

Environmental Management Study of the Tangkiling District along River Rungan in Central Kalimantan, using Remote Sensing and GIS

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ABSTRACT

Vast areas of peat swamp forest (PSF) cover the coastal plains of Central Kalimantan from the Java Sea up to the provincial capital of Palangkaraya and further North. PSF is among the earth's most endangered ecosystem, with a huge carbon storage capacity, extremely fragile to disturbance. The PSF in the study area goes gradually over into heath forest, which lies on lightly higher altitude.

Landsat ETM images 118-61, 118-62, acquired on 14. Jan and 15. Feb 2003, were compared by using detailed analysis of the region around the Tangkiling granite hills and the black water river Rungan north of Palangkaraya. These images show major changes in this largest remnant of tropical peatland related to extreme rates of deforestation and the worst fires in 2002, since 1997, compared to older Landsat images from 1991, 1997, 2000, ref. 3.

With the establishment of the Mega Rice Project (MRP, One Million Hectare Mega Rice Project) and the infrastructures of roads, many people were able to enter the previously inaccessible interior of this peatland landscape, exploit residual timber resources, mostly on an illegal basis, and using fire for land clearance as the most economical method.

Ground truthing were done in this study area 2004 with a map-size of 26 km by 42 km in the Tangkiling district and around the hills itself of Sei Gohong and Rungan Sari in a small scale of approx. 12 km by 18 km with PSF, grassland, agriculture, scrub, riparian gallery, regrowth, secondary forest, home gardens, burnt areas from 2002, settlement, sand, water bodies etc. The zoning areas were evaluated according to landscape ecological principles along river Rungan and along smaller rivers for development and conservation purposes. We did an environmental diagnosis for the zones under study, which classifies area of interest based on socio cultural and economic aspects as well as ecological aspects. We formulate and prioritize strategies for the management of the areas trying to combine needs of conservation and local people necessities through alternatives of biodiversity utilization and land rehabilitation. We define the guide-lines to implement the strategies.

- Maps regarding the present environmental condition of the assigned areas will be presented in large and small scale around Tangkiling village which describe and analyse the present situation
- A zoning maps are produced for development and conservation areas regarding to three objectives based on the landscape ecological analysis:
 - Conservation of large preservation and restoration areas, such as high steep slopes, PSF, woodlands, green corridors, etc.
 - Conservation of small vegetation areas
 - Conservation of the vegetation along the river as a green corridor and water protection
- Areas in the small scale mapping around Tangkiling hills describe the current land cover such as agriculture, traditional home gardens, scrub and grass lands, forest and forest regrowth, housing and recreation areas, etc.

The minor el Nino of 2002 led to human health problems in that region, although somewhat less serious than in 1997. Our analysis showed that 7.6% of the approx. 100,000ha area was burned. Previous legal logging prepared the ground for further degradation of forests by fire and illegal logging. If this situation continues there is a high risk of most peat swamp forest of Central Kalimantan being destroyed within a few years. This would have grave consequences for the local hydrology, climate, biodiversity and livelihood of local population.

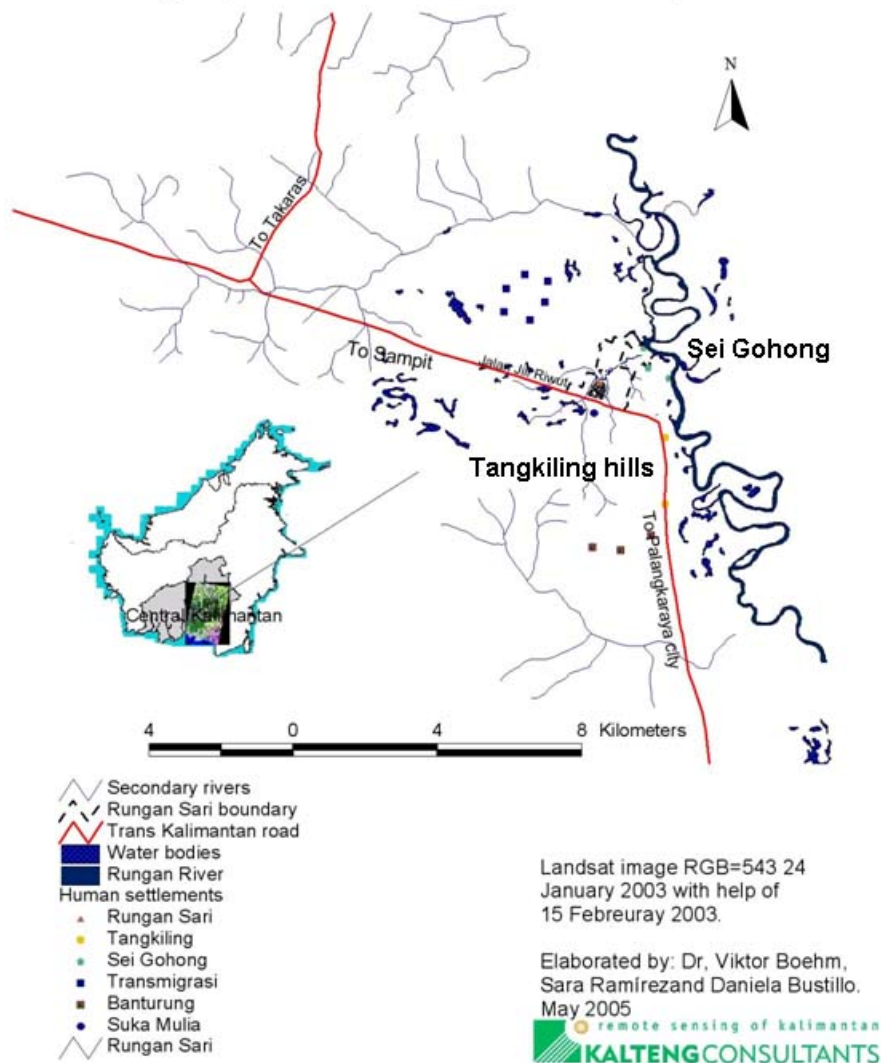
Keywords: Central-Kalimantan, Tropical Peatland + PSF, Conservation, Environmental Management, Zoning Areas, Fires 2002, Remote Sensing + GIS, GPS, Tangkiling, Sei Gohong, Rungan Sari

1. Introduction: Geographic location of the study site

Tangkiling District is located to the North of Palangkaraya in Central Kalimantan. The Tangkiling village is approx. 34 km away from the province’s capital *Palangkaraya* on the way to Sampit. Two villages are under special consideration *Sei Gohong with Rungan Sari* and *Transmigrasi* village at km 38 and the *Tangkiling* village, see **Map N°1**.

The communities around the study side are mainly Dayak and Javanese who work in agriculture, fishing, granite rock exploitation, timber and other harvesting and gathering activities as well as government employees; however unemployment in the region is still very high. Regarding the landscape aspect we find mainly an alluvial peatland plain 30 meters over the sea level with the meandering *Rungan River* in between, Fig.1+2, and as exception the Tangkiling hills, see Fig.1+5, a granite formation of seven hills, some are approx. 150 m high. The area around the hills was covered in the decade of 1980 with primary Peat Swamp Forest (PSF) in which the black water River Rungan runs down to River Kahayan and then to the Java Sea. Fig. 2 shows Sei Gohong.

Geographic location of the study site



Map N°1: Geographic location of the study site on BORNEO ISLAND, Central Kalimantan, Tangkiling / Rungan area



Fig.1: View from Tangkiling Granite Hills into the plane peatland with the Rungan basin



Fig. 2: Rungan River with Sei Gohong village and surrounded PSF



Fig. 3: Rungan Sari development inside secondary PSF and the Kalimantan highway to Sampit



Fig. 4: Secondary PSF with scrubs in the foreground and remaining PSF in the rear



Fig. 5: Tangkiling Granite Hill, stone partly cracked



Fig.6: Alang-Alang growing on opened peatland, very sensitive for fire

Fig. 3 shows an aerial photo from Rungan Sari development, Fig. 4 secondary PSF, 5 the stone braking in the Tangkiling hill and Fig.6 opened peatland with Alang-Alang grass.

2. Methodology

2.1 Data Processing

Basic image processing was done using the Remote Sensing Software ENVI 4.1. Raw image files were imported into ENVI and bands 3, 4 and 5 were selected to produce a colour RGB image.

Band assignment was 5, 4, 3 = RGB. Each channel was interactively contrast enhanced in a reference LANDSAT TM image (118-61, Jan. 2003) in order to maximise overall image contrast. This band combination proved to be the best in this tropical region. It allowed separating more than 20 vegetation and land use classes. Using the result of a histogram analysis of the reference image the adjacent scene (LANDSAT TM 118-62, 2003) was adapted in contrast and colouring to the reference image. This procedure was applied to all LANDSAT TM scenes from different years. With a Global Positioning Sensor (GPS) points were collected during field trials using the continuous track mode of the GPS acquiring measurements every 30s. With the Geographic Information System (GIS) software ArcView SW 3.3 the pixel size was set to 30m. By using the ArcView Image Scaler extension the image was then moved interactively into a position, in which the GPS measurements matched unambiguous features like rivers, roads, channels etc. Thereby we achieved an accuracy of one pixel (30m) for most of the study area. LANDSAT TM images from 1991, 1996, 1997, 2000, 2001 and 2003 (Boehm et al. 1995, 2000, 2002, 2003, 2004) were compared in Arc View. The classification was done by visual interpretation with delineation of several classes in the images. A land cover map was prepared for an area of 26km x 42km - around Tangkiling using mainly the Satellite images from Jan and Feb. 2003 (**Map N°3**, Boehm et al. 2000). Information research and field trials took place within the aim of the specific objective stated later in this document.

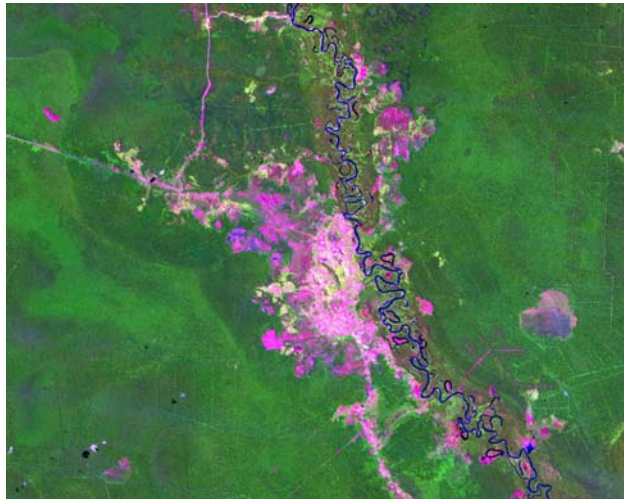


Fig. 7: Landsat image from Tangkiling area, June 1991, PSF in green colour, starting to open PSF in reddish colour, Ref.3

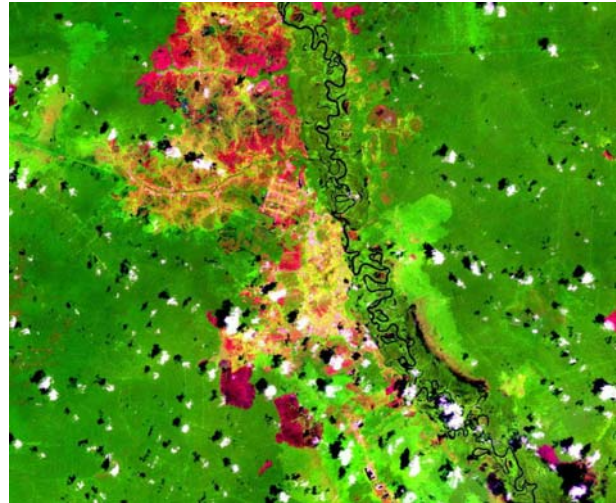


Fig. 8: Same Landsat image from Jan. 2003 with opened peatland and burnt scars from fires in 2002; see different red, yellow and light green colours

2.2 Landscape ecology survey

To develop this aspect, several components were defined:

A. Land cover classes with existing types of vegetation:

The maps were made from satellite images LANDSAT TM 3-4-5 of 2003 and for monitoring the field trials a GPS was used. First the land cover classes were defined, see Fig. 9.

A survey was made in the four working areas in which the study site was divided: East area, North West area, South West area and North area. This orientation was in relation to *Rungan Sari*; the areas are shown in the **Map N°2**. Field work was done once a week during the first two months and each time a form was filled with the biophysical data observed. A printed portion of the satellite image corresponding to the area visited was also used in order to make image interpretation directly from the site. GPS waypoints and photos were taken to complement this ground truthing exercise.

In the case of places without a possibility of access, LANDSAT images of 1991, 1997, 2000, 2001 and 2003 as well as some aerial photos were helpful for monitor changes. This information was processed using *Arc View*.

B. Landscape according to structure and pattern:

The landscape ecology analysis helps to understand complex processes that occur in the territory. These processes are the result of social, cultural and natural elements interacting with each other in a selected area. It is a tool for understanding the environment as a whole.

In the field the analysis started with the identification and definition of every element in the landscape. Land cover classes were defined which vary according to their structure and composition. They can play a role in the connectivity between ecosystems when acting as corridors. On the other hand, forest fragmentation and land degradation can be analyzed by the classes. If for example a landscape has classes of natural vegetation with none or little fragmentation, this class reflects as a landscape in a good condition. On the contrary, if the natural vegetation is limited to isolated patches then the landscape is fragmented and on its way to degradation.

For the landscape analysis in the area under study the *Classes analysis extension* of the ArcView program was used and the definition for ecological classes in the landscape were the ones shown in the Fig. 9. This was a useful tool for incorporating ecological knowledge into planning. During the landscape ecological evaluation conservation biology principles were kept in mind.

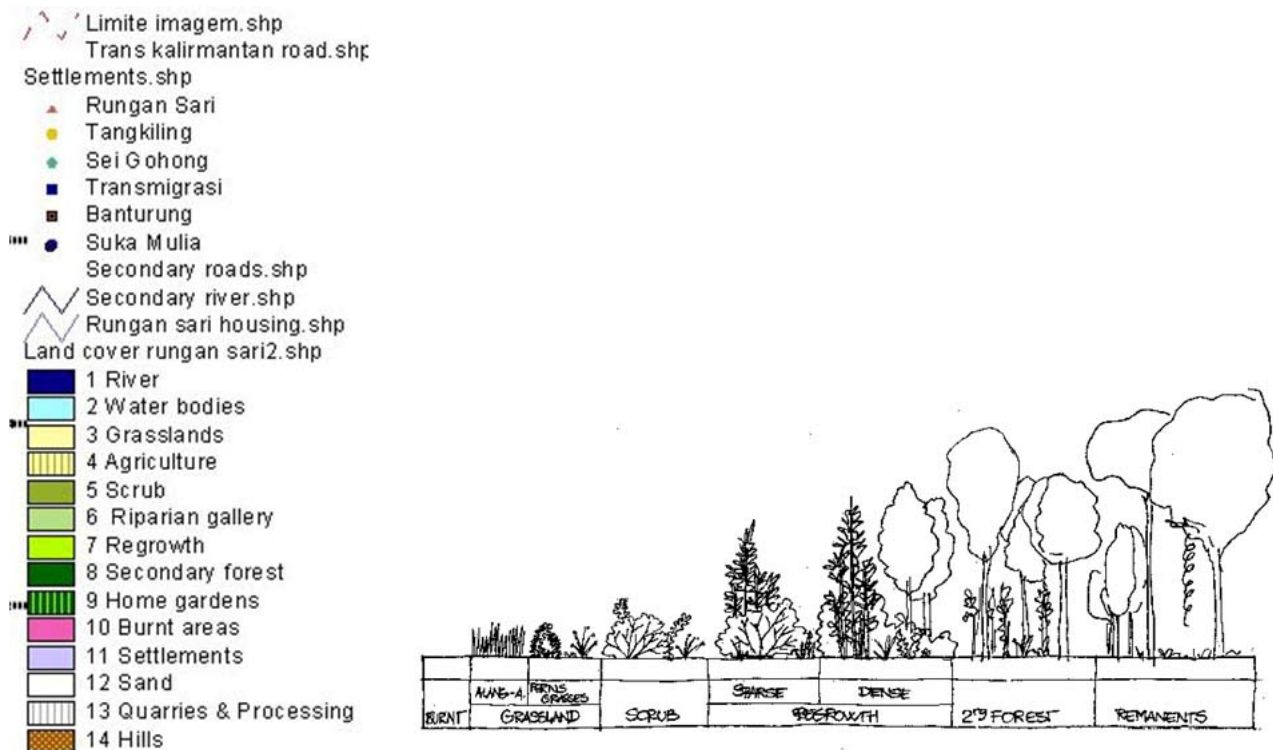


Fig. 9. Legend for the Maps No.4+5 and definition of vegetation and polygon classes, delineated

C. Landscape biodiversity regarding birds:

Besides all the human and ecological elements gathered by the methods described until now, a regular bird monitoring was carried out as a way of complementing and completing the analysis data base (Ref. Ramirez et al. 2005).

“Transects samples” was the methodology implemented which means that transects were established throughout the area and visited regularly during bird observation visits. Forest, forest re-growth, grasslands, scrublands and housing areas were the habitats types established for each transect. All birds seen and listened were registered and identified by using two field guides of the birds of Indonesia. Birds difficult to identify were discussed and identified with the help of some ornithologist with experience in the region.

The data was then organized in an Excel program file and figures about feeding behaviour, habitat preferences and relevant families were made. Species under any type threat category according to the IUCN (International Union for the Conservation of the Nature) red list were marked (Ref. Ramirez et al. 2005).

2.3 Field survey of the communities and their activities

During the field survey key persons with knowledge of the area under study were identified and addressed to have an introduction to the main environmental aspects of the study area. A preliminary survey was made in order to recognize human settlements, access roads, strategic points for information collection, hours in which local people are active and to identify “wise men” and community leaders. During the survey different actions took place:

Social Ecology Techniques were implemented such as “participants observation”, informal conversations with “wise men”, interviews and descriptive notes were taken.

The field work for each settlement was made three times per month during the first three months and then only once a month during the last three months.

During the days in the field observations were made about people in their every day activities such as agriculture, fishing, gathering and harvesting forest products, hunting and other daily activities like cooking, washing clothes, bathing, resting, entertainment, making handicrafts, children at school and so on. Information about infrastructure services, mosques, churches, cemeteries, houses, basic sanitary elements were recollected. At the end of the field day the observer would compile all the information on the notes taken and complement it when pertinent.

The “wise men” provided information about human settlements history, traditional and present ways of using the natural resources, traditional and ways of life and some aspects about local people’s occupations, health and nutrition. As a complement, some interviews were made with one of the executive directors of LPKB Foundation (Lembaga Pengembangan Kehidupan Berkelanjutan), which has projects in the region under the name of TSLiCK (Towards Sustainable Development and Livelihood in Central Kalimantan). From this project it was possible to obtain information about populations, their origins, quality of life, employment and infrastructure services of the people in the three villages around Sei Gohong-*Rungan Sari*.

The recollection of social data ended with one of the social integrating techniques of social ecology known as “cognitive maps”. This activity took place in form of a workshop and one of the staff members of the TSLiCK project was the facilitator in the process. The participants were divided into two groups: “the wise men” and the “younger ones”. Each group made a drawing or a “map” in which they illustrated, according to their perception, relevant components of their environment and those with higher value for them. After the drawings were completed, a member of each group would explain to the whole group their “vision” of the territory followed by a discussion regarding “problems and solutions” according to the community point of view. The facilitator would take notes in a visible place listing all the ideas discussed.

All this information was relevant when the environmental diagnosis and conservation plan were made since it allowed an analysis and attribution of priorities to the problematic situations exposed by people during the workshop.

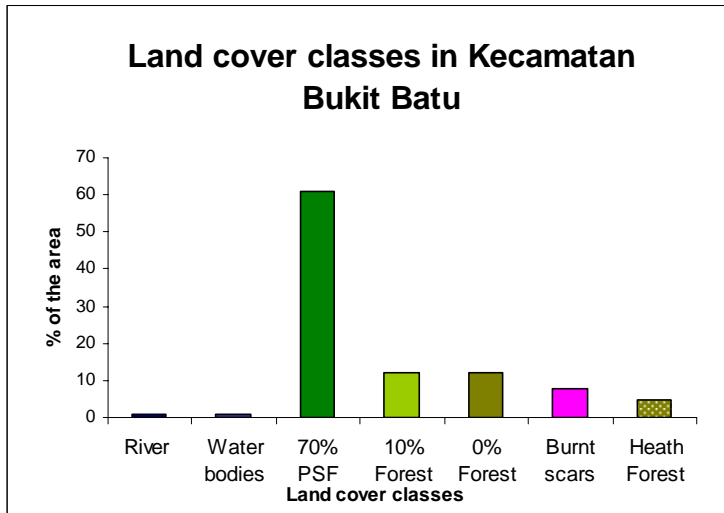
3. Results

3.1 Evaluated environmental aspects:

• Ecological aspects:

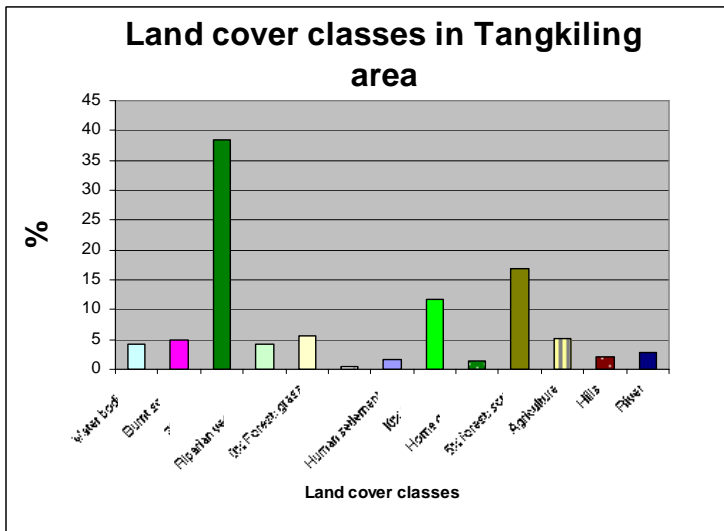
The ecological process existing in the landscape was described in relation to vegetation changes caused by disturbances such as forest and land fires from 2002 and slash and burn agriculture areas. A classification of the land vegetation types were made by which areas with important value for conservation and other degraded lands that need rehabilitation or restoration were identified. All the ecological aspects were evaluated under landscape ecology and conservation biology principles. Maps were elaborated showing current land cover and landscape ecological elements such as green corridors and forest classes; see Maps 3, 4, 5, 6 and 7. The results are shown in

Map N° 3 + 4 + 5 for land cover classes and Map N° 6 + 7 for zoning. **Burnt scars of 2002** had an amount of **7.6%** in the larger area and **4.9%** around Tangkiling. Burnt scars are re-growing quickly.



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

Table1: Land cover classes in Kecamatan Bukit Batu, see Map 3, taking 95909 ha into account



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

Table 2: Land cover classes in Tangkiling area; see Map 4

• Socio-economical and cultural aspects:

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

• Institutional aspects:

The presence of government and non governmental institutions was described as an idea of area development. The possibilities of an institutional cooperation with them could bring benefit to all.

3.2 Synthesis of the main problematic situations in the region identified by the local communities

Table 3 shows the problems of conversion of PSF into agriculture land, which occurs since 1980.

The main problems resulting of the land use changes are considered below:

- Deforestation by legal or il-legal logging
- Fires nearly every year caused by opened canopies and dry debris's
- Loss of fishing resources caused by changing black water rivers through sediments into yellow/brown water which changes the biosphere
- Lack of technical assistance and self- management process
 - Food insecurity
 - Difficult access to markets for agricultural products
- There is little information about the interconnection of ecosystem, biodiversity and natural resources availability
- Poor social health care, sanity conditions and water supplies
- Poor institutional effectiveness
 - High rate of unemployment, caused poverty
 - KKN (Korrupsi, Kolusia dan Nepotism, *indo.*) - Local investments are low

3.3 Action plan

Table 4: Proposed action plan

PROGRAMME	PROJECTS	GOAL	TERM	POSSIBLE SOURCE OF FUNDING
Conservation	Alternative for the dismination of the presure on natural resources.	The improvement and establishment of more and better productive practices will lead to the well being of people and conservation of natural resources.	Long	<ul style="list-style-type: none"> • Agreements for international cooperation. • The United Nations Children's Fund - UNICEF under the programme "Indonesian family nutrition improvement programme" • Tropical forest research (Tropenbos International), (Indonesian programme)
	Rehabilitation of degraded lands		Long	
	Consolidation of wide vegetation corridors along major water courses.		Long	
Knowledge	Inventory and characterization of biodiversity.	To know the components of biodiversity, the conservation needs and the potentials and opportunities for biodiversity utilization.	Middle	<ul style="list-style-type: none"> • WWF (World Wildlife Fund) Indonesia • Global Enviromental Facilities (GEF) • Private investment
	To recovery and traditional knowledge and practices.	To know and to promote traditional pactices in the management of the natural resources.	Middle	
Use/utilization	Establishment of geographic information systems	Monitory of the land uses and environmental changes, this is an importan tool for planning.	Middle	<ul style="list-style-type: none"> • Cooperation projects with Centre for International Cooperation in Management of Tropical Petlands (CIMTROP) and Towards Sustainable Livelihood in Central Kalimantan (TSLiCK) • Opening spaces for students from Indonesia and around the world, to come to the area to make their thesis in related topics with their own financial assistance. • KUK - Kalimantan Unggul Karya • KTD - Kalimantan Tourism Development
	Promotion of better practices for food production.	Improvement of the nutritional level of population.	Long	
	To develop the economic potential of biodiversity.	Local communities organized and achieving enterprises initiatives.	Long	
	Establishment of systems for cleaning residual waters.	To improve water quality.	Long	
	Training and education	<ul style="list-style-type: none"> • Training local communities in academic, echnical and enterprise areas with the puroposeof encourage them to work in their own benefit. • To develop communicative programmes and didactics materials about conservation themes. 	Middle	

4. Summary

4.1 Conservation strategy

• A synthesis of the main problematic situation identified by communities located around Tangkiling / Rungan Sari and by the environmental diagnosis made, allowed to formulate a strategy for natural resources management in Tangkiling and Rungan Sari area:

Principle: The strategy addresses the conservation of the relevant elements of the landscape and the management of the available natural resources, leading to a rehabilitation of degraded lands, conservation of forest remnants and improvement of the local community's economy.

Potential institutions involved, e.g.:

- World *Subud* Association
- LPKB (TSLiCK Project)
- Communities
- Government
- Palangkaraya University
- EU and World Bank

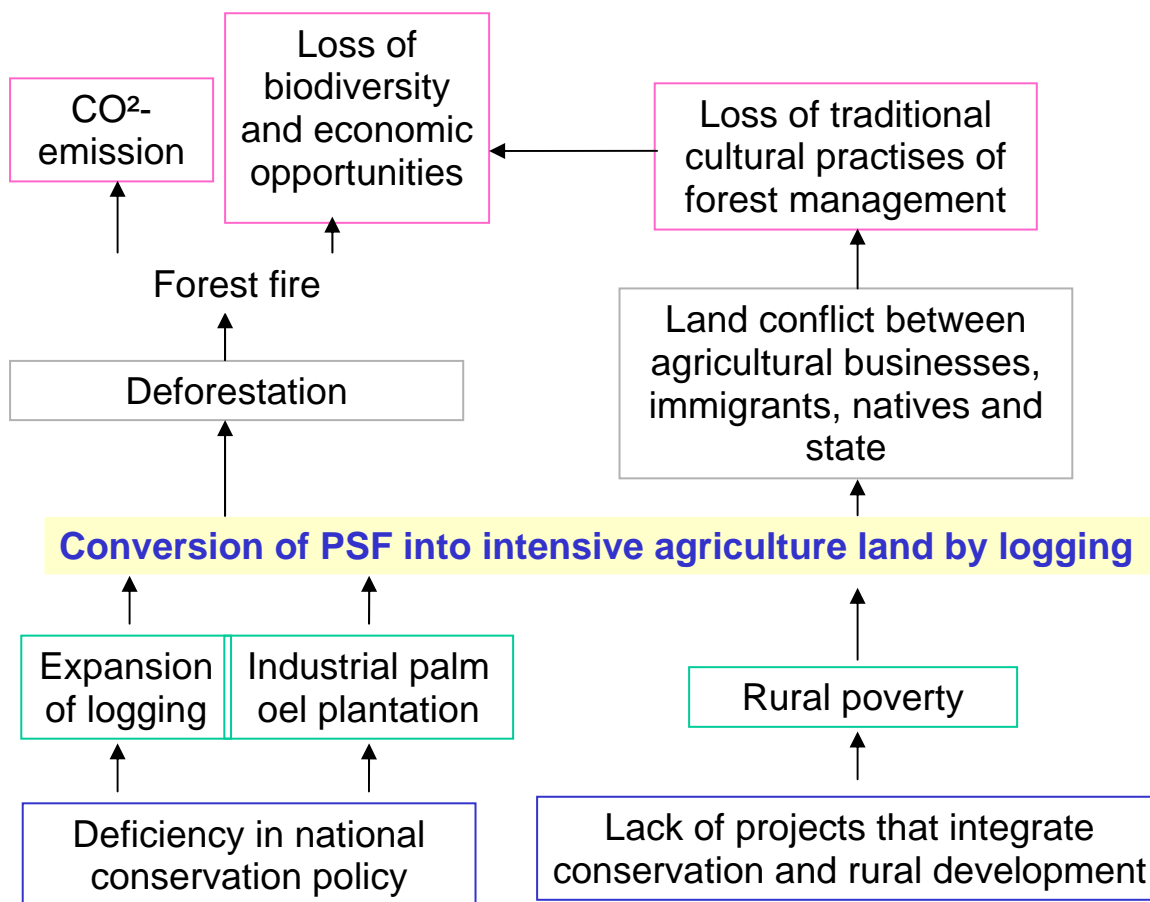


Table 3: Conversion of Peat Swamp Forest into intensive agriculture land by logging

4.2 Main points of the strategy

The combination of social and technological elements, as well as research, education and institutional cooperation is bound to lead to the conservation of the selected landscape. The main points of the strategy are described below:

- Environmental zoning for land rehabilitation, management, and proper use of the available land.
- Monitoring, research and a geographical information system - data base (GIS) is required in aspects such as: Rehabilitation of degraded lands, agro-forestry, agriculture and biodiversity.

C. Education and conscientiousness:

- Technical formation
- Business formation
- Academic formation with environmental emphasis
- Communication programmes for spreading knowledge of the local ecosystem, biodiversity, fire problem awareness and fire prevention
- Ecotourism

D. Institutional cooperation

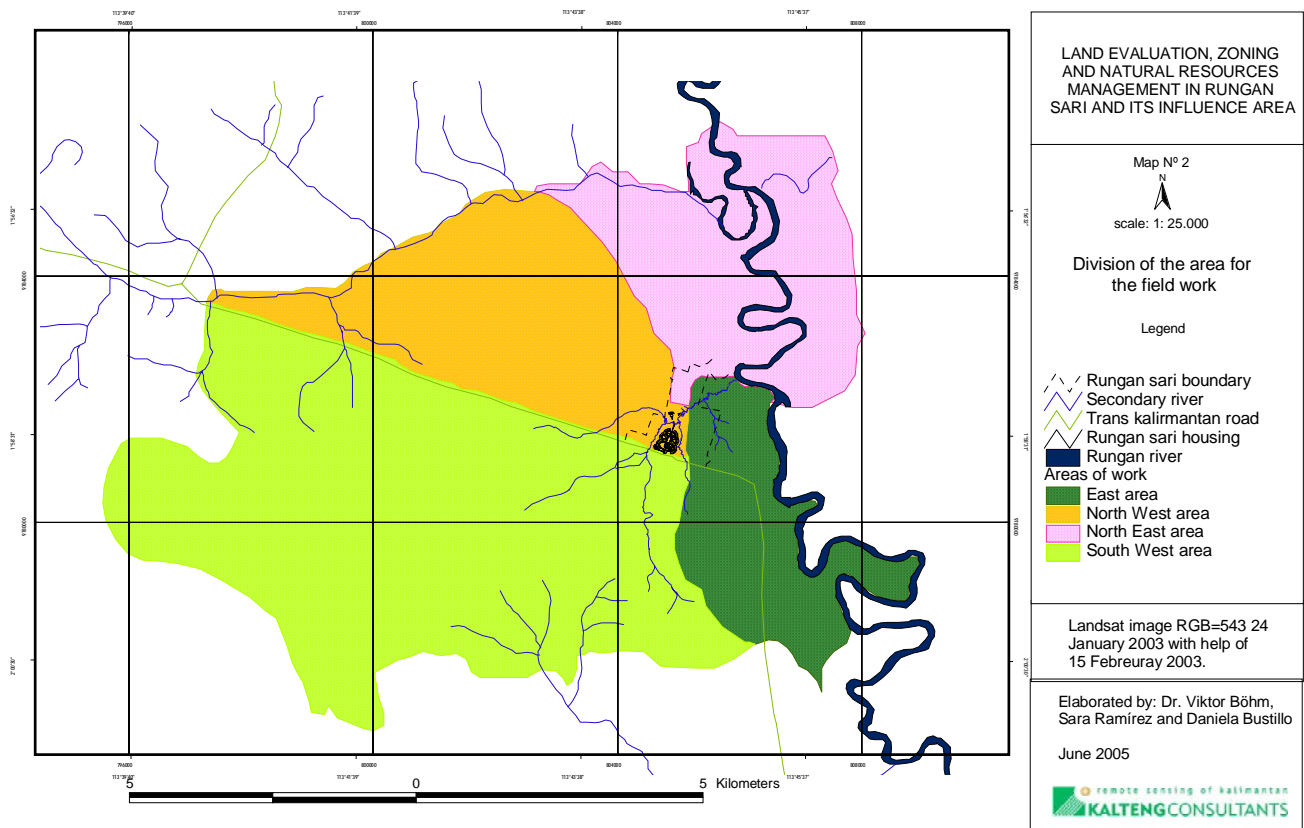
- Participation and coordination of the local, national and international institutions both governmental and non governmental
- Communitarian organization, participation and self-management

The strategy can be developed through the establishment of an Institute that leads the environmental research, monitoring, information systems incl. GIS as well as academic, technical and enterprise formation to promote a proper land use, a natural resources utilization and a good development of the communities.

5. Maps: The following maps were generated in 2004/2005:

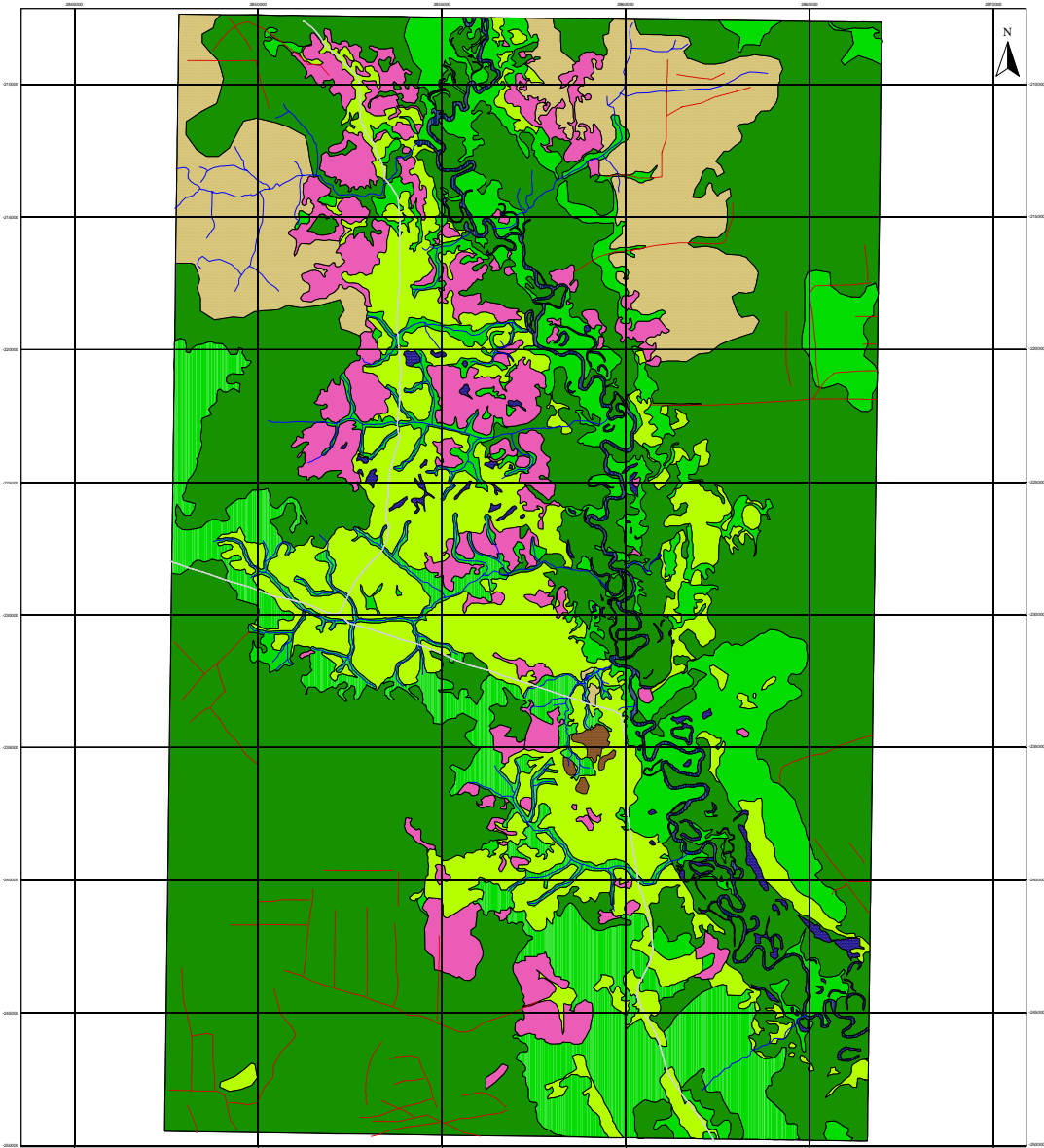
- Map N° 1: Geographic location of the study site
- Map N° 2: Division made in the area for the field work
- Map N° 3: Land cover classes in Kecamatan Bukit Batu
- Map N° 4: Land cover classes in Tangkiling area
- Map N° 5: Land cover classes in Tangkiling area – detail for Rungan Sari
- Map N° 6: Zoning proposal for Tangkiling area
- Map N° 7: Zoning proposal – detail for Rungan Sari

Map N°2: Division made in the area for the field work



Map No.3

Land cover classes in Kecamatan Bukit Batu



LEGEND

- Trans Kalimantan road
- Secondary rivers
- Logging roads
- Border line
- Tangkiling hills area
- Land cover classification**
- River
- Water bodies
- 70% PSF (logged)
- 10% Forest (regrowth)
- 0% forest: Converted into grasslands and scrub by clear cutting
- Burnt scars from 2002
- Heath forest
- Sand

Total area: 95909 Hectares
represented by:
Water bodies: 0.79%
70% PSF: 61.14%
10% Forest: 12.29%
0% Forest: 12.14%
Burnt scars from 2002: 7.62%
Heath forest: 4.96%
River: 1.06%

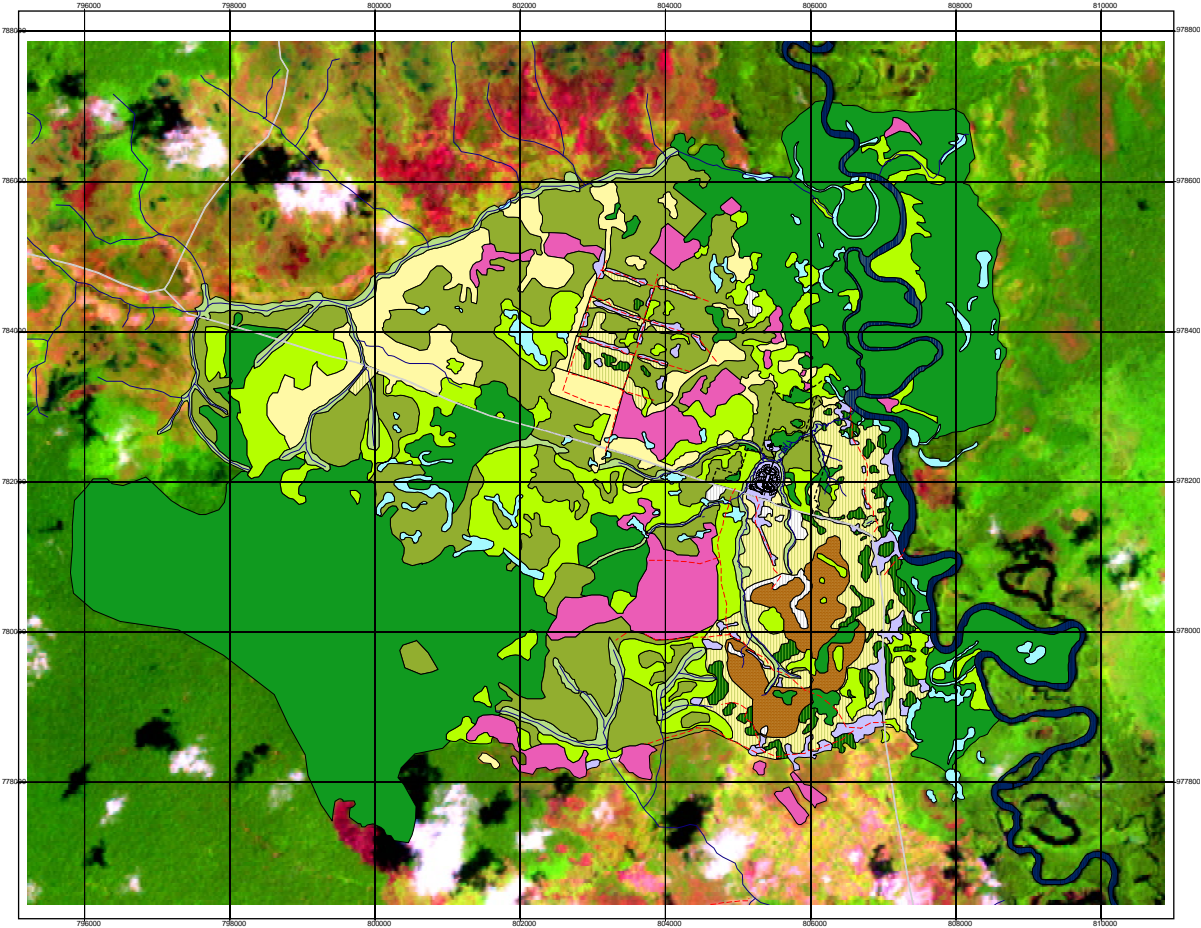
Landsat image RGB=543
14 of January 2003, with the help
of 15 February 2003

Elaborated by: Dr. Viktor Boehm,
Sara Ramirez and Daniela Bustillo
June 2005



Map No.4

Land cover in Tangkiling area



- Rungan Sari boundary
- Secondary roads
- Secondary river
- Rungan Sari housing
- Transkalmantan road
- Land cover Rungan Sari**
- River
- Water bodies
- 0% Forest:Grass
- Mixed 2: Agriculture
- 5% forest: Scrub
- Riparian vegetation
- 10% Forest: regrowth
- 70% Forest (logged)
- Mixed 1: Home gardens
- Burnt areas (from 2002)
- Settlements
- Quarries & Processing
- Mixed 3: Hills

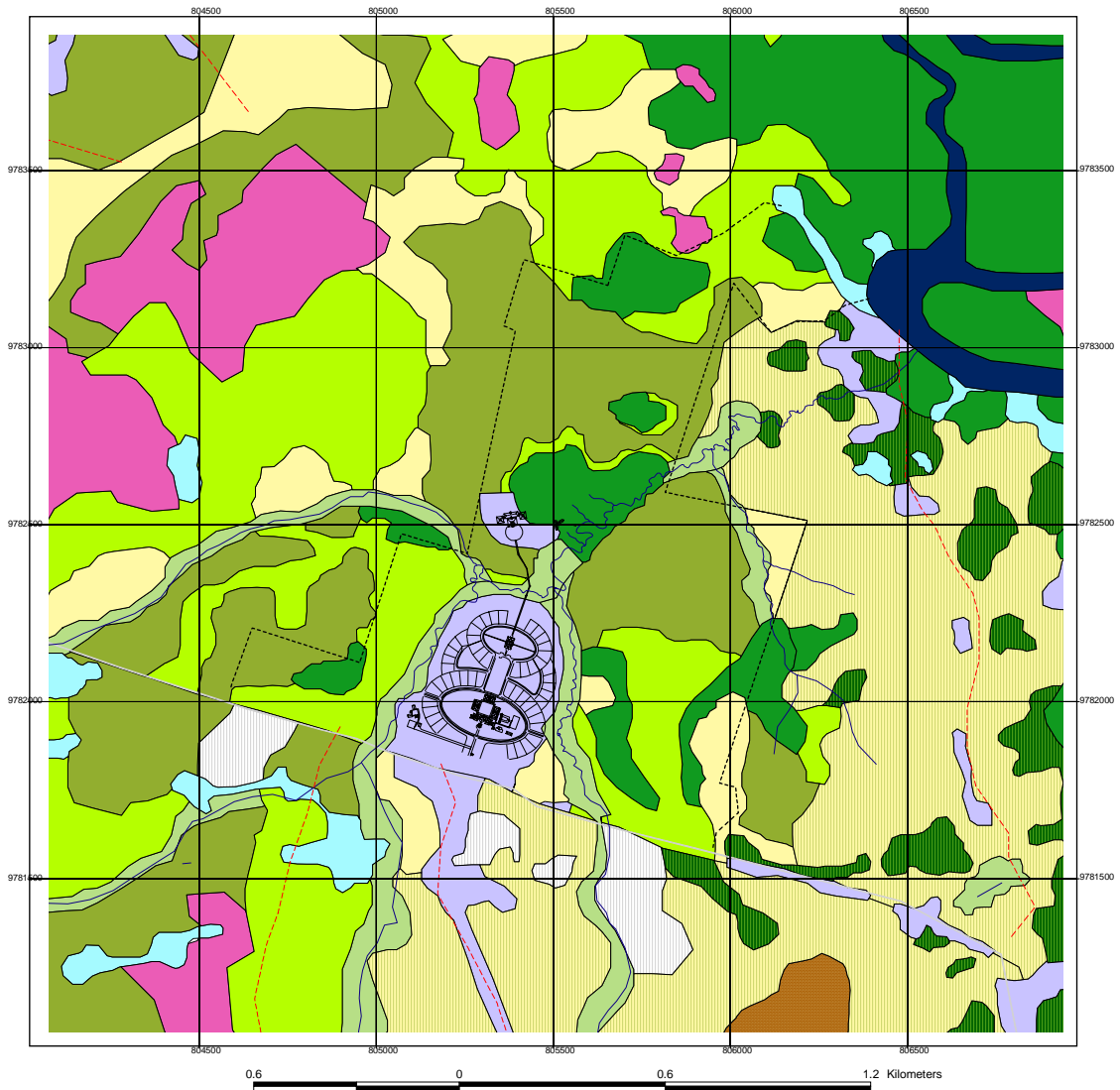
Total area: 9296 hectares
 represented by:
 Water bodies: 4.32%
 Burnt scars from 2002: 4.95%
 70% PSF: 38.44%
 Riparian vegetation: 4.11%
 Grass: 5.72%
 Scrub: 16.93%
 Quarry: 0.46%
 Human settlements: 1.67%
 10% forest: 11.82%
 Home gardens: 1.48%
 Agriculture: 5.22%
 Hills: 2.15%
 River: 2.73%

Landsat image RGB=543
 14 of January 2003, with the help
 of 15 February 2003

Elaborated by: Dr. Viktor Boehm,
 Sara Ramirez and Daniela Bustillo

Map No.5

LAND COVER INTANKILING AREA - DETAIL FOR RUNGAN SARI-



- Rungan Sari boundary
- - - Secondary roads
- ~ Secondary river
- ⋈ Rungan Sari housing
- ⋈ Transkalimantan road
- Land cover Rungan Sari**
- River
- Water bodies
- 0% Forest: Grass
- Mixed 2: Agriculture
- 5% forest: Scrub
- Riparian vegetation
- 10% Forest: regrowth
- 70% Forest (logged)
- Mixed 1: Home gardens
- Burnt areas (from 2002)
- Settlements
- Quarries & Processing
- Mixed 3: Hills

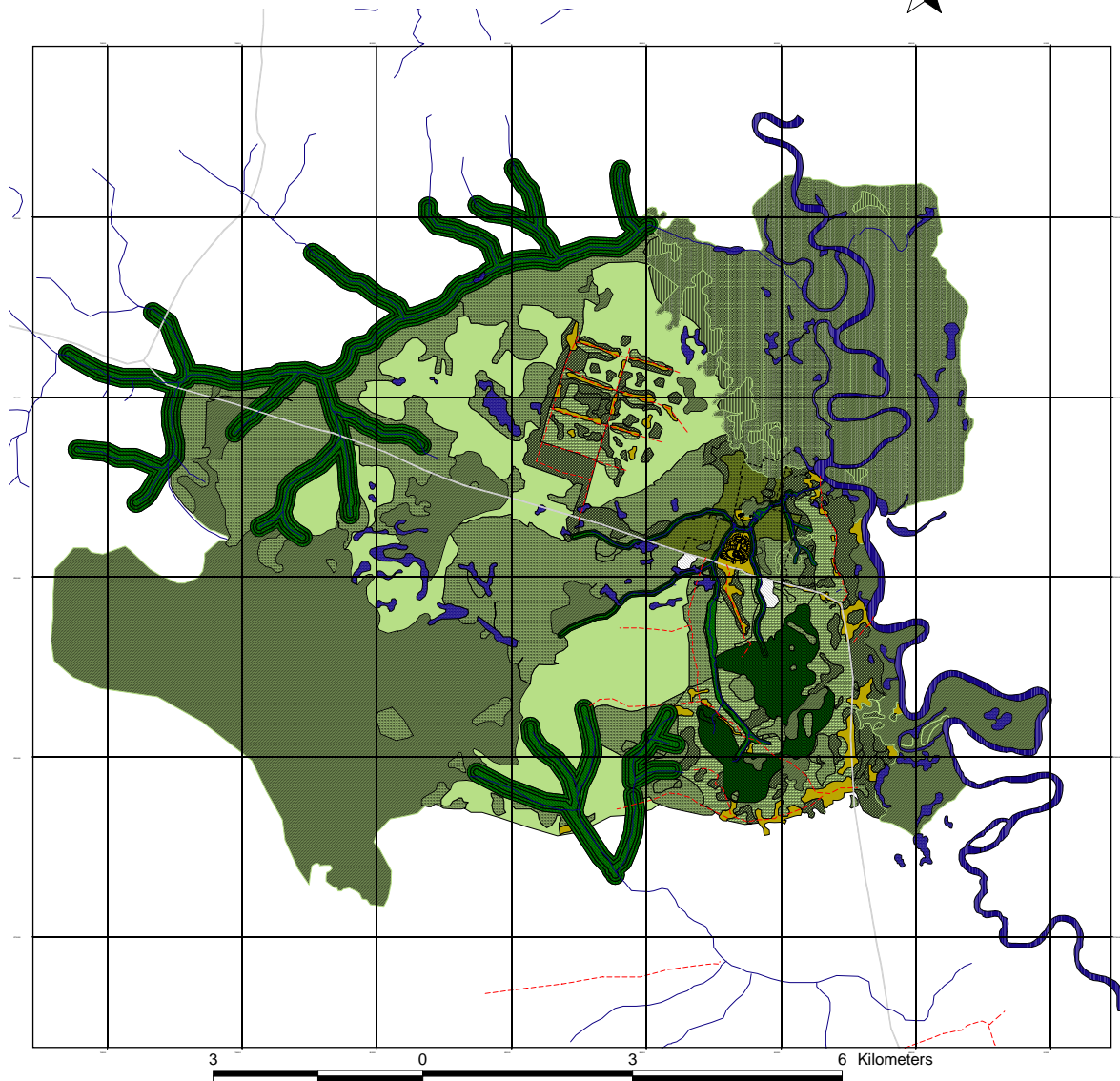
Landsat image RGB=543
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June 2005

remote sensing of kalimantan
KALTENG CONSULTANTS

Map No.6

ZONING PROPOSAL FOR THE TANGKILING AREA



LEGEND

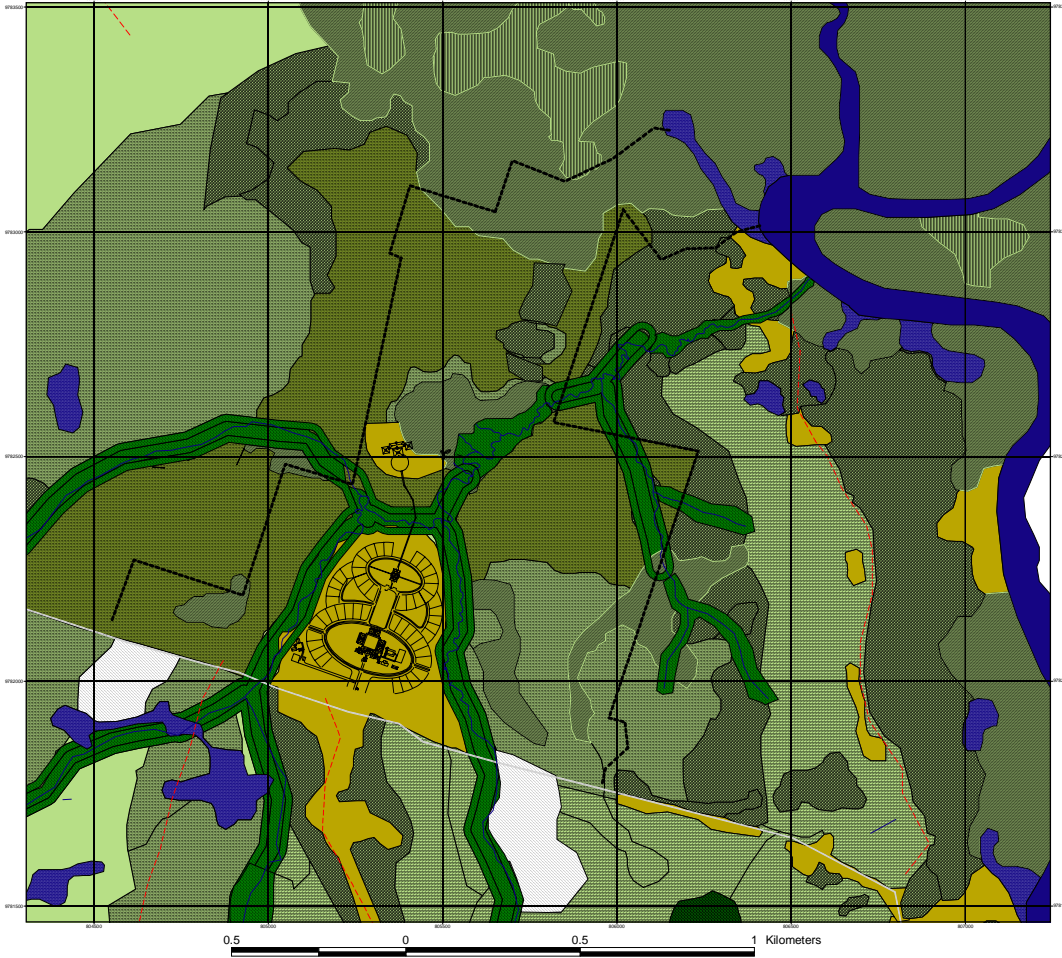
- Rungan Sari boundary
- Secondary roads
- Secondary river
- Rungan Sari housing
- Transkalimantan road
- Rungan river
- Water bodies
- Zoning proposal**
- (ZET) Zone of special treatment
- (ZCa) Zone of conservation a: Large patches of 70% forest
- (ZCb) Zone of conservation b: Small patches of vegetation: home gardens helping in landscape connectivity
- (ZCb1) Zone of conservation b1: Agricultural areas
- (ZCc1) Zone of conservation c1: Wide vegetation corridors along water courses
- (ZCc2) Zone of conservation c2: Green corridors of 10% forest
- (EZ) Expansion zones
- (S) Settlements
- (ZO) Different uses zone
- (UZ) Forest gaps for agroforestry practices
- Sand

Landsat image RGB=543
14 of January 2003, with the help
of 15 February 2003

Elaborated by: Dr. Viktor Boehm,
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June 2005

Map No.7

ZONING PROPOSAL -DETAIL FOR RUNGAN SARI-



LEGEND

- Rungan Sari boundary
- Secondary roads
- Secondary river
- Rungan Sari housing
- Transkalmantan road
- Rungan river
- Water bodies
- Zoning proposal
 - (ZET) Zone of special treatment
 - (ZCa) Zone of conservation a: Large patches of 70% forest
 - (ZCb) Zone of conservation b: Small patches of vegetation: home gardens helping in landscape connectivity
 - (ZCb1) Zone of conservation b1: Agricultural areas
 - (ZCc1) Zone of conservation c1: Wide vegetation corridors along water courses
 - (ZCc2) Zone of conservation c2: Green corridors of 10% forest
 - (EZ) Expansion zones
 - (S) Settlements
 - (ZO) Different uses zone
 - (UZ) Forest gaps for agroforestry practices
 - Sand

Landsat image RGB=543
14 of January 2003, with the help
of 15 February 2003

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June 2005



6. References

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