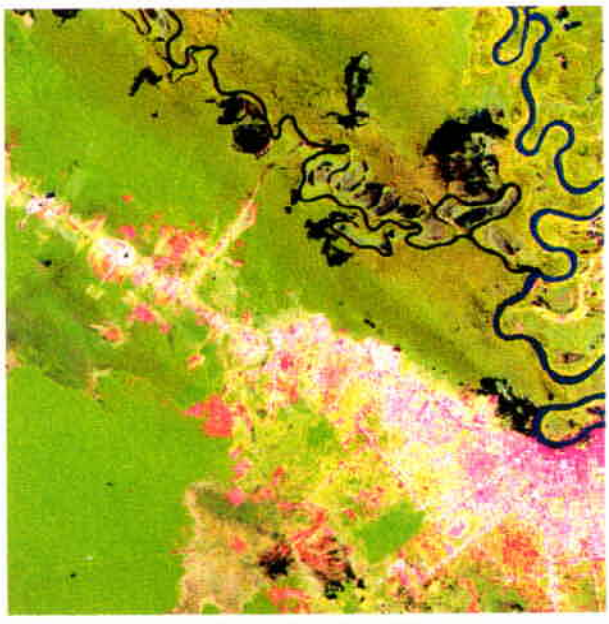

Figure 7: LANDSAT TM image (24 July 1994, RGB = 542) showing the province capital Palangkaraya with the rivers Kahayan and Rungan. Green indicated P.S.F., red indicated clear cuts. (Image size 15.4km x 15.4km; File: 94_ORIG.bmp).

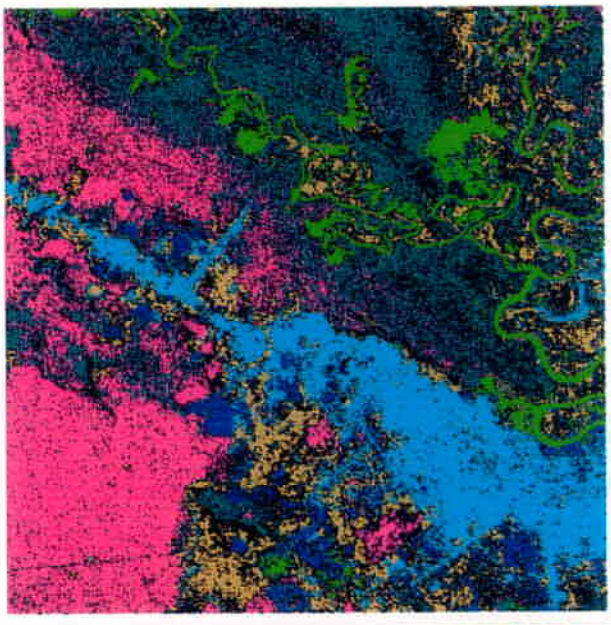

Figure 8: Classified LANDSAT TM image (24 July 1994). Processing with a neuronal net classifier shows 6 different classes: Green = water bodies/rivers(1); pink = primary-/secondary P.S.F.(2); blue = clear cut, open ground(3); light-blue = settlements(4); grey-blue = swamp area(5), brown = bush land/ alang alang (6). (Image size 15.4km x 15.4km; File: 94_NEU.bmp).

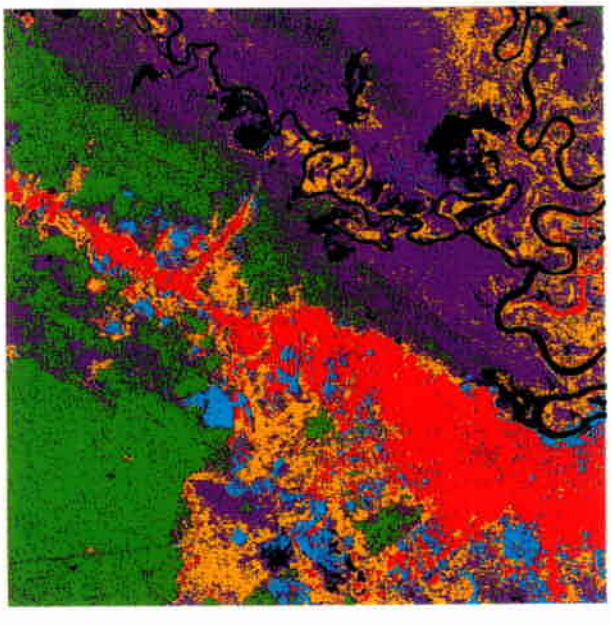

Figure 9: Classified LANDSAT image (24 July 1994). Processing with a minimum distance classifier shows 6 different classes: Black = water bodies/rivers (1); green = primary-/secondary P.S.F. (2); light-blue = clear cut, open ground (3); red = settlements (4); violet = swamp area (5), brown = bush land/ alang alang (6). (Image size 15.4km x 15.4km; File: min-onne.bmp).

Blocks A, B, C and D faced the strongest changes in the last 30 months by clearcuts and forest fires (see Figs.12, 13, 25, 28). 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 (ref.27).

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.

4.2 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".

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 approx. 28km . A second channel, *Anjir Basarang*, and also approx. 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, approx. 13,000 families in the Dadahup – Lamunti region were settled, facing hard conditions clear-felled areas.

Parent, main, secondary, third and quarter level channels for irrigation and transport were built with high pressure from Spring 1996 to 1998. Over 4000km of channels were built in 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.10, 11): 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.11,13, 29). At present, they are not equipped with water-pumps for irrigation. Where possible, channels are used for 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 cut ways into the remaining forest left and right of the PPC. Large parts of the forest burned during the 1997 fires, causing severe financial loss.

Figure 10: Aerial Photos acquired during flight on 13 June 1998. **A:** Lecturers from UNPAR and Viktor Böhm before flight, **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.

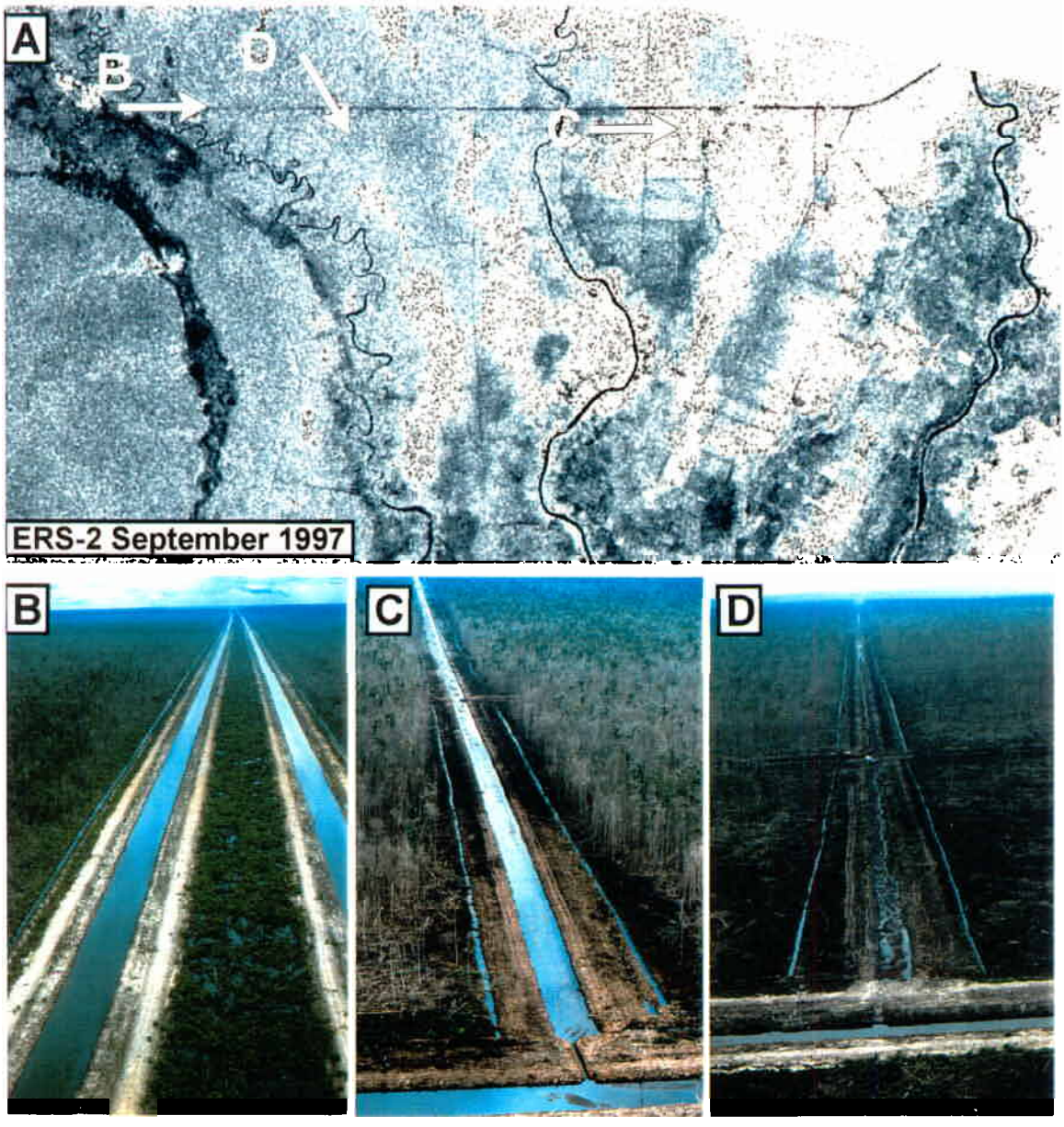

Figure 11: Irrigation channels of the 1 Million ha rice project. A: Gamma map filtered ERS-image mosaic showing irrigation Channels (PPC, MPC, SC, TC) of the "Mega-Rice-Project" at the river Kapuas region. (ERS images acquired 18 Sept. 1997 and 2 Sept. 1997). **B**: Main Channel, 110 km long, **C**: 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.

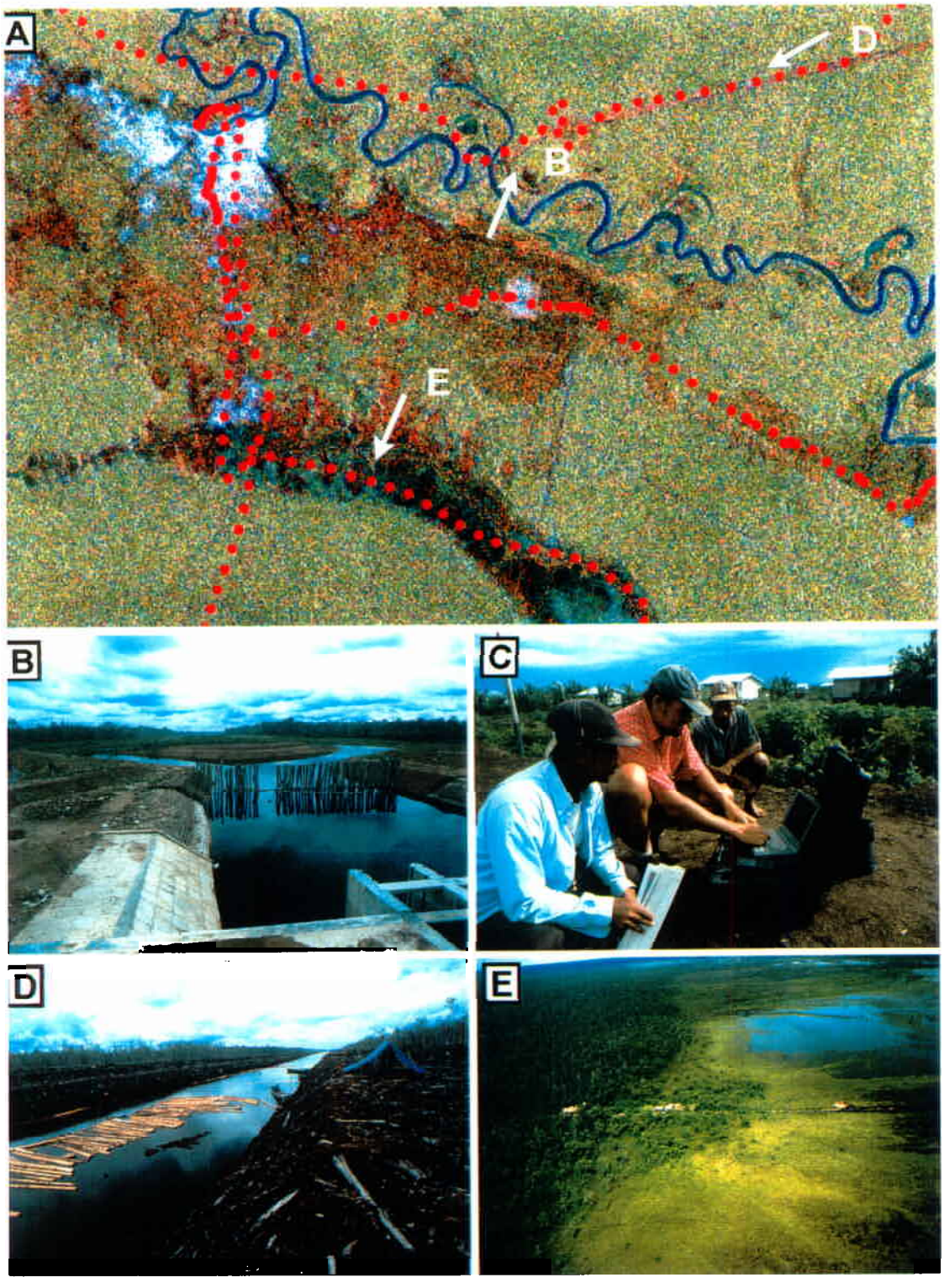

Figure 12: Palangkaraya and irrigation channels A: ERS-2 Change Detection Image (22 Oct. 1996 and 2 Sept. 1997) showing Palangkaraya and Catchment Sebangau (25km x 35km). White-blue signatures designate settlements (corner reflection from roofs), the Sebangau catchment shows up green, brown colours designate deforested land. Ground survey and flight GPS tracks (red dots) are overlaid. The main irrigation channel starts form the river Kahayan (above right in red colour), side channels are visible between the rivers Kahayan and Sebangau near the village of Berengbengkel. **B**: Sluice of PPC at Kahayan. **C**: Acquisition of GPS points and storage into a laptop computer by Florian Siegert. **D**: 3 meter thick peat along the main channel. **E**: Catchment Sungai Sebangau, Setia Alam research station.

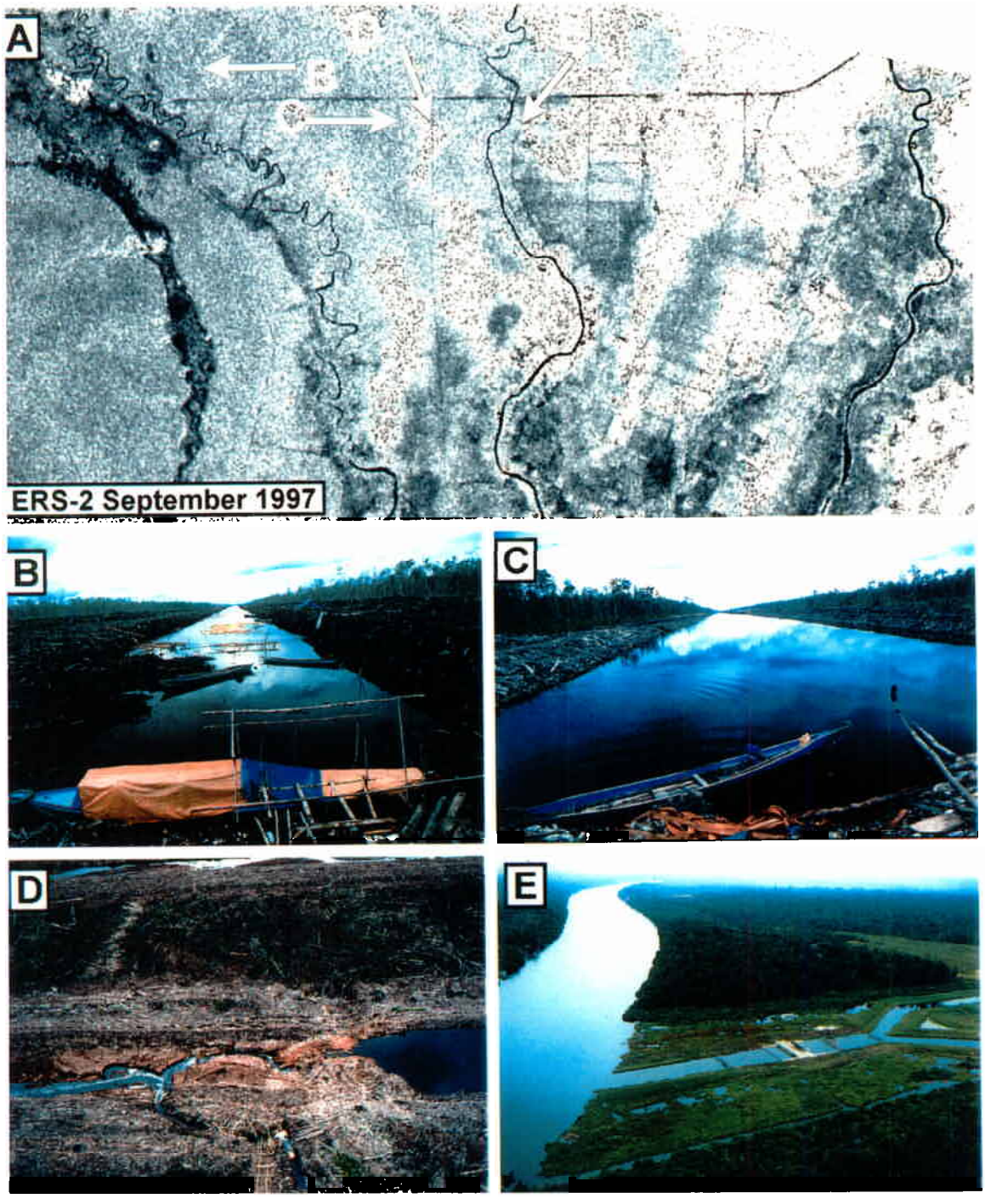

Figure 13: Irrigation channels and peat barriers. **A**: ERS-image mosaic showing irrigation Channels (PPC, MPC, SC, TC, ERS image 18 Sept. 1997 res. 2 Sept. 1997). The arrows indicate the location of the ground photographs. **B**: Main channel viewed from a peat barrier towards the Kahayan river (approx. 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.

In dry and intermediate periods, the 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 peat. Furthermore, for agricultural purposes water quality would have to improve to a pH value of 5 to 6. Untouched P.S.F. has an average value of pH 3.8. During the draught in autumn 1997 waters reaches an acidity of pH 2, unsuitable for drinking for 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, ref.11). 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.

4.3 Bukit Tangkiling (River Rungan), Transmigration Area of Transsabangdep, river Tilap to the Edge of the Heath Forest

Bukit Tangkiling is a well known area some 35km along the main road from Palangkaraya. Six hills of intrusive young Alkali Granite from the Miocene age (27-28 million years old, ref. 3) grow unexpectedly out of the flat P.S.F. region. They have an altitude of 125m, 130m, 135m, 164m, 174m and 186m. Indigenous people use tin-covered wood fires on the rock-surface to crack parts of the granite, subsequently broken into smaller pieces by children, for road- and house construction. Ground, this material would make excellent fertiliser due to its good mineral composition (K^2O). Even so, villagers around the hills enjoy good crops. The same is true for the area down to the black-water river Rungan with the villages Tangkiling Harbour and Sei Gohong. North-east of the hills, the road that has been following the Rungan makes a sharp bend and leads through peat-forest to the village of Kasongan, where a big metal bridge crosses the Katingan. From there, the road leads further to Sampit, Kalteng´s second biggest town. At km 38 from Palangkaraya a big transmigration plot was recently established that has already caused peat soil to degenerate.

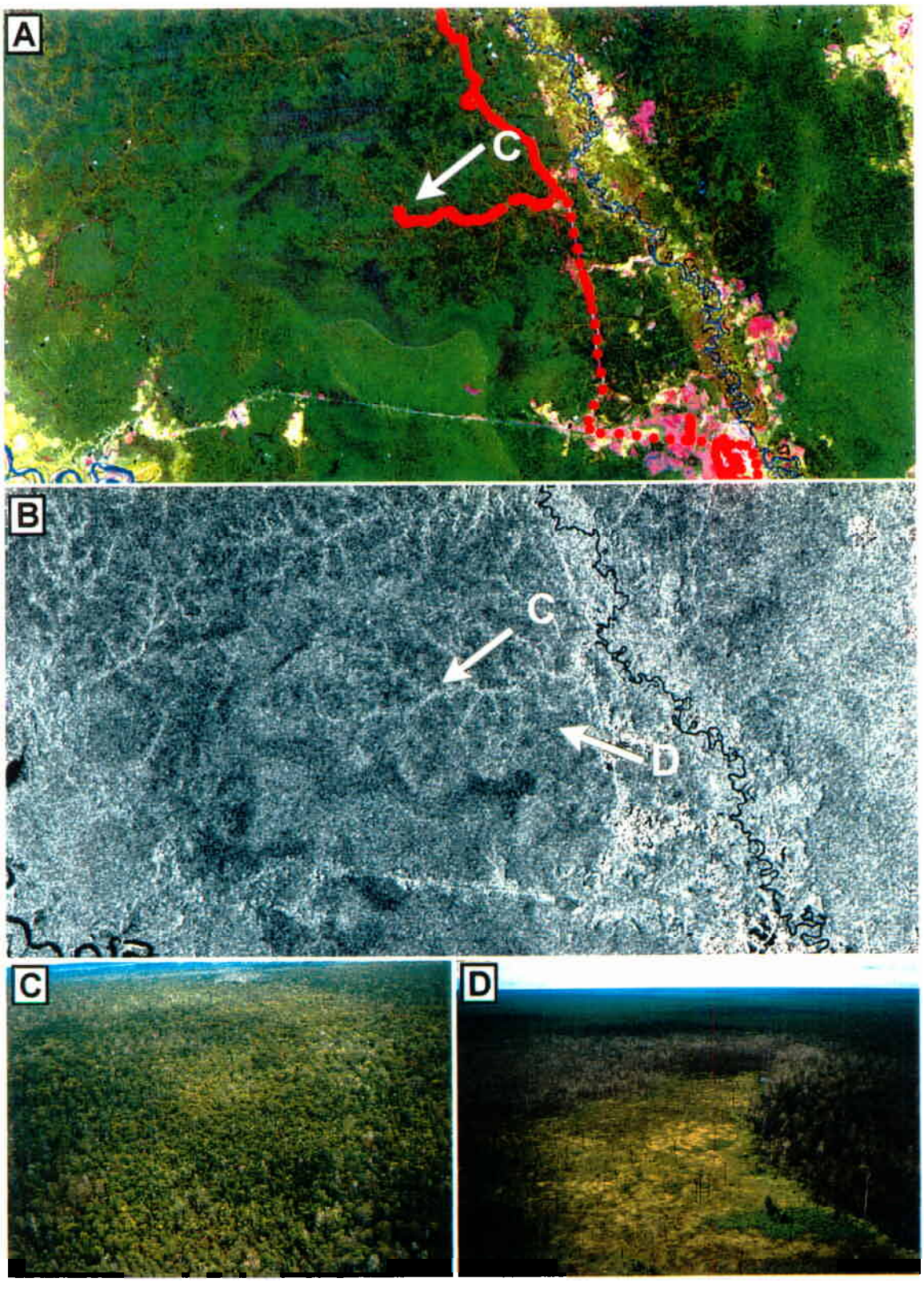

Figure 14: Transition zone of peat swamp and heath forest A: LANDSAT TM image (30 June 1991) with GPS-tracks from the boat tour and car trip. River Rungan (right) and Bukit Tangkiling (lower edge right) and Katingan river with Kasongan (left). Peat (green colours) and heath forest (brown colours) form a complex intermingled pattern in this area. **B**: ERS-image (6 May 1993) of the same area. Both forest types can be discriminated due to their different canopy structure and leaf size. The river structure is clearly visible. **C**: Undisturbed heath-Forest. **D**: Degraded and burned heath forest.

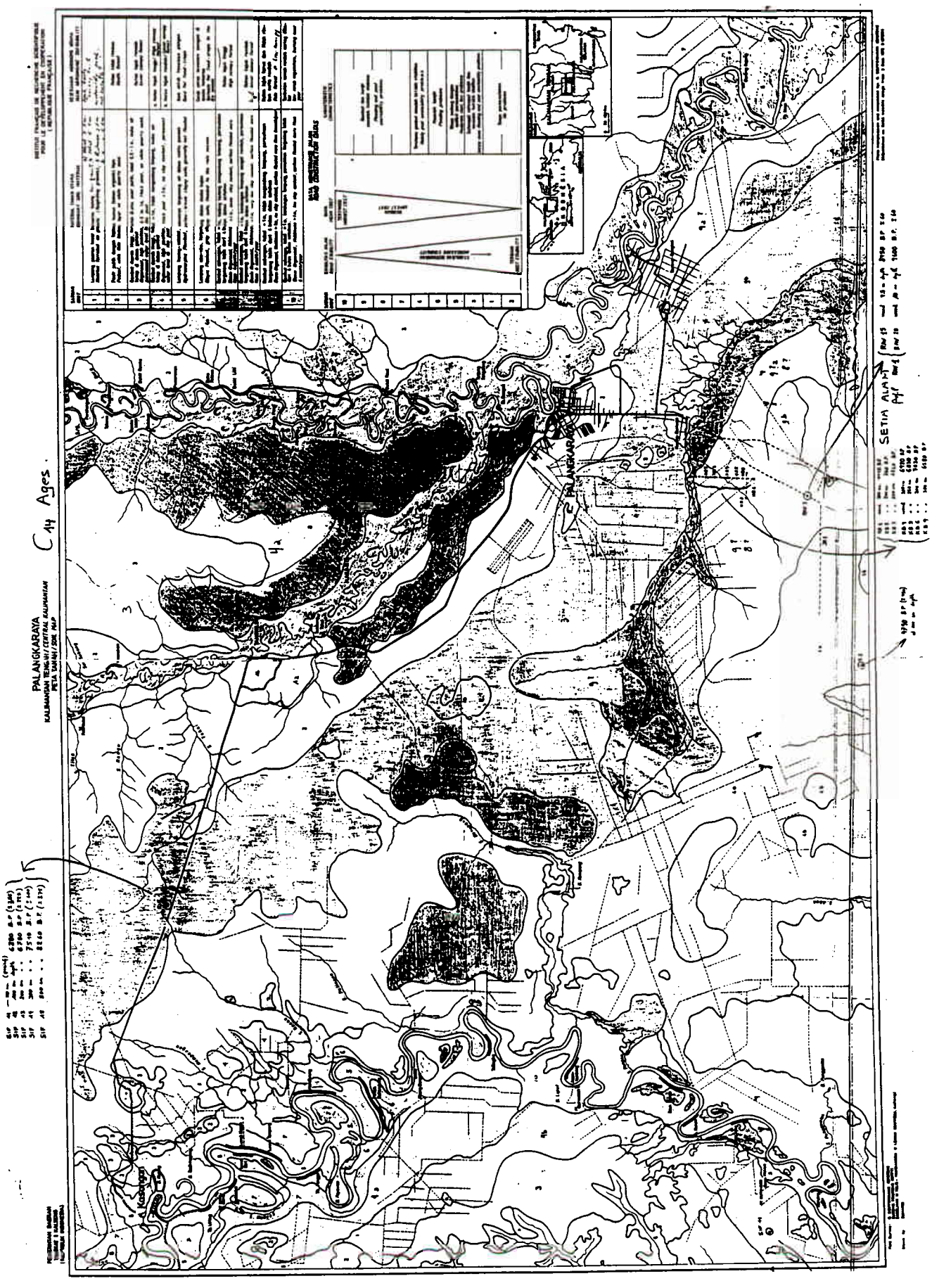

Figure 15: Soil Map of the area around Palangkaraya. The age of the P.S.F. is indicated (prepared by Dr. Sieffermann).

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.

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.

Approx. 5km south of the hills and 5km from the main road the transmigration village of Transsabangdep was constructed in 1993 on relatively shallow peat between 10cm and 2m in height. Nephentes pitcher plants are growing everywhere. The village is built in rectangular shape, criss-crossed by small water channels. The inhabitants are poor. We visited the area several times in 1996, 1997 and 1998. Since 1996 many villagers have left the area. By now, the remaining ones earn half their income by felling trees. Behind the village, an area was cut into the forest that looks like a hammer (see LANDSAT image from 8/7/94, ref.2, 3). In the ERS image of 2 Sept. 1997, the clear-cut's sharp edges have already become diffuse. This change is caused by numerous new cuts into the P.S.F. using rail techniques. On 1 Nov.1998 we saw new logger camps and saw-mills along railroads used for the transport of trunks out of swampy forest. This activity provides basic income for concessionaires and local indigenous people.

On 2 Nov.1998 a trip was undertaken to the village of Petakbahitang, where the small river Tilap flows into the bigger Rungan. We wanted to examine the fine structure of the river net left of the Rungan seen on an ERS Satellite image from 1993 and on LANDSAT images from 1991 and 1994. These had suggested that here is the border between peatland and heath forest.

At a bridge19km north of the junction Palangkaraya/Kasongan, we hired a boat and a crew of three. We followed the Tilap, a small black-water river, 10km up. The water level was high due to the rain period. Every now and then, we had to avoid floats, gently pulled by motorboats and guided with sticks by skilled workers, which came down the narrow river. When the canopy above us opened the sun came through, but soon heavy rain stared. We had to protect our photo apparatus and S-VHS-video camera. The Garmin GPS 12 was working excellently even in these conditions (see figs. 12, 14, 18,). Later we followed a side-arm of the stream to the north west for

2km and then went by foot into mixed P.S.F. alternating with heath forest for approx. 1km. The air was humid and hot, and insects and birds made typical sounds. On the map we saw a dark-coloured peat dome but couldn't reach it because of heavy rain. Back at the bridge, we took our Jeep and followed the road north to Tumbang Talaken and Tumbang Jutuh for several km over bridges which cross many small black-water rivers. On the way back we followed a new logging road on quartz sand for approx. 3km parallel to our river. This was definitely heath forest. Selective logging was done everywhere, in some areas even clear-cuts.

4.4 Trans-Kalimantan Highway between Kahayan and Mangkutup

We visited this area first in April 1996 and in Nov. 1998 for the second time. A bridge over the Kahayan is under construction in Palangkaraya. From there a sandy road leads up to the Kahayan villages of Bukit Ravi and Bukit Liti. During our second visit we chose a boat from Palangkaraya to Bukit Ravi and then hired a car. The road, nominally a highway, is a dirt-road, sandy, full of pot-holes and with tree-trunks serving as bridges across small rivers. It leads to the river Mangkutup and further to Buntok, a village on the banks of the Barito. Heath forest on quartz sand (podzol) alternates with P.S.F. Compared to 1996, the forest has been opened up much more along the road. Ramin trunks up to 60 cm in diameter are transported by loggers. A lorry with heavy trunks was stuck in the mud. Proprietor's labels have been put up everywhere. The plan is to grow oil-palms on peatland. We followed the road approx. 20km to the river Mangkutup. This is the northern border of Block E, the planned 400.000 hectare extension of the "Mega-Rice-Project". Also here heath forest alternates with P.S.F. Peat thickness here is up to 4m. Any future access from the "Trans-Kalimantan Highway" to the forest left and right will open the P.S.F. drastically.

4.5 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 here. Selective logging was officially discontinued in 1996, and unless regular repairs are undertaken, the rails will rot quickly and render them 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 (figs.12, 17), . 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 17A: 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.

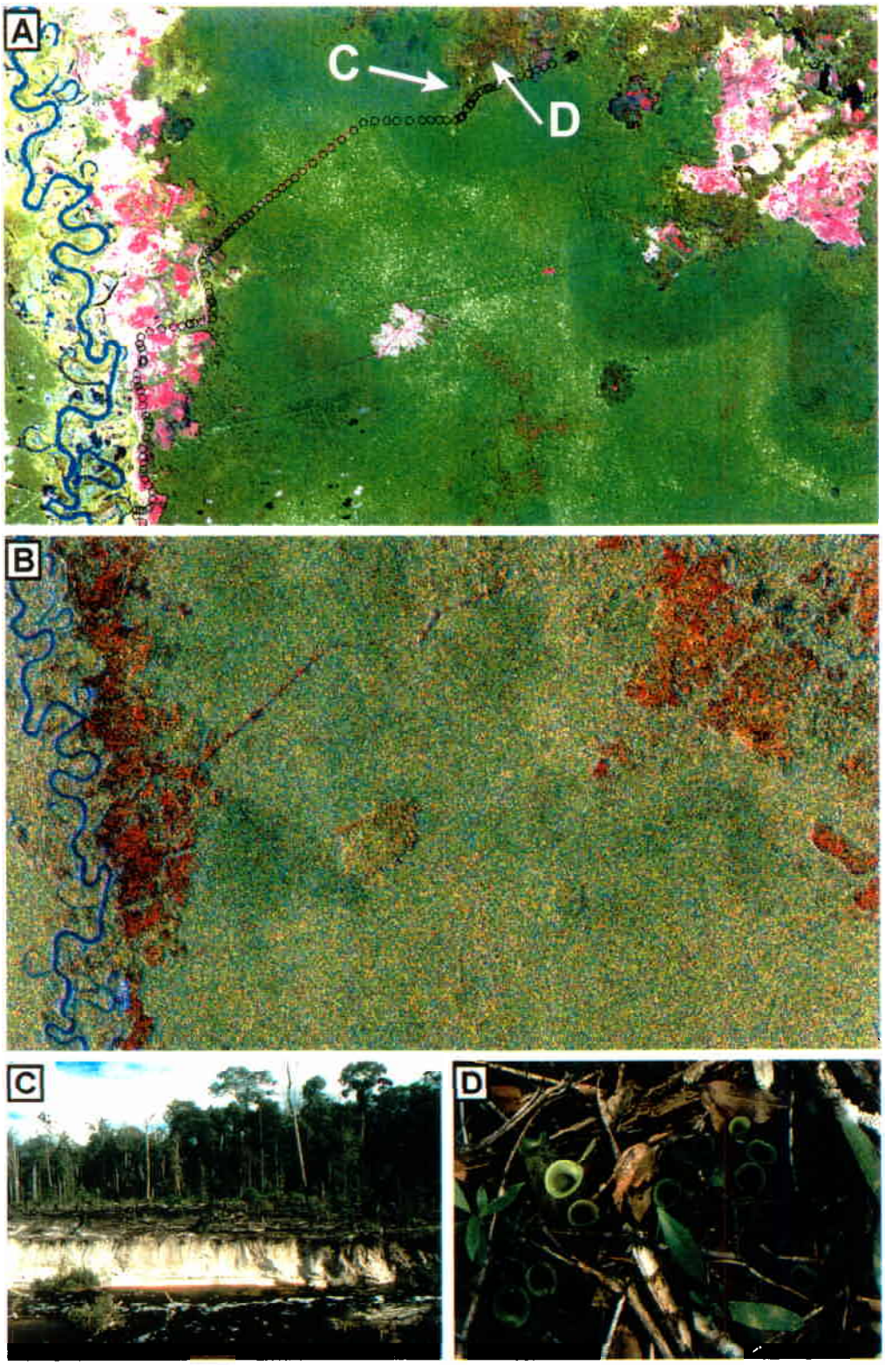

Figure 16. Transition zone of peat swamp and heath forest. A: LANDSAT TM image (8 July 1994, RGB = 542) showing river Kahayan to the left and the villages Bukit Ravi and Bukit Liti. (Image size: 25km x 35km). The "Trans-Kalimantan Highway" can be seen clearly, with GPS track overlaid. The canopy structures of the peat swamp and heath forest can be discriminated by their colour. **B**: The same area as before as ERS change-detection image. Reddish-brown segments show settlements or clear-cuts into the P.S.F. **C**: Heath-forest and podzol soils, **D**: Many pitcher plant species (*Nephentes* sp.) grow in the heath forest.

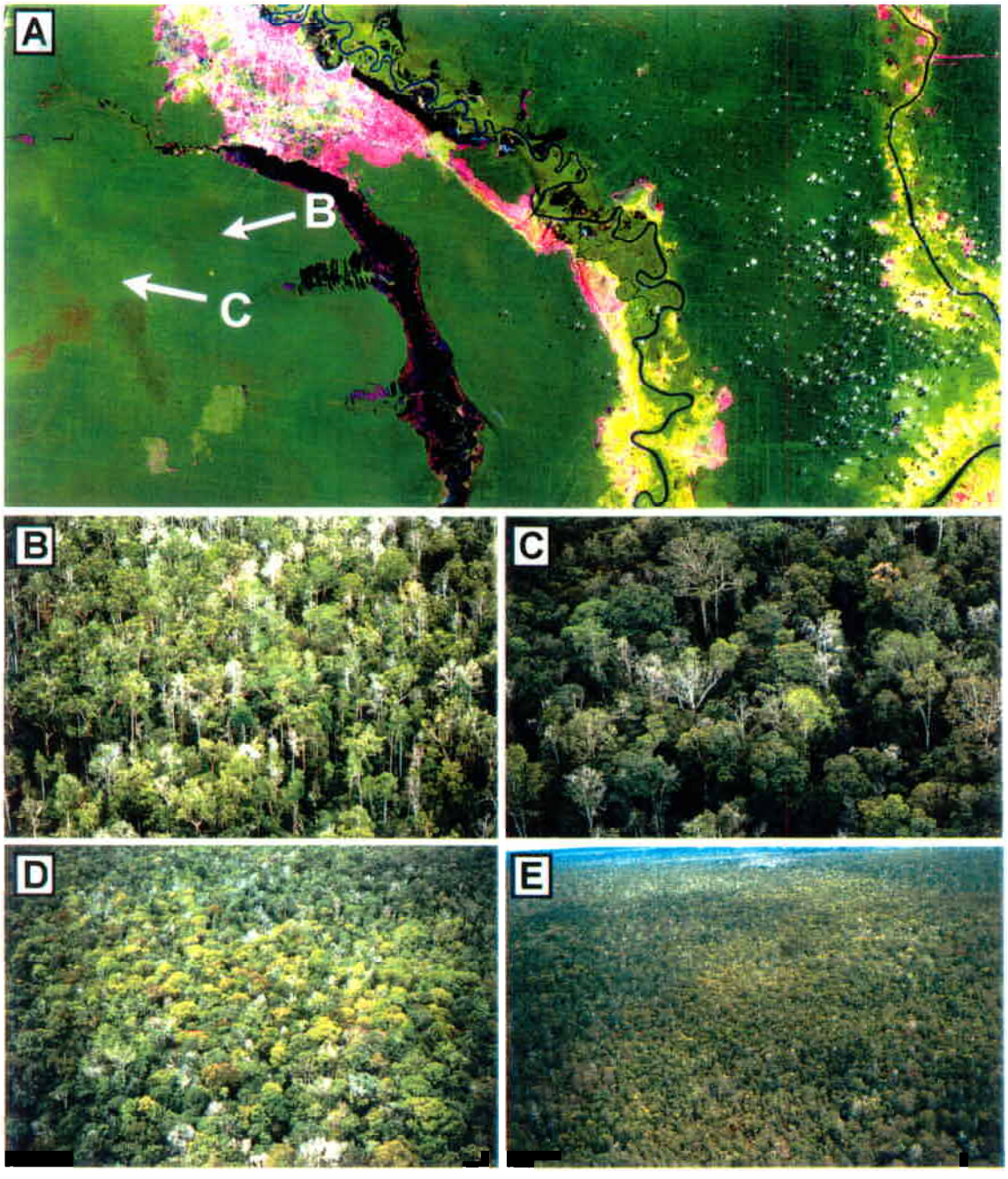

Figure 17: Different peat swamp forest types (P.S.F.). A: LANDSAT TM image (118-62, 10 May 1996, RGB = 543) showing Palangkaraya and the surrounding peat swamp forests. A close look reveals different shades of green within the peat swamp forest, which can be related to different types of forest and likely 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.

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 (ref.3, 22-26, 36). 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.

4.6 Old Transmigration Areas: Berengbengkel, Murang, Garong and Pangkoh 9

The transmigration village Berengbengkel 1 is approx. 25km from Palangkaraya on the way to Pulang Pisau. Berengbengkel 2 lies 4km further and is located on the Kahayan river. During rain periods, Berengbengkel 2 can often only be reached by boats or robust 4WD. A flooded swamp area parallel to the Kahayan and clear-cuts makes any wet-season passage difficult. On 4 Nov.1998 we hired a boat in Berengbengkel 2 and went up the Kahayan to get to the PPC sluices 4km upstream. The sluices were completed since our last visit in June, but still lacked pumps. To get into the PPC, one had to use a third auxiliary channel for 1 km, as the PPC is not connected to the Kahayan. Near the Kahayan, the peat soil rises approx. 50cm above the water level, whereas a few kilometres further towards Kapuas the difference is 3m. At the highest point of the water-shed the peat-dome reaches approx. 10m. The difference in height is compensated by steps in the channel which are approx. 3m high. (Exact measurements of peat-depth will be provided by members of the University of Palangkaraya in connection with the EU project). We followed the channel for approx. 20km, passing three channel-steps (water-barriers) on the way, which necessitated a change of boat each time. Heat and obstacles prevented us from reaching the water-shed. Loggers were working at every section. Aerial exploration on the previous day showed an already existing logging rail over the PPC approx. 24km from the Kahayan.

Berengbengkel 1 is a transmigration village built in the 80ties. Peat-thickness there is only moderate and alluvial in character near the Kahayan. The first settler-generation has left the area, disappointed with peat-soil conditions and low yields. A second generation is trying to cultivate the ground by heavy fertilisation and regular burning. Vegetables and fruits thus produced are sold along the main road. This method of cultivation, combined with rainfall and soil drainage has reduced acidity and increased pH-value. (PH-value, exchange capacity and base saturation are important parameter for the measurement of soil quality).

Appox. 2km from Berengbengkel 1 a channel of the "Mega-Rice-Project" crosses the road. It is 9.5km long, part of Block C and supposed to connect the Kahayan and Sebangau rivers. It is equipped with steps (barriers) to avoid excessive draining of the area. As the bridge across the channel is relatively easy to reach from Palangkaraya, it is frequently photographed by scientists, ecologists and members of the government. Students from UNPAR have measured peat-thickness here since Sept. 98 in connection with their work for CIMTROP.

The junction leading to Marang lies north of Palangkaraya at km22 (ref.3). Marang, 3 – 4km off the main road towards the Rungan river, is also a transmigration area from

the 80ties. Settlement was not successful. Neither rice nor fruit grew properly on the swampy peat. 230 families left for better places. Marang itself has moved to the banks of the Rungan, where villagers gain modest income from fishing and agriculture.

On 31 Oct. 1998 we drove by car in the direction of Pulau Pisang, stopping at Garong to hire a boat for a trip along the 10km long SC channel which leads to the MPC. (The MPC, with a 25m surface width and 5m depth leads along the peatdome from the north to the south and is 122km long). The SC has a 15m surface width and is 3m deep. Also here, the peatdome increases in height towards the water-shed between the Kahayan and Sebangau rivers, reaching a height of 2 –3 m at the MPC. Blackish water flows through the SC into the Kahayan. A small hole in the peat-barrier provides access for boats to and from the MPC. Along the SC was burnt forest from the autumn 1997 fires. We saw a Dayak woman clearing an area of approx. 1 hectare by starting fires at regular intervals. We met students from UNPAR who had just finished measuring peat thickness along this SC. The P.S.F. impressed us as being very degraded and showed many scars from burning. Complete clearing of the area seems to be only a matter of time.
On 5th Nov. 98 we drove to the village of Pangkoh 9, a location we'd monitored by plane on 11th April 1996 (see ref.2 and 3), crossing another SC (part of Block C) and passing numerous established rubber plantations on the way. The village of Pangkoh 9 was designated for transmigration in the 80ties and subdivided into Blocks A, B, C, D and E along a specially built black-water channel of 12km length. To the South, other channels were dug parallel to the first one. All of them are too long for tidal influence to be felt all the way, thus thwarting the desired effect of washing out excessive acidity. Consequently, soil quality along the blocks has a gradient of fertility according to the amount of water-circulation increasing pH-value. (Traditional, Banjar hand-dug channels, 4-9km long, are more successful as they utilise tidal movement in their entire length).

The drive to the end of the 12km channel was possible by motorbike only. The influence of the gradient is clearly visible in vegetation and agriculture. At the end of the channels peat-ground, approx. 3m thick, is so dried out that it is elastic to the step. An HTI (Hutan Tanaman Industri; forest crop industrial) planted there was destroyed by fire in autumn 1997. Replantation is now futile due to the impending "Mega-Rice-Project". (As it is, sufficient cleared ground for rice production is available. But it isn't used because of peat-thickness and soil degradation). In the distance, 2-3km to the West, we saw remaining P.S.F. According to ERS image from 1997 the 122km long MPC and the water shed between Kahayan and Sebangau should be about 2km west from there.

At Block C of Pangkoh 9 we met a transmigrant peat-farmer from Kuningan-Ceribon (Java) by the name of Belon, who has been living there for 15 years. He fertilises his app. 5000m² sized field 2 times per year with 7kg of Orea at a price of 750Rp per kg. Additionally, phosphate is used costing 2400Rp per kg. Twice a year he harvests peanuts (katchang), pineapples, maize, manjok, schatana, rubber (karetz). Recently he has started to plant coffee. In Block B productivity is slightly better. Another farmer from Java, also resident for 15 years, has palms and rice but needs to buy additional rice to feed himself and his family. Other farmers fish at a pond behind the campong. The tide works only in part of the main channel, but not in the side arms. In the evening we crossed the Kahayan by ferry to Pulang Pisau and

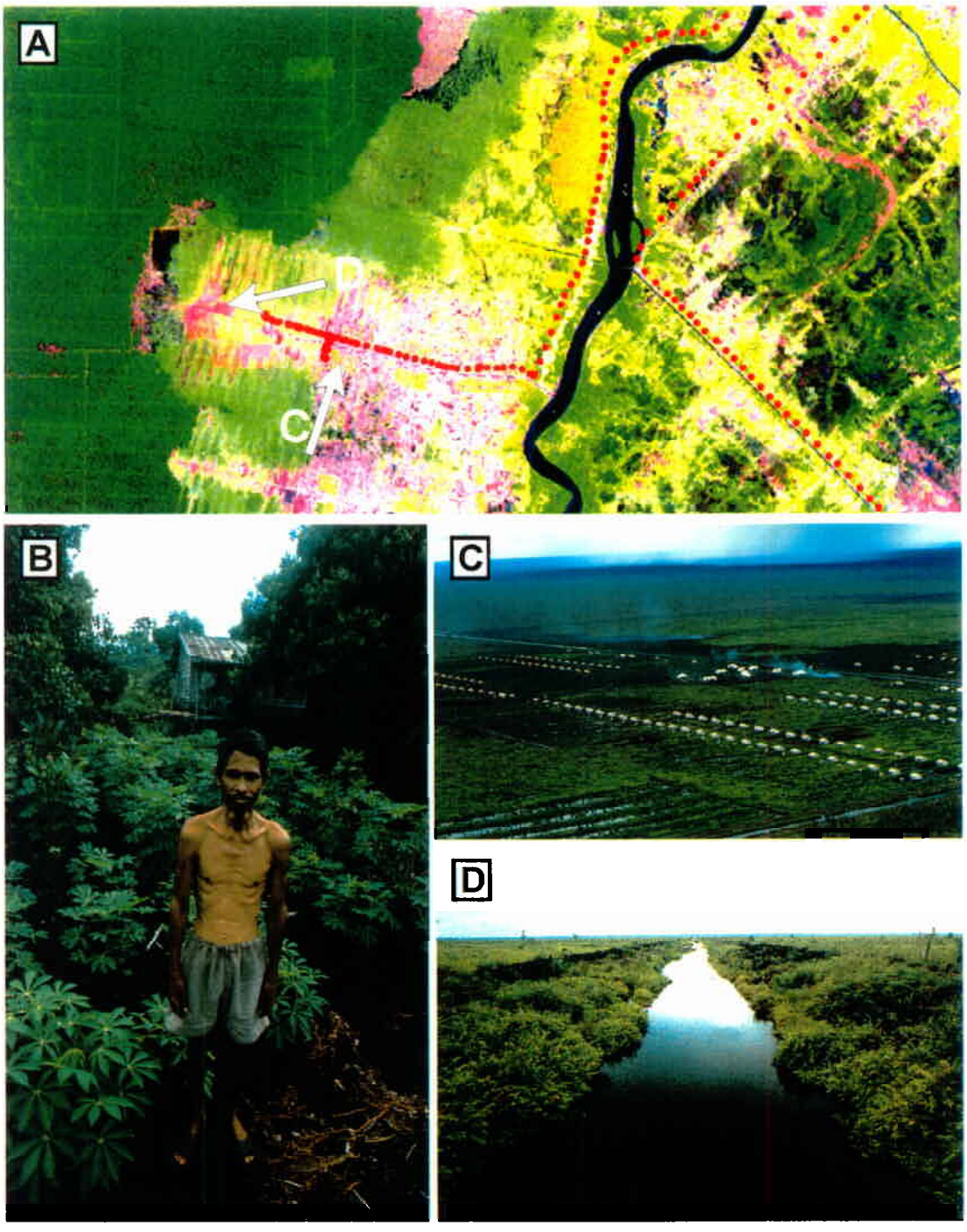

Figure 18:Transmigration area Pangkoh 9. A: LANDSAT TM image (10 May 1996, RGB = 542, 18km x 24km) showing the Kahayan river, the transmigration area at Pangkoh 9 and the 12km irrigation channel. P.S.F. appears dark-green, degraded forest and railroads in light green. Red dots is the GPS track. Arrows indicate the location of the ground photographs. **B**: Farmer resettled from Java, living here on peat soils since 1984. **C**: Transmigration settlement. **D**: Block E with the HTI totally destroyed by the 1997 fires.

drove parallel to the Anjir Kelampan towards Mandomai and then took the road to Anjir Baserang. The 28km road is of exceedingly poor quality, although being the main thoroughfare from Banjarmasin to Palangkaraya. Cars stuck in the darkness in wet ground caused delays and hold-ups. We decided to use a ferry and crossed the Kapuas in moonlight to the town of Kuala Kapuas. (A new bridge was built but couldn't be used because of the poor condition of connecting roads). We stayed one night at Kuala Kapuas and visited the junction of the Kapuas and Kapuas Murung rivers on the next day, the 6th of November 1998. We also visited the new bridge over the Kapuas Murung which had been inaugurated by President Suharto in 1997.

4.7 Palingkau Lama and UPT Palingkau

On 6th of November we drove the road from Kuala Kapuas to Palingkau Lama. Many traditional "handil" (handmade) channels of the Banjars lead from the river Kapuas Murung inland, 4 to 9km long. Tidal influence can be detected. Vegetation is good and the peat layer small. Lots of Ramboutan and Durian trees grow along the road, established rice fields are seen as well as Gelam-tree plantations (see Figure 20). The map in Figure 19 was produced by two ORSTOM students as part of a thesis handed in at the University of Montpellier in 1997 (ref. 8) from a processed geocoded LANDSAT image from 10 May 1996, using different LANDSAT bands and classifications, which one of us had prepared in April 1997. The students used these Satellite images in their field surveys. Palingkau Lama with its busy market is located directly on the Kapuas Murung. The UPT Palingkau project (Unit Pemukiman Transmigrasi; Transmigration settlement unit) was started in autumn 1996 as a transmigration project between the rivers Kapuas Murung und Kapuas and has a size of approx. 5km x 9km (see map, Figure 20B). Rectangular drainage channels can be seen on the ERS image from 18 Sept.1997 (Figure 20B).

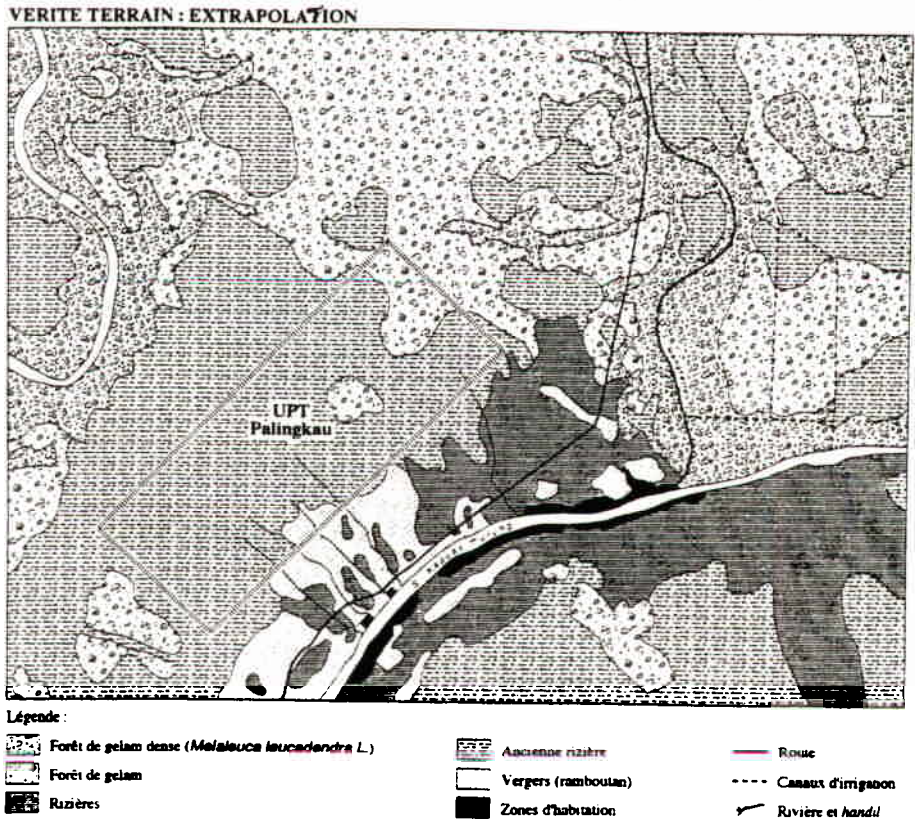

Figure 19: Palingkau map from M.-L. Gutierrez, S. Ramonteu (1997) taken from LANDSAT-image 10 May 1996.

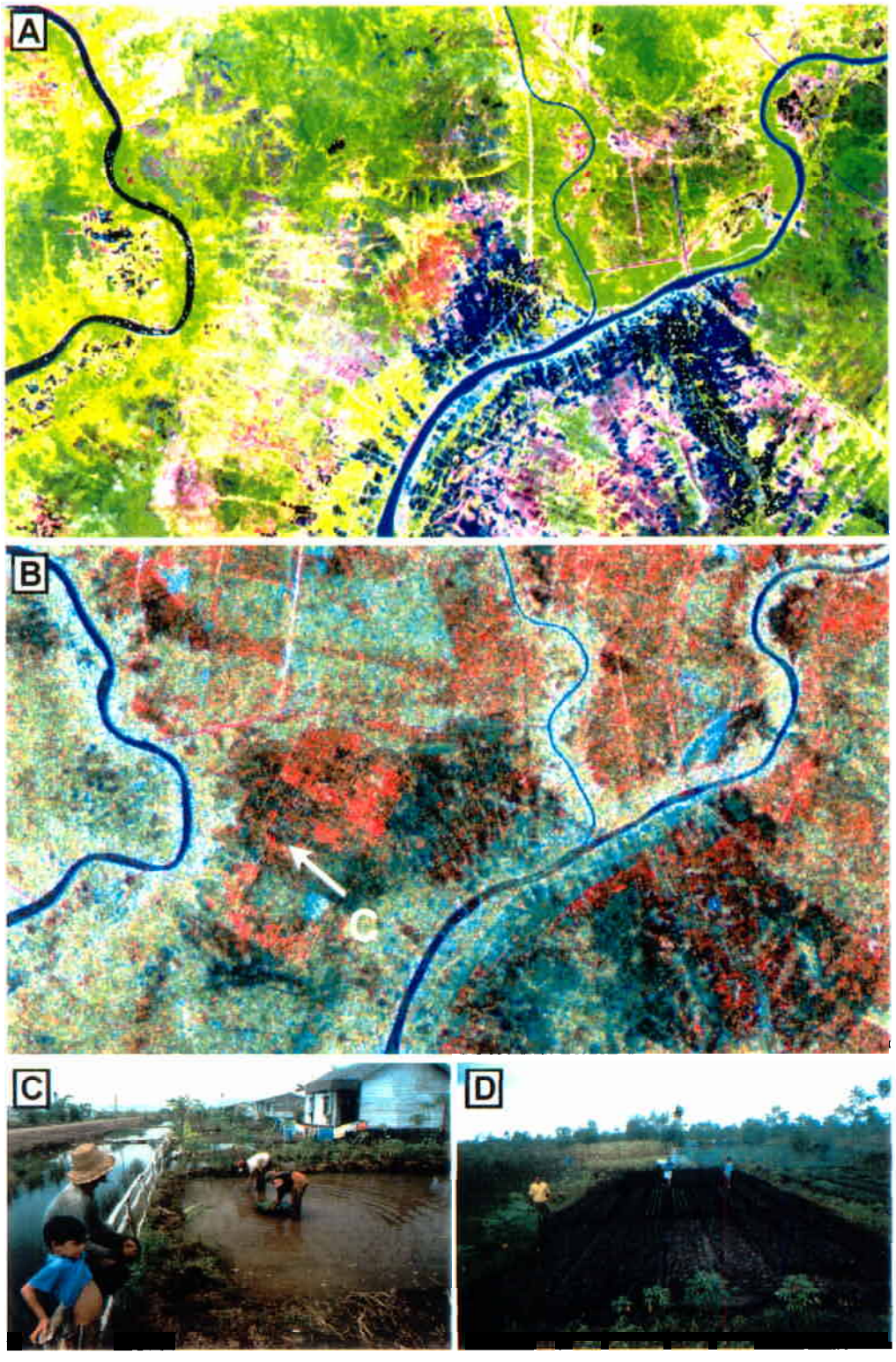

Figure 20: **A**: LANDSAT-TM image (10 May 1996, RGB = 542, 15.6km x 27km) used for the ORSTOM map. The rivers Kapuas (left), Kapuas Murung (right), Mengkatip (small) and village Palingkau Lama. **B**: ERS Change Detection Image (7 Nov. 1996 and 18 Sept. 1997) showing the same area in which a new transmigration area UPT was established in autumn 1996. New irrigation channels are visible in the radar image. **C**: Rice planting in UPT Palingkau. **D**: Agriculture on dry peatland.

4.8 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 figs.5, 20A). On the ERS image from 18 Sept. 1997, the MPC, the SC and the TC can be seen to be nearly completed. 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 shows the fire situation clearly. Aerial photos from 13 June 1998 (fig.10) included here show the many channels dug in connection with the "Mega-Rice-Project". All forest at Dadahup has been cleared and houses of transmigrates 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 21B) 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 21A shows a LANDSAT-TM image (10 May 1996) of the Dadahup area and Figure 21B 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 stared 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 draught proved a good opportunity to clear the land for transmigration settlements. Systematic land-clearing by fire is however still in progress in 1998.

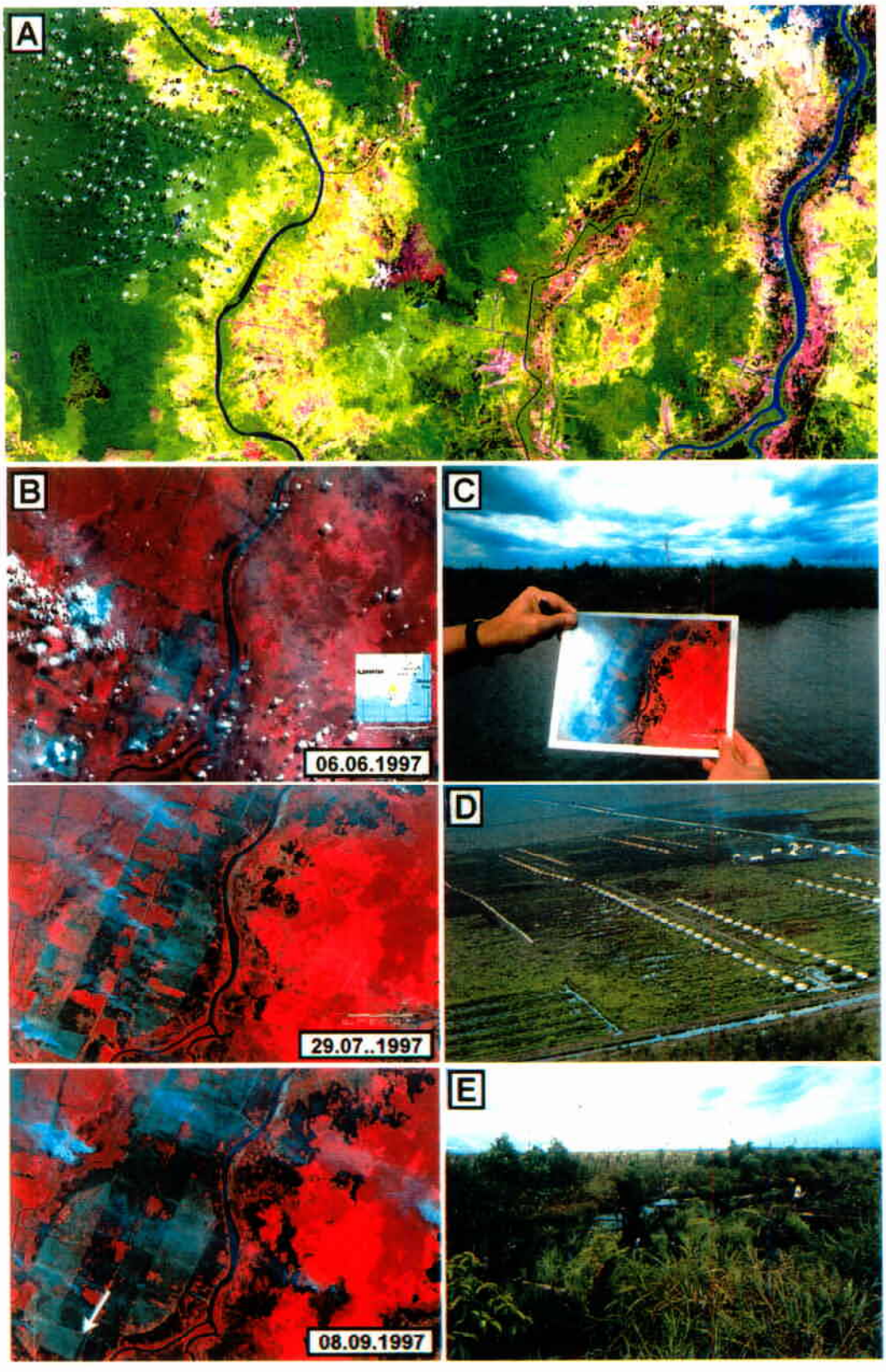

Figure 21: A: LANDSAT-TM image (10 May 1996) showing the Dadahup area between Barito and Kapuas river. **B.** A time series of SPOT-images (acquired by CRISP) of the Dadahup area acquired during the great fires in autumn 1997 (compare the rivers in A + B, see text). **C:** Ground survey in the Dadahup area, location indicated by arrow in B. **D:** New irrigation channels and transmigration houses in this area. **E:** One year after the fires.

4.9 Lamunti and the Black Water River Mentangai

At the village of Alaska we hired motorbikes to drive along the poor quality roads parallel to the SC channel. In the evening we reached the Lamunti Baru, a new village approx. 25km from Alaska in 290° direction. There were transmigrates working their fields and burning trunks. This newly developed region looks pretty good. There is new government housing, bridges and lots of channels were built in the last two years. Three days previously we had seen the area from above, flat, drawn out, with houses and channels to the horizon.

When darkness set in at about 5.30 p.m., we hired a boat to bring us to the Lamunti Lama, the old village. With us was a mother with her young children. After dropping her at Lamunti Lama, we went upriver the Kapuas to the village of Mentangai. We slept in a simple "losmen" (log cabin for hire). Next morning, we hired another boat for a trip up the black-water river Mentangai. Our plan was to compare the junction between the PPC and the Mentangai with the images we'd seen days before from the air. Going along the Mentangai is an almost romantic experience. There are lots of pandanut trees (big, fruit-bearing reed-plants growing in the water and along the shore). But soon secondary channels appeared on the right and left side with forests clear-cut for transmigration housing. The hole area between the Mentangai and Kapuas rivers has be cleared and criss-crossed with channels of different types (see satellite images Figure 22A+B)

During our 40km long trip up the Mentangai the landscape changed considerably. The river became broader, with big trees, partly burned standing in the river which by now had almost the size of a lake. At a certain point we saw large sawmills and logging-rails leading into the forest. Floats of tree-trunks passed us.

Toward the PPC, the river narrowed and became curved. Some small hills appeared. Exactly as we had gathered from the GPS, but almost invisible from the river and not connected to it, the big PPC appeared. Small speed boats passed us, there was big activity on the river. On the way back, our water-pump used for cooling the engine developed a fault. While the boatman unsuccessfully tried to repair it, we swam in the blackish water.
Another boat towed us back to Mentangai. Suddenly, a 3m long crocodile appeared and dived away. Sunshine changed with wind and strong rain. From Mentagai, a speed boat brought us to Mandomai, covering the 60km distance in one hour. There we met our driver and a German couple, wood specialists working in an institute connected to the Basel Mission, a Christian community which owns a beautiful house directly on the river-bank.

In darkness we returned over the Kahayan bridge to Palangkaraya. Frogs sat on the warm asphalt and were crushed by the hundreds by the many cars which crowded the road. Suddenly, the road was flooded. Heavy rains had caused a side-arm of the Kahayan to overflow. About fifty cars were awaiting their turn to pass the stream. Some made it, others got stuck in the water. After three hours our turn came. Our driver managed brilliantly. When we returned to Palangkaraya at midnight, all restaurants were closed.

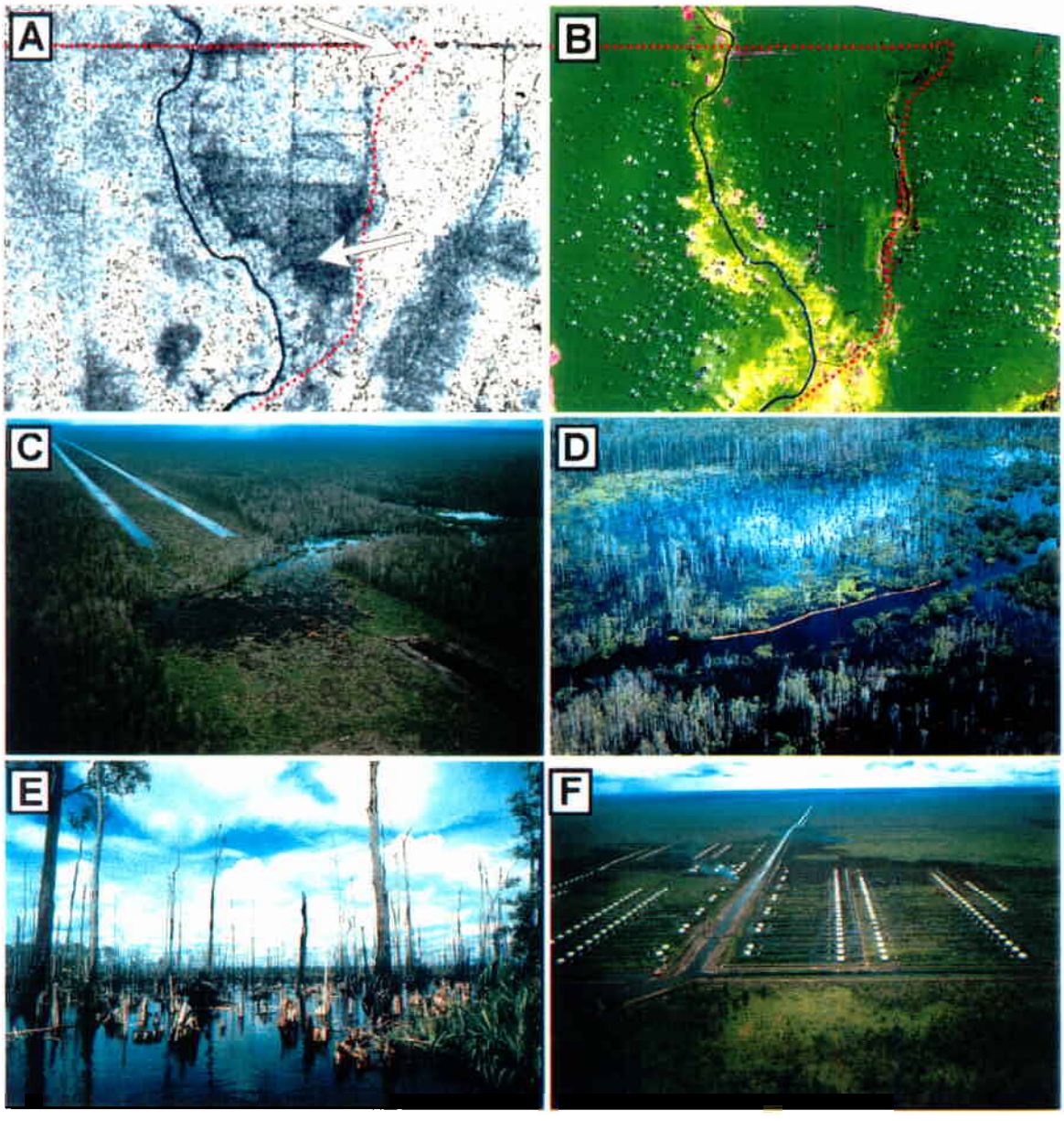

Figure 22: **A:** ERS-image (18 Sept. 1997) showing the rivers Kapuas and black water river Mentangai, the new channels and the flight route from 3 Nov. 1998 (dotted lines). **B:** LANDSAT-TM image (10 May. 1996, RGB = 543) of the same area without channels. **C:** Mentangai river crossing the main channel, channel construction had to be interrupted. **D:** Illegal logging along Mentangai river. **E:** Dead trees along Mentangai river, remnants from the great fire in 1997. **F:** New Transmigration settlement established after the land clearing by fire in 1997 (compare LANDSAT image) not yet inhabited, location indicated by arrow in A.

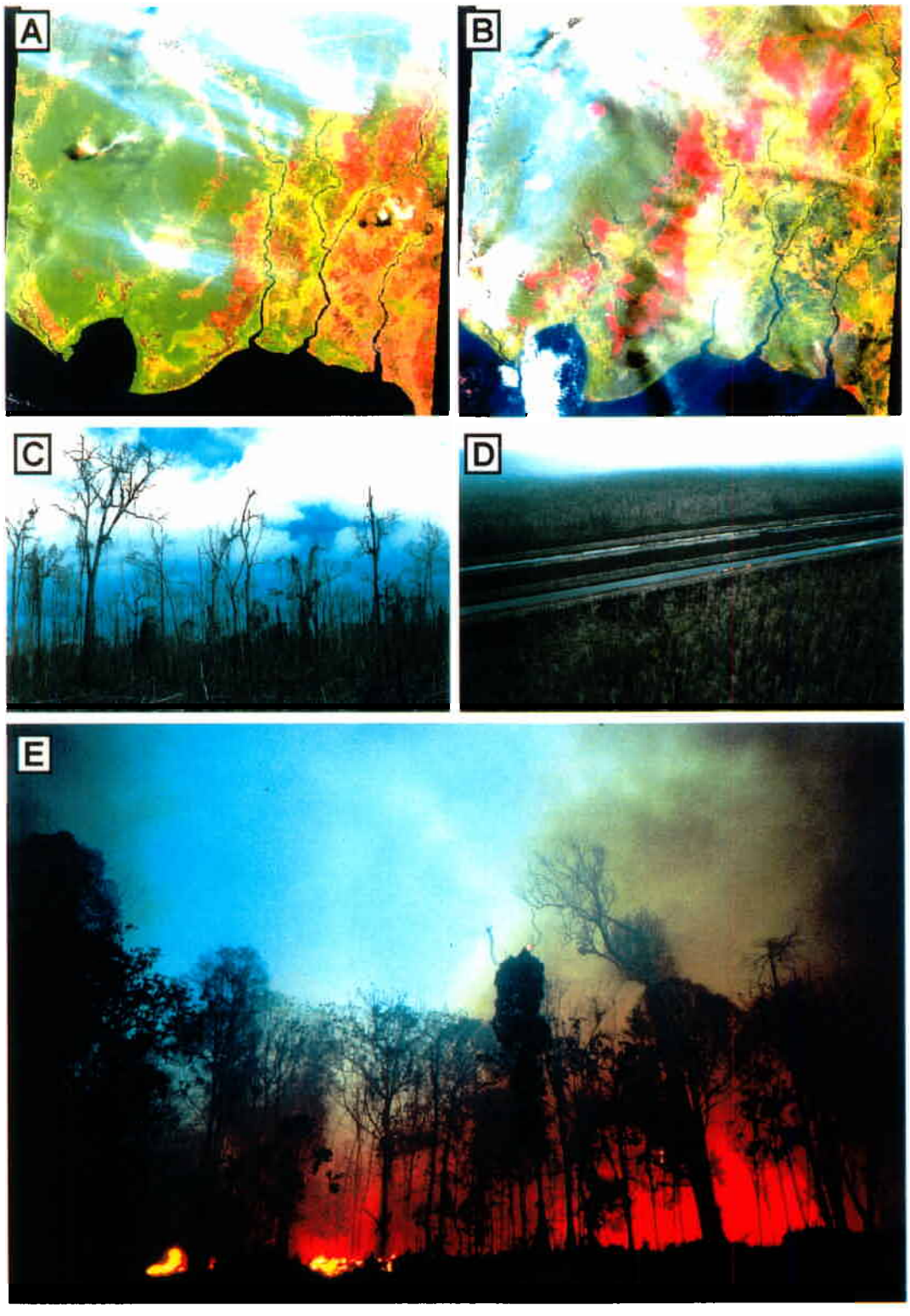

Figure 23: **A:** LANDSAT-Quicklook acquired during the fires (2 Sept. 1997, 118-62). **B:** LANDSAT-Quicklook acquired 6 months after the fires (29 March 1998, 118-62). Red areas indicate burned P.S.F. Approx. 700,000 ha have been burned. **C:** Burnt trees along a side channel. **D:** Burned forest along the Main channel. **E:** Fire inferno in Kalimantan.

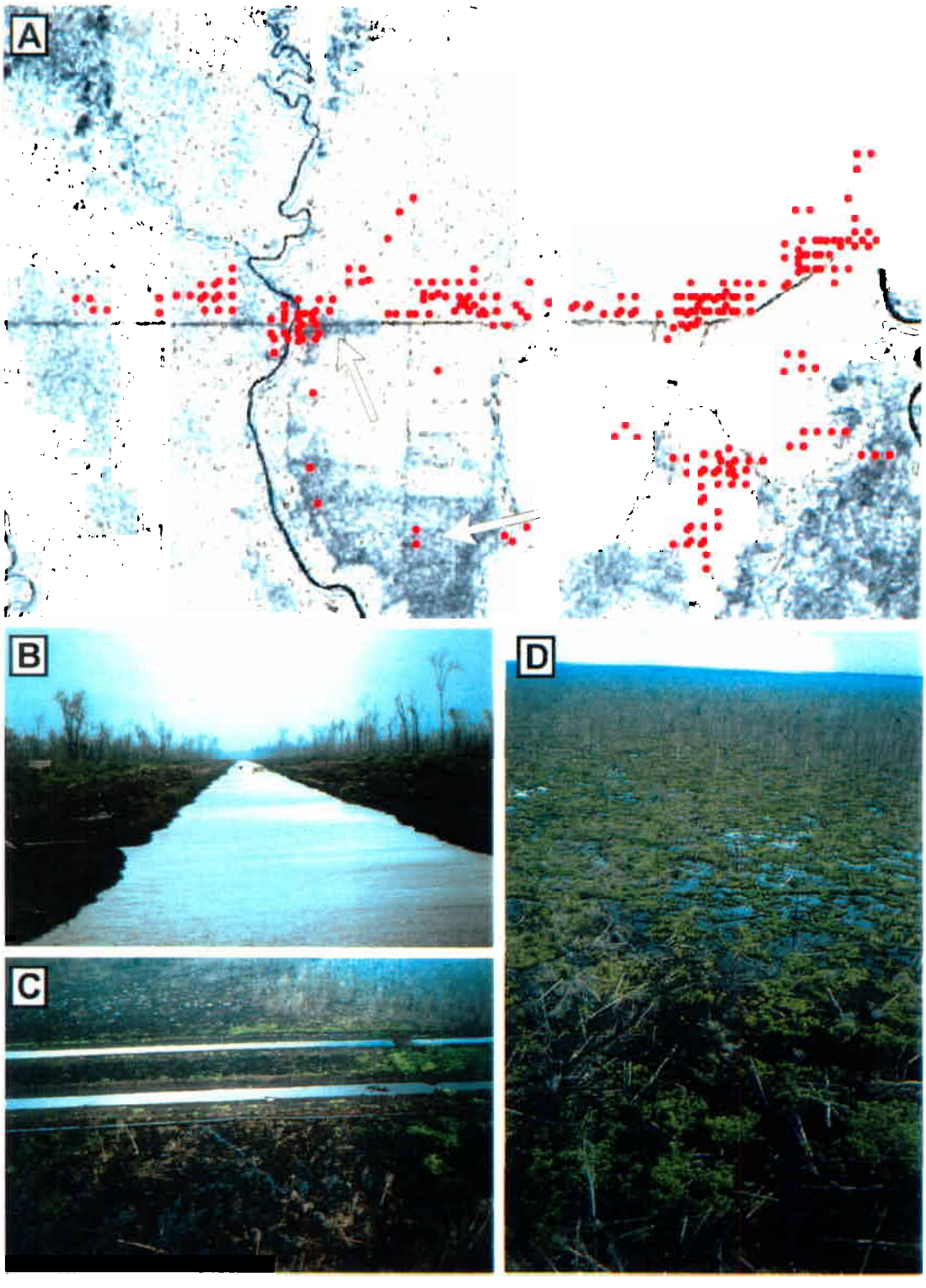

Figure 24: A: ERS-image (18 Sept. 1997) with the Main channel and NOAA AVHRR hot-spots (red dots) acquired between January and April 1998. Received and processed by IFFM (Mrs. Anja Hoffmann) in Samarinda (Kaltim). **B:** Irrigation channel and burnt trees. **C+D:** Totally destroyed P.S.F. along the main channel, location of D indicated by arrow in A.

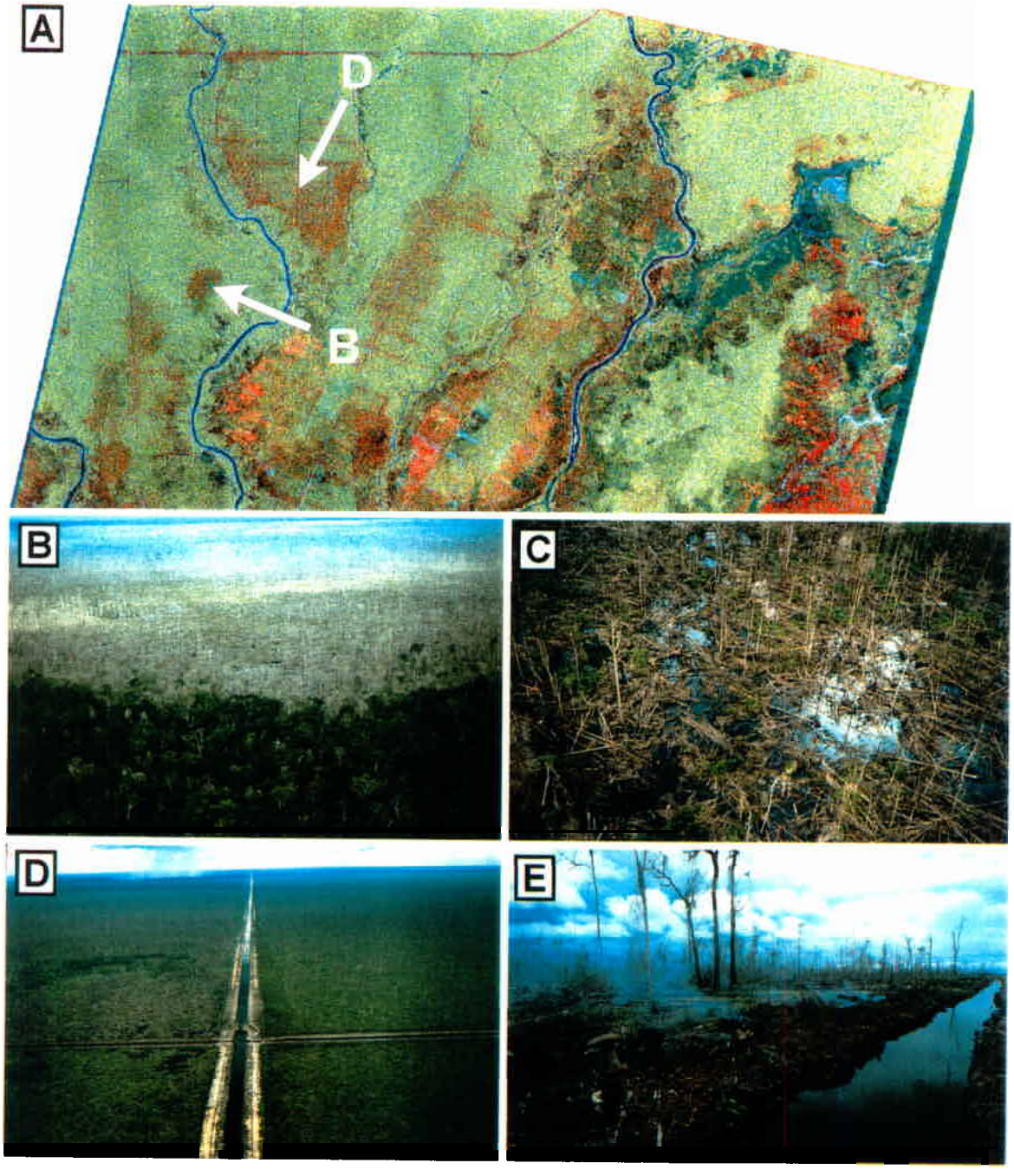

Figure 25: A: ERS Change Detection image (7 Nov.1996 and 18 Sept. 1997) of the 1 Million. ha rice project between the rivers Kapuas and Barito. Burnt scars appear in reddish colours. Compare aerial photos as indicated by arrows. **B:** Burned scar. **C:** Totally destroyed P.S.F. **D:** MPC and SC crossing each, no trees remain. **E:** Spontaneous farming along side channels.

4.10 Fires and Drought Hazard, Burnt Scars in 1997

Rainforests often grow 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 happened in 1982/83, 1987, 1994, and 1997 in Kalimantan, it will take centuries until a new forest with a similar species diversity will regrow. 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 the exploitation and conversion of tropical rain forest proceeds uncontrolled and with increasing rate. To analyse changing land use patterns, up till now mainly optical satellite images and aerial photos were evaluated. 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.
In 1997, Central Kalimantan was one of three main regions in Indonesia where forests and peatlands were on fire. The "Mega-Rice-Project" was one major location of "hot spots" because burning for land clearance for the project started at the onset of the dry season. In June, several months before the fire and smog had become a serious health hazard to millions of people in South-east Asia, the areas upstream of the reclamation project already suffered serious food shortages. A marked drop in the water-level of the major rivers combined with poor visibility due to the smog hindered food transport to communities and a lack of water for irrigation has made it impossible to plant crops. In September and October famine, forest fires and drought was reported in the area. Most of the fires were man made. (Compare Figs.21, 23, NOAA hot-spots are presented in Figure 24A)

5. Economical 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 austerity 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 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 forest land conversion from outside the forest sector.
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.
The economic crises of 1997/98 forced people to earn their living by washing gold. Figures. 26, 27 show small-scale gold-mining at the upper rivers of Kalteng.

Figure 26: Small-scale gold-mining. **A**. Gold float with 5-6 people each on the Kahayan river digging for alluvial gold. **B:** A working machine at Tumbang Samba in Katingan river transporting sand with gold particles over carpets. **C:** The result of one day work. **D:** Meandering Kahayan river with intact tropical *Dipterocarp* forest.

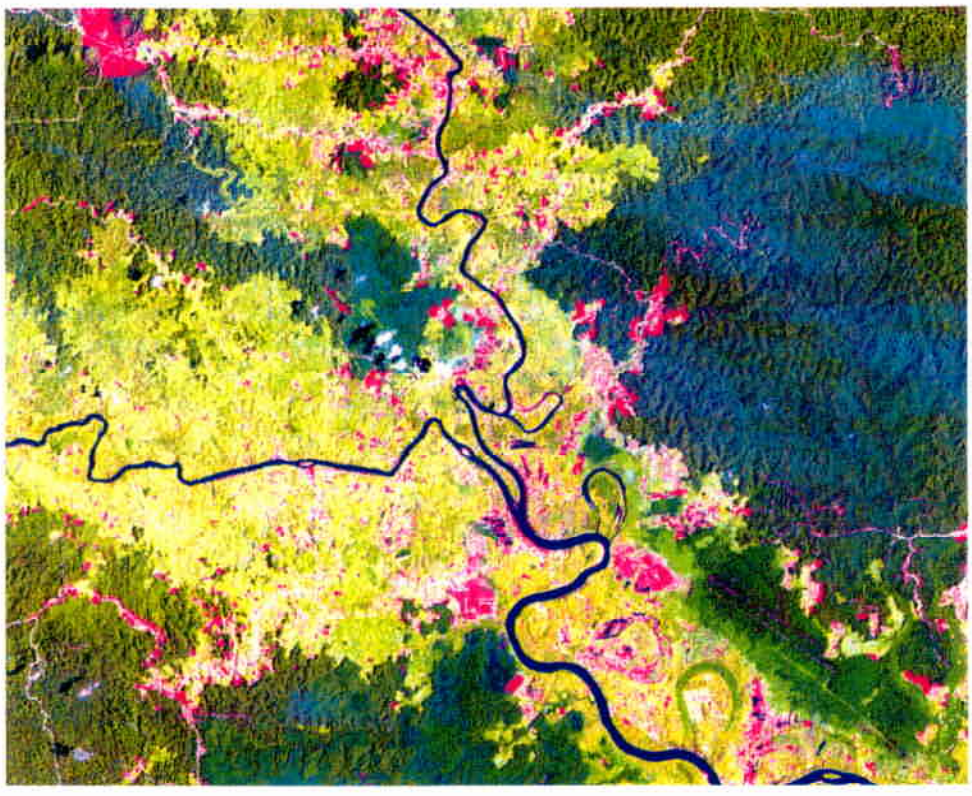

Figure 27: LANDSAT TM image (RGB=542, 24km x 30km, 3 Feb. 1993) from Tumbang Samba with rivers Katingan, Samba with village Tumbang Samba. Visit of the gold digging area in the Katingan river on 26 June 1998 by speed boat res. 27 June 1998 by water plane with GTZ. Tropical forest with highland dipterocarp trees (file: 930203-542A.bmp).

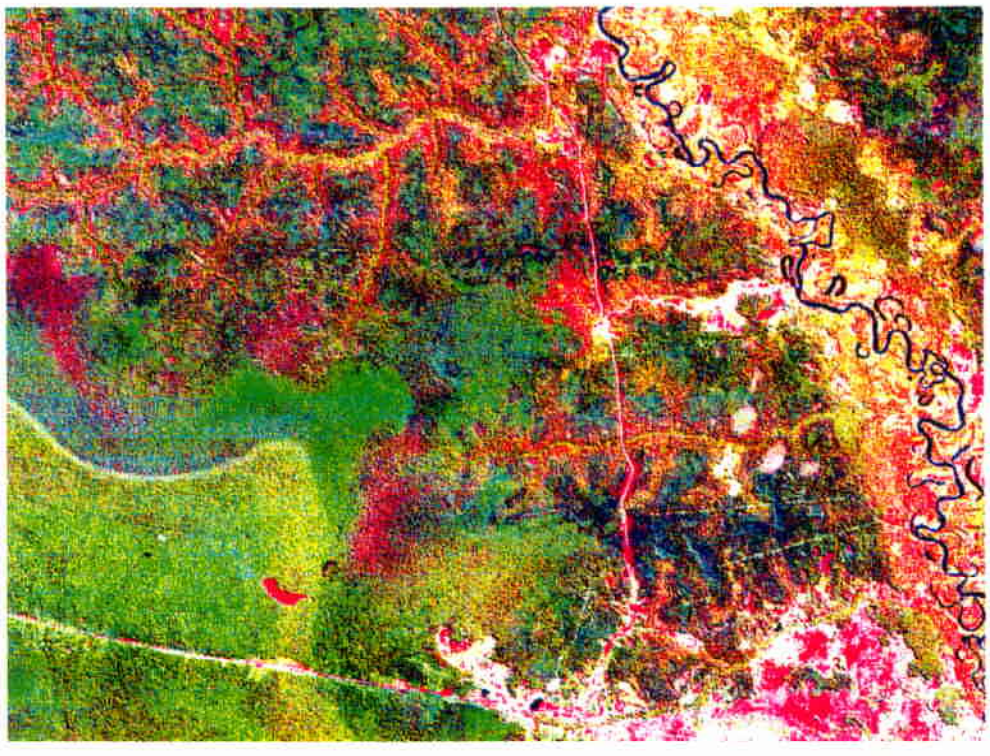

Figure 28: LANDSAT-TM image taken on 30 June 1991 (RGB=542, 18km x 24km). It shows the structure of black water river Tilap leading to Rungan and Tangkiling area in the lower right. P.S.F. and heath forest alternating (compare Fig. 14. File: 118_061Bequ.tif).

6. 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 with indigenous people conducted over a two year period, 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 be increased 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.

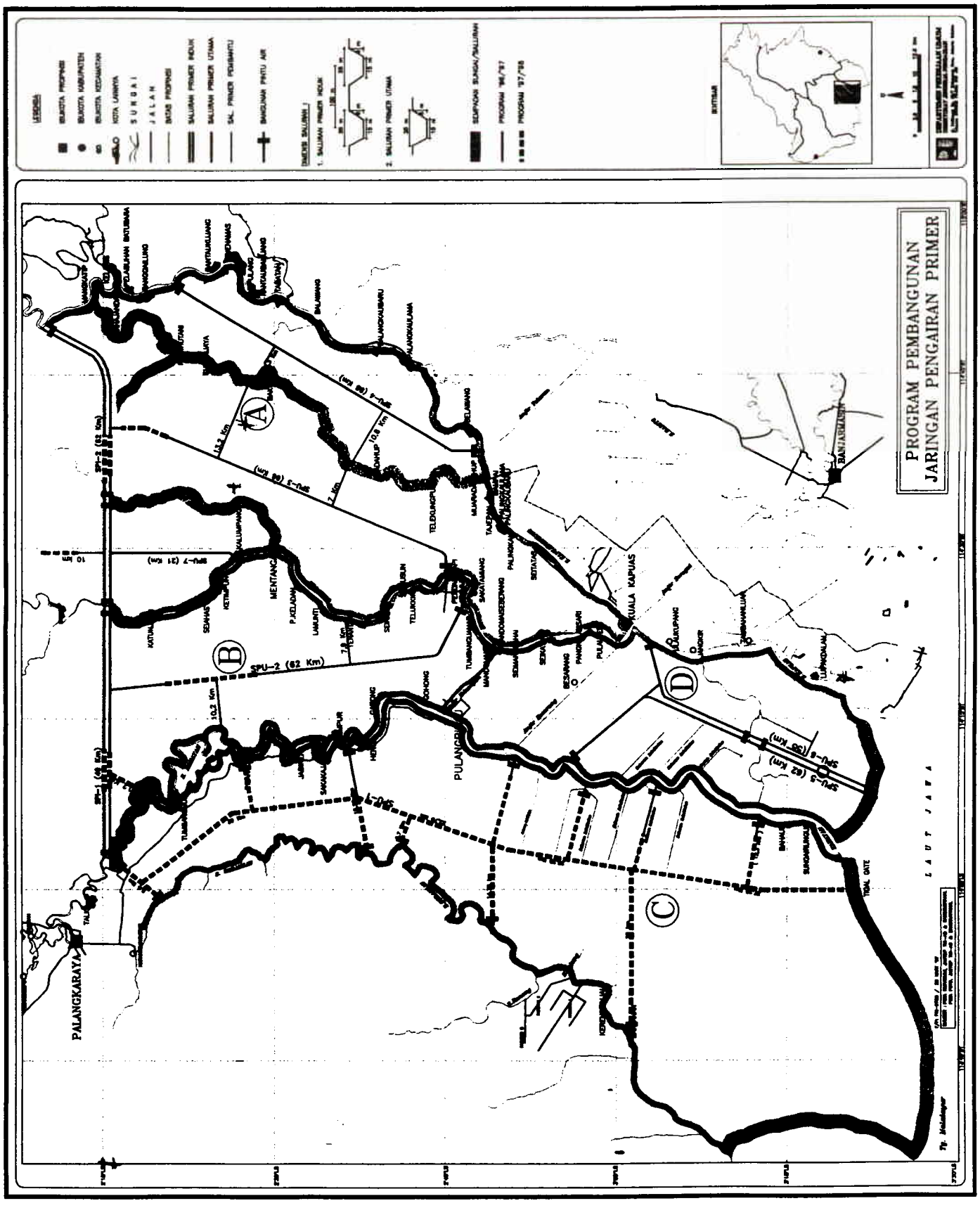

Figure 29: Construction Map from Public Works (28 March 1997) of the Mega-Rice-Project to convert 1 Million hectare peatland in the Blocks A, B, C and D.

7. 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.

Draught and/or low water-table cause trees to die. Frequent fires give forests no time to recover and the tropical climate causes quick overgrowth by ferns and alang-alang 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, questions 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 1960ties, 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 transmigrates 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 forest industry and channel construction companies. After the Indonesian economic crisis of 1997/98 the financial situation is much 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 pot-holes cost time and money; even though bridges have been constructed over the Kapuas Murung, Kapuas and Kahayan rivers.

The next step within the frame of the EU-project is to process, filter, geocode and mosaic satellite images and to delineate forest types, agriculture areas, settlements, water bodies, burn scars, channels etc. All satellite data and information is to be stored in the GIS. Procurement of new ERS images from 1998 is necessary. The result will be thematic maps. Workshops on LANDSAT and ERS SAR image processing and GIS application should be arranged for our Indonesian partners.

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9. Abbreviations

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

10. Figures

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