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IMPLEMENTATION OF A GEOGRAPHIC INFORMATION SYSTEM (GIS) ON THE YAYASAN SABAH CONCESSION

PRELIMINARY STUDY

Collaborative project between

- **Innoprise Corporation Sdn.Bhd.** and
- **CIRAD-forêt**

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AKNOWLEGEMENT

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Summary

The present report is the result of 6 months study realized for the first phase of preliminary assessment of the "Forestry GIS project". The project is a collaboration between Innoprise Corporation and CIRAD-forêt for the implementation of a Geographic Information System on the Yayasan Sabah concession.

The study concentrates first on a "preliminary assessment prior to the GIS implementation". Three main areas of activities should be covered by the GIS : Primary forest, Secondary forest and Plantation. ICSB needs more particularly a system to gather and display up-to-date information, and to produce maps easily and quickly. A need of demonstration has also been raised. According to the forest activities of the concession and the needs, 8 main objectives are proposed

 -Demo to present the concession and its activities
 -Demo on a Reduce Impact Logging project
 -Concession progress consultation
 -Road network management
 -Preparation of coupe in Primary forest
 -Logged-over forest management
 -Plantation management
 -Support to research

The description of the data available and their quality allow to foresee the possible technical difficulties of implementation. The GIS should be organized from a main system based in the headquarter of Innoprise and monitored by an independent GIS team. Two other modules, more or less independent from the main system, could be developed later according to the equipment available: an Executive Information System to be handled by senior management for the purpose of demonstration and fast progress consultation, and a localized GIS for local management such as for Rattan plantation in Luasong.

For a first step of implementation, a solution with 2 PC 486 has been proposed. However, upgrading the system to workstation is desirable for a GIS on the whole concession. Moreover, satellite imagery should be a very interesting source of data for the system and must be envisaged later. Two pilot areas have been chosen to start the project on small scale: The Luasong project area and The Ulu Segama Forest Reserve. In the chapter "detailed information for the pilot project", the study proposes 6 objectives with expected outputs and gives the detail of the necessary data to be captured. Finally, the study proposes a planning of implementation for the pilot project that should be achieved quickly, between 6 months to 1 year.

INTRODUCTION

Geographic Information System are computer-based systems that are used to store and manipulate geographic information. This technology has developed rapidly over the past two decades and is now accepted as an essential tool for the effective use of geographic information.

Forestry is typically an area of activities which involves many geographic information. Examples of GIS implementation in temperate forests exist already but the introduction of such a system for the management of tropical forest is still a new experience.

In this context, the "Forestry GIS project" has been launched as a collaborative project between Innoprise Corporation Sdn. Bhd. (Malaysia) and CIRAD-forêt (France). The purpose is to implement a GIS for the management of the Yayasan Sabah forestry concession, which covers almost 1 million ha in Sabah, Borneo.

CHAPTER I

INTRODUCTION
TO THE
GEOGRAPHIC INFORMATION
SYSTEM (GIS)

I. INTRODUCTION TO THE GEOGRAPHIC INFORMATION SYSTEM (GIS)

1. The Concept of Geographic Information System

1.1 Geographic information

Geographic Information refers to any information related to one point or a group of points spatially referenced on earth: natural resource distribution (soil, water, vegetation), administrative boundaries, location of roads, networks, building and even statistical data. Geographic information is very important for those who have to manage an area or objects scattered in this area.

1.2 Maps

Maps are the main way to display geographic information. The most common map is the **topographic map** which display the main elements of landscape like rivers, roads, building, vegetation. But other kinds of map are necessary to provide information on specific theme, the **thematic map**, for geology, soils, land capabilities,... Maps are not only a descriptive tool, they help in management decision making.

But maps printed on paper have some drawbacks:

map edition is time consuming and costly.

to be easily legible, a map cannot display too much information at once.

the map is a static vision of reality. Once it is printed, it will not evolve until the next updating. Some maps are already outdated when they are printed, this is a very important problem for those who have to manage a fast moving world.

no analysis can be easily undertaken if one wants to use data from different maps at the same time, especially when it is not the same scale.

Today, needs in geographic information go most often to documents quickly available, up to date and adapted to a specific purpose. Traditional maps do not respond to these new requirements.

1.3 GIS

Progress in computer technology have allowed people to digitize geographic information and to manage it with computer. Gradually, computers proved to be a very useful tool to assist map production and spatial analysis. Thus, was born in the 60s the concept of Geographic Information System (GIS).

GIS are computer based systems used to store, manage and manipulate georeferenced information. They gather **geographical data,** which can be drawn and **descriptive data,** which represent qualitative information corresponding to the geographical data.

1.4 GIS and Remote Sensing

Remotely sensed information have proved to be very efficient and useful source of data, especially to follow evolutive phenomenon such as deforestation, forest fires, erosion. The most common remotely sensed information are the aerial photos but a new technology has developed rapidly that offers more possibilities : the satellite imagery.

Specific softwares have been developed for the processing of these new data and for a short time, connected with Geographic Information System. The trend is nowadays to mix satellite image processing with geographic analysis, characteristic of the GIS, in only one system.

1.5 GIS applications

The size of GIS, in terms of computer equipment, staff, spatial extent and data number varies greatly from one application to another. But beyond these differences, 4 main types of application can be distinguished. In order of increasing complexity:

> Cartography
> Management
> Analysis
> Modelisation

A GIS must be considered as a model of the real world that allows to elaborate, to test and to chose scenarios of actions.

2. Components of a GIS: from the concept to the reality

Four different components can be distinguished in a GIS : data input, data management, data manipulation and analysis, and data output.

2.1 Data input

It is the procedure of encoding data into a computer readable-form and writing the data to the GIS data base. Data input can be carried out by different ways :

- Input of spatial data

    - *Keyboard entry* : the coordinates of the points (in vector model) or cells (in raster model) are captured manually on the keyboard.

    - *Manual digitizing* : the map whose features have to be captured is affixed to a digitizing table and a pointing device is used to trace the features. The digitizing table electronically encodes the position of the pointing device. It uses the vector model of representation. The accuracy depends on the number of points encoded and the skill of the operator. The process of tracing lines is time consuming and error prone but it requires few equipment: one computer, that can be separated from the system monitoring the database, is enough.

What are the characteristics of this soil?

Which soils have a PH > 5?

```
polygone#      513

code
nom       podzol
pH          5.5
```
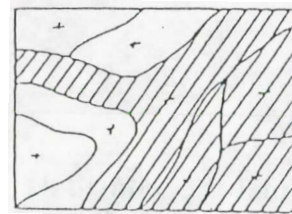
polygone#	code...
513	3
514	19
. . .	. . .

Fig.I.1   The 2 types of query

- *Scanning* : in scanning a digital image of a map is produced by moving an electronic detector across the map surface. It uses the raster model of representation. It is a fast and automatic way of digitizing, interesting for the acquisition of a great number of data. But it requires equipment (that can be shared) and more sophisticated softwares.

- *Existing data* : capturing data can be carried out by transferring existing files (after purchase or exchange). This is especially the way to input remote sensing data.

- Input of attribute data

- *Keyboard entry* : database management systems are often more suitable than GIS for this task. Data are captured separately from the GIS and transferred afterwards.

- *Existing data* : programs can be achieved to extract data from an existing file and to transfer them to the GIS.

If the data and their quality are an important aspect of the data input component of the GIS, the database design is fundamental. The way the data are structured (data structure) and the way files can be related to each other (organization of the database) influence the way in which data could be retrieved and the speed of the retrieval. It depends on the short and long term objectives of the user. A specialist is required for this design.

Data input procedure is said to be one of the most time consuming and the most expensive stage in the implementation of a GIS. Thus, it must not be under-estimated.

2.2 Data Management

The data management component of a GIS includes the functions of any data base management systems:

- Storage	it requires to take into account the size of the memory needed.
- Data edition	to correct the mistakes of the database.
- Updating	to add new information
- Retrieval of data	the retrieval of information can be done either by an exhaustive consultation of files, or by making queries. There are two different types of query (**fig. I.1**) :
	- to ask for the attribute data of an object whose location is known.
	- to ask for the location of objects according to some specific characteristics.
- Back-up	highly necessary to avoid to lose some data when a large amount is captured.

4
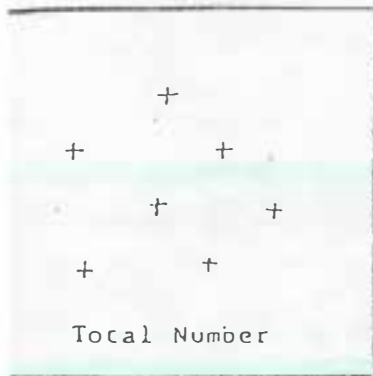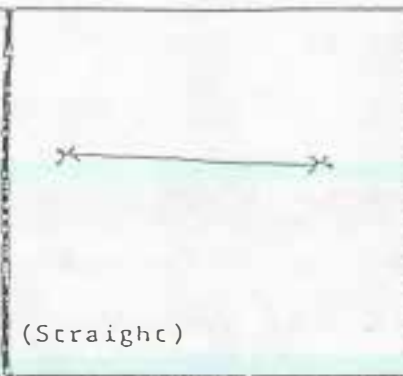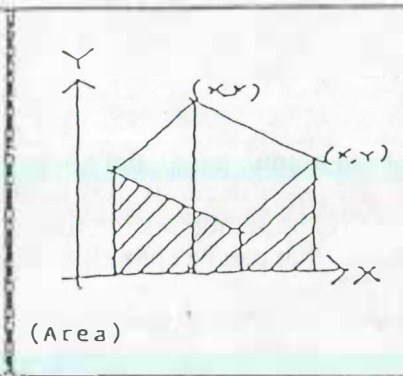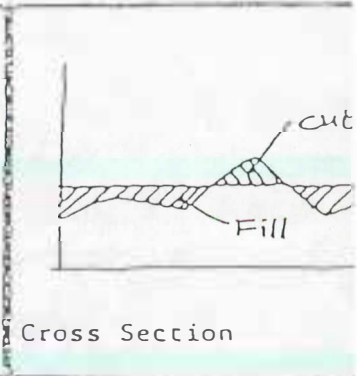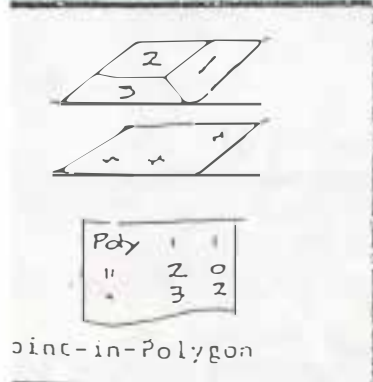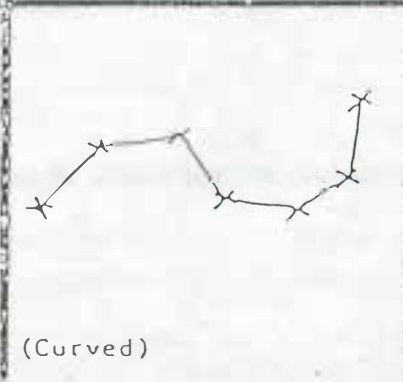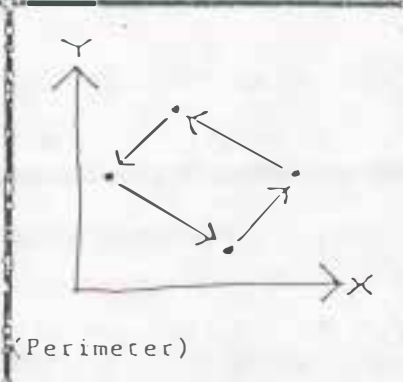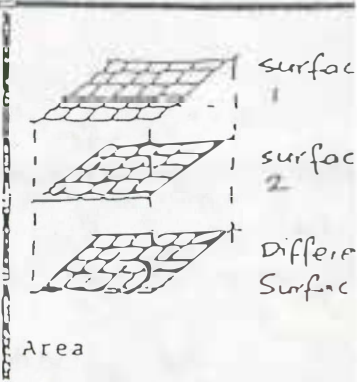
Total Number	(Straight)	(Area)	Cross Section
Point-in-Polygon	(Curved)	(Perimeter)	Area
POINTS	DISTANCE	AREAS	VOLUMES

Fig.I.2 : Some of the functions of a GIS   Measurement functions
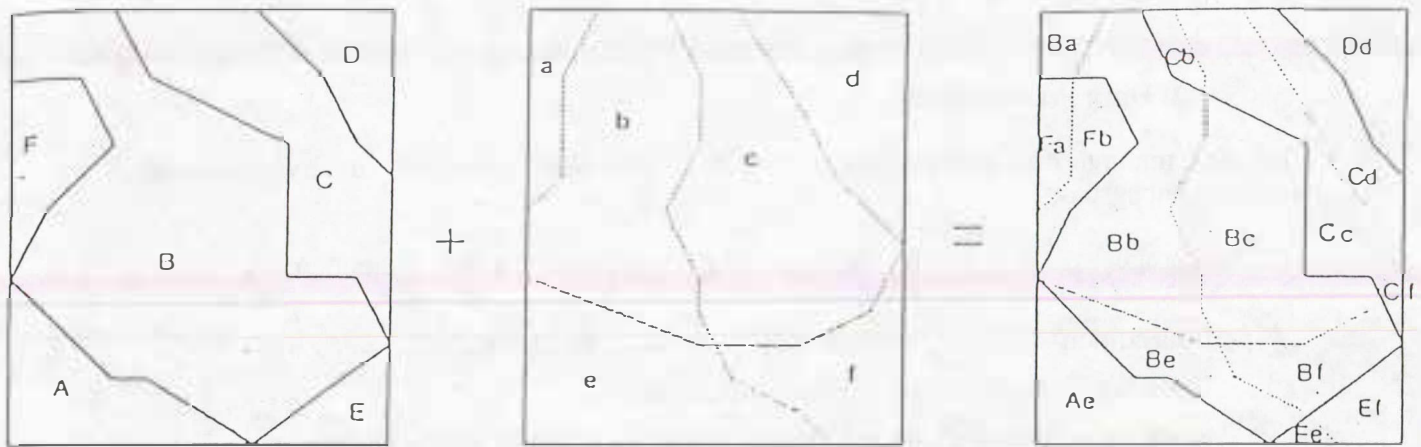
Overlaying in vector mode
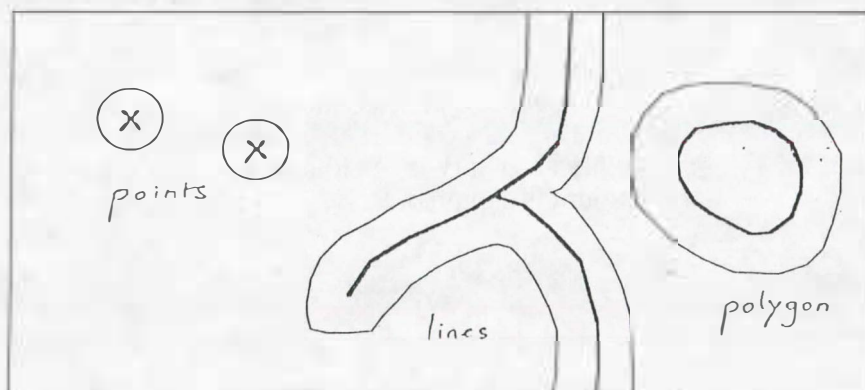
Bufferzones

2.3 Data manipulation and analysis

These functions make the difference between GIS and other information systems. A GIS has especially the following possibilities (**fig. I.2**):

- Measurement functions :

    distance between two points alongside a segment or an arc, perimeters

    calculation of areas

    calculation of volume (cuts and fills)

    direction of a segment and angle between two segments

- Classification or aggregation functions :
  They allow to classify polygons according to a special criteria and merge them.

- Overlay operations :
  Two kinds of overlay operations can be distinguished. Arithmetic overlays include operations such as addition, subtraction, division and multiplication of each value in a data layer by the value in the corresponding location in a second data layer. Logical overlays involve finding those areas where a specified set of conditions occur together.

- Neighborhood operations :
  These operations are based on the spatial connection between objects. Among many operations, we can mention the following ones:

    definition of buffer zones around polygons, or corridors around arcs.

    assessment, from one point, of all the nearest points having special characteristic.

    Computation of the slope from contours by means of a Digital Terrain Model.

    Interpolation and contourage.

2.4 Data output

The information of a GIS can be output in different forms. In list or tables, figures or graphs, or in maps. The GIS has all the necessary tools to choose the area to be represented, to adjust the scale, to create symbols and legend or to add text. Some GIS modules can also provide 3.D image or a set of images for animation.

STAND NUMBER	VOLUME LOSS M^3/Ha.	TOTAL VOLUME	CUMULATIVE VOLUME	HARVEST PERIOD
89	-40	700	700	1
20	-32	1610	2310	1
.	.	.	.	.
.	.	.	.	.
.	.	.	.	.
358	-27	950	8900	1
107	-26	1100	10 000	1
6	-17	830	810	2
93	-14	1460	2290	2
.	.	.	.	.
.	.	.	.	.
220	-8	680	10 000	2
149	-6	1680	1020	3
.	.	.	.	.
.	.	.	.	.
.	.	.	.	.

Steps 3, 4 and 5 in harvest scheduling. Stands are sorted by volume loss, the harvest proceeds through the queue, and the resulting time of harvest is assigned. (This example uses 10,000 m^3 as the periodic harvest level)

Period of harvest	Stand no.	Geographic data	Stands to be harvested in first period
1	1	X,Y.	
5	2	X,Y.	
1	3	X,Y.	
3	4	X,Y.	
2	5	X,Y.	
1	6	X,Y.	
1	7	X,Y.	
4	8	X,Y.	
.	.	.	
.	.	.	
1	400	X,Y.	
3	401	X,Y.	
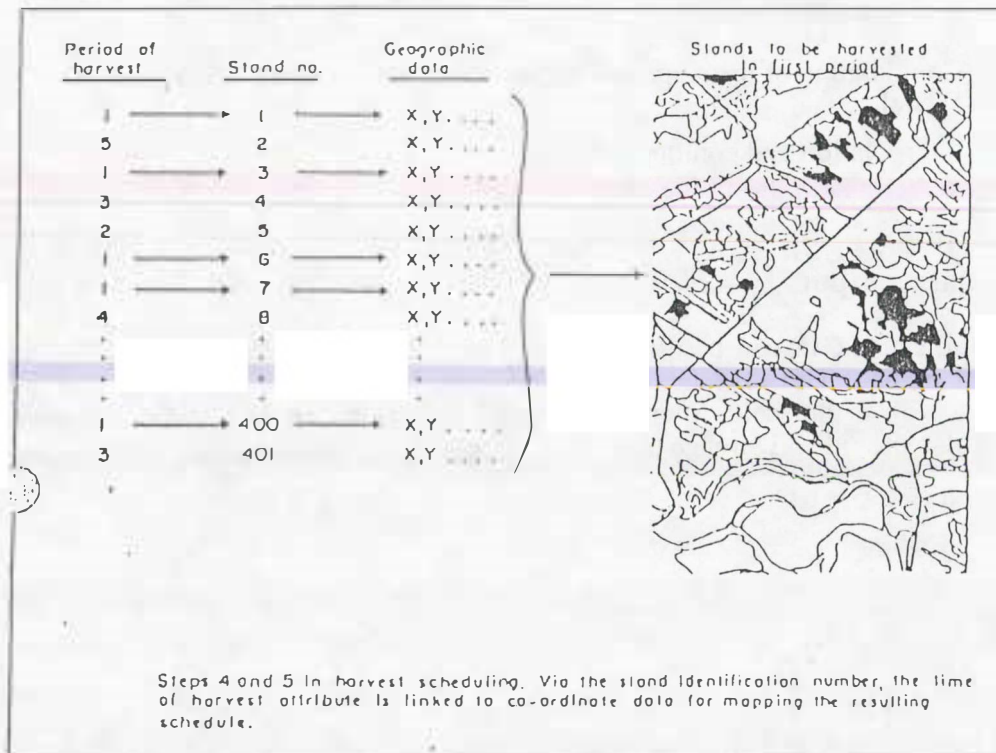
Steps 4 and 5 in harvest scheduling. Via the stand identification number, the time of harvest attribute is linked to co-ordinate data for mapping the resulting schedule.

Fig.I.3 : Example of GIS application in forestry (Erdlet and Jordan, 1984)

3. GIS and forestry

Although not specifically designed for forestry, the functional capabilities of GIS have been successfully implemented in variety of forest management organization.

Forestry encompasses the management of a wide range of information and the need for more and more accuracy in these information increase the number of data to be stored and managed. Hence the interest of forestry companies or agencies for computer assisted system of database management. Moreover the needs for specific maps production have led to the use of Computer Assisted Design softwares. In that way, the GIS, gathering and managing both descriptive and georeferenced data seems to be a very promising tool for forestry.

The following examples of application come from different cases of GIS implemented on temperate forests.

Inventory data management
An inventory gather typically both descriptive data like diameter, height, species and spatial data for the location of stands. Descriptive data are collected on the field while stand limits can be established by aerial photos or satellite imagery. GIS might be viewed merely as an advanced tool for maintaining a computer based forest inventory and providing information in a table or map form. (MURPHY, 1990).

Harvest scheduling
The inventory is the basis for production planning. It provides the assessment of the resource available and determine directly the planning of the coupe or silvicultural treatment. The interest of the GIS is its capabilities to assist the programming of field operations, taking into account the spatial distribution of the stands (ERDLET & JORDAN G. 1984).

Figure I.3, the rule states the oldest stands must be harvested first to minimize mortality and maximize growth which means sorting stands in decreasing order of volume loss. Stands to be harvested during a period are chosen from the top of the sorted queue, until accumulated volume equals annual harvest level. A numeric period indication is attributed to each stand. Finally, a map provides location and harvest period for each stand.

The **figure I.4** shows how to use the GIS for the following step in the scheduling. A harvest schedule map is produced to take into consideration accessibility of stands as well as harvest priority.

Transportation planning
A procedure might be programmed to produce a map highlighting the distribution of hauling costs (**fig. I.5**).

6
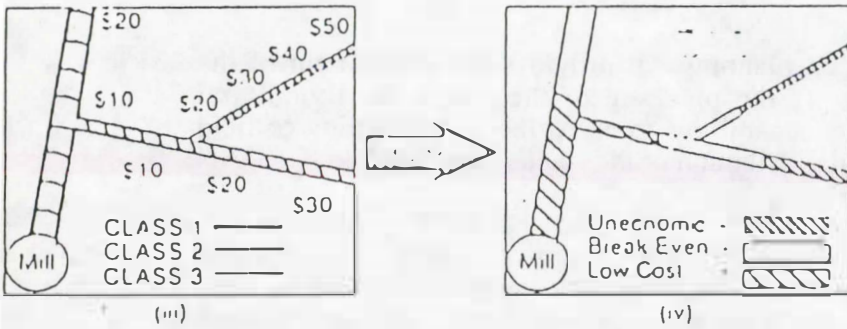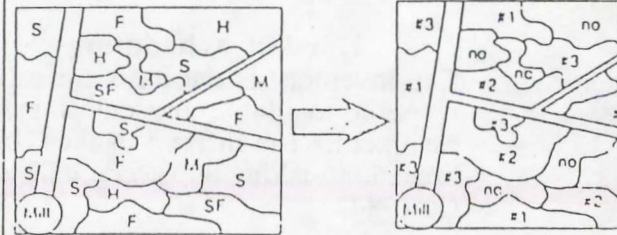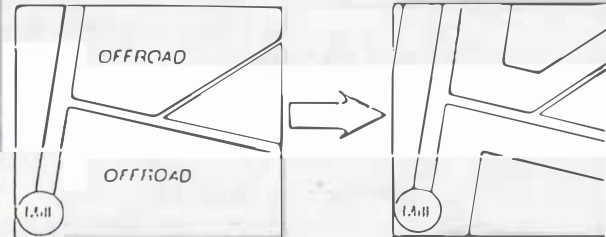
Fig.I.5 : The GIS for transportation planning

Fig.I.4 The GIS for harvest scheduling

These examples give a general view of the capabilities of a GIS in forestry. GIS proves to be a very precious tool, from a technical point of view, for map production, calculation or modelisation possibilities, as well as from a general management point of view with the possibilities to manipulate an up-to-date data base.

Satellite imagery provides an additional interest to GIS in forestry : aerial photos quickly become obsolete and they are cost-prohibitive when rephotographing is needed often. Remote sensing proved a very interesting tool for **prestratification** of forest areas into broad cover type classes and even to differentiate different classes of yield. Remote sensing is also used very efficiently to **monitor changes** in infrastructures or in the forest resource (BARKER & ROBINSON, 1982).

Conclusion :

Recent advances in computer hardware and software have brought GIS technology to a state where it is of practical and monetary appeal. All this explains the growing interest of forestry agencies for this new technology. GIS has been experimented and implemented successfully in many cases in temperate forest areas. But there are still few examples in tropical countries. Attempts to use GIS for natural resources management multiply in these areas but it seems that few organization have really an operational system yet. In Asia, there is no example of forest concession managed with a GIS.

Forestry, and Forest management in general, is different in temperate and tropical countries. Most often, tropical ecosystems are more complex, less information are available and with less accuracy. Most probably the GIS application described previously could not be applied the same way. The implementation of a GIS in an Asian forest concession is thus a very new experience. With a GIS possibly complemented with remote sensing technology, we can expect a net improvement of the mastery of this environment.

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CHAPTER II

THE
FORESTRY GIS PROJECT

II. THE FORESTRY GIS PROJECT

1. Presentation of the project

The forestry GIS project is a collaborative project between the following two partners:

- Innoprise Corporation Sdn Bhd (ICSB):
Malaysian company which has to manage an approximately 1 million ha forest concession attributed for 100 years, in order to generate the funds necessary to the state organization Sabah Foundation (Yayasan Sabah).

- CIRAD-Forêt:
French organization specialized in research and development in tropical forests.

The aim of the project is to jointly develop on the Yayasan Sabah Concession a Geographic Information System meeting the specific needs in resource management, planning and monitoring of a forest company.

2. Interest of the project

A forestry GIS, possibly connected with satellite imagery has first a technical interest. As described previously the possibilities of these tools in terms of data management and analysis and in terms of map production are now essential for the management of such a big area.

Moreover the ecological preoccupations of the international community lead nowadays to promote a sustainable management of natural resource and more particularly of tropical forests with safeguard of environment and a rational way of logging. GIS technology, well designed and adapted to the specific needs of forestry should be a good tool to take into account these recommendations.

3. Presentation of the study

The project is planned in two parts:

a first phase of 6 months for a preliminary study of assessment

a second phase of 2 years for the implementation

The present report is the result of the first phase. The purpose is to prepare the implementation of the GIS by gathering and defining all the necessary elements for it :

assessment of the needs of ICSB in terms of forestry management.

definition of objectives.

assessment of the data available or needed.

definition of pilot areas to start the project on small scale.

definition of the equipment and the staff needed.

Recommendations and planning for the following steps.

9

CHAPTER III

ASSESSMENT
PRIOR TO
THE GIS IMPLEMENTATION

III. ASSESSMENT PRIOR TO THE GIS IMPLEMENTATION

1. Context of implementation

Yayasan Sabah is a statutory organization whose mission is to improve the quality of life and education of the people of Sabah. ICSB has been founded as the investment arm of Yayasan Sabah to generate the necessary fund to support its activities. The main source of revenue comes from the exploitation of a forest concession of approximately 1 million ha attributed for 100 years (**fig. III.1**) Rakyat Berjaya (RBJ) is the forest management arm of ICSB.

A long term management plan was produced for the years 1984-2032 by RBJ. The aims of this plan can be summarized into two major points:

> Maintaining, in perpetuity a productive resource base for the production of timber and other forest products economically justified.

> Conservation of bio-diversity and protection of environment.

In that way, three different areas of activity are currently developed on the Yayasan Sabah concession : **natural forest management**, **forest development** and **conservation**.

1.1 Natural Forest Management

Logging :
Only first growth forests are currently being cut. Logging operations are carried out by contract loggers with tractor logging as the most common method used. Around 20,000 ha are logged every year. An important aspect of the management in this area of activity is to locate and delimit the next logging areas and to assess the expectable production through an inventory. The harvesting of a coupe must be planned up to 5 years in advance in order to carry out the survey of the coupe boundaries, the pre-felling inventory and to get the official coupe permit after submission to the Forestry Department.

Logged over forest management
Although the remaining area of virgin forests can still allow harvesting for decades, ICSB tries from now on to take into account reharvesting possibilities of logged over forest areas. The present silvicultural system in Sabah is the Malayan Uniform System (MUS) with a theoretical rotation of 60 years. It means that this kind of forest should not be reharvested until 60 years after the first harvest but it actually depends on the intensity and the quality of the logging operations, and on the regenerating capabilities of the site concerned.

ICSB currently carry out inventories to improve the knowledge of the quality of the remaining stand. The Linear Regeneration Sampling (LRS) provides information in terms of stock and gives recommendation of silvicultural treatments. Moreover, an attempt to distinguish and delimit the different stands by photo interpretation has been carried out on two pilot projects.
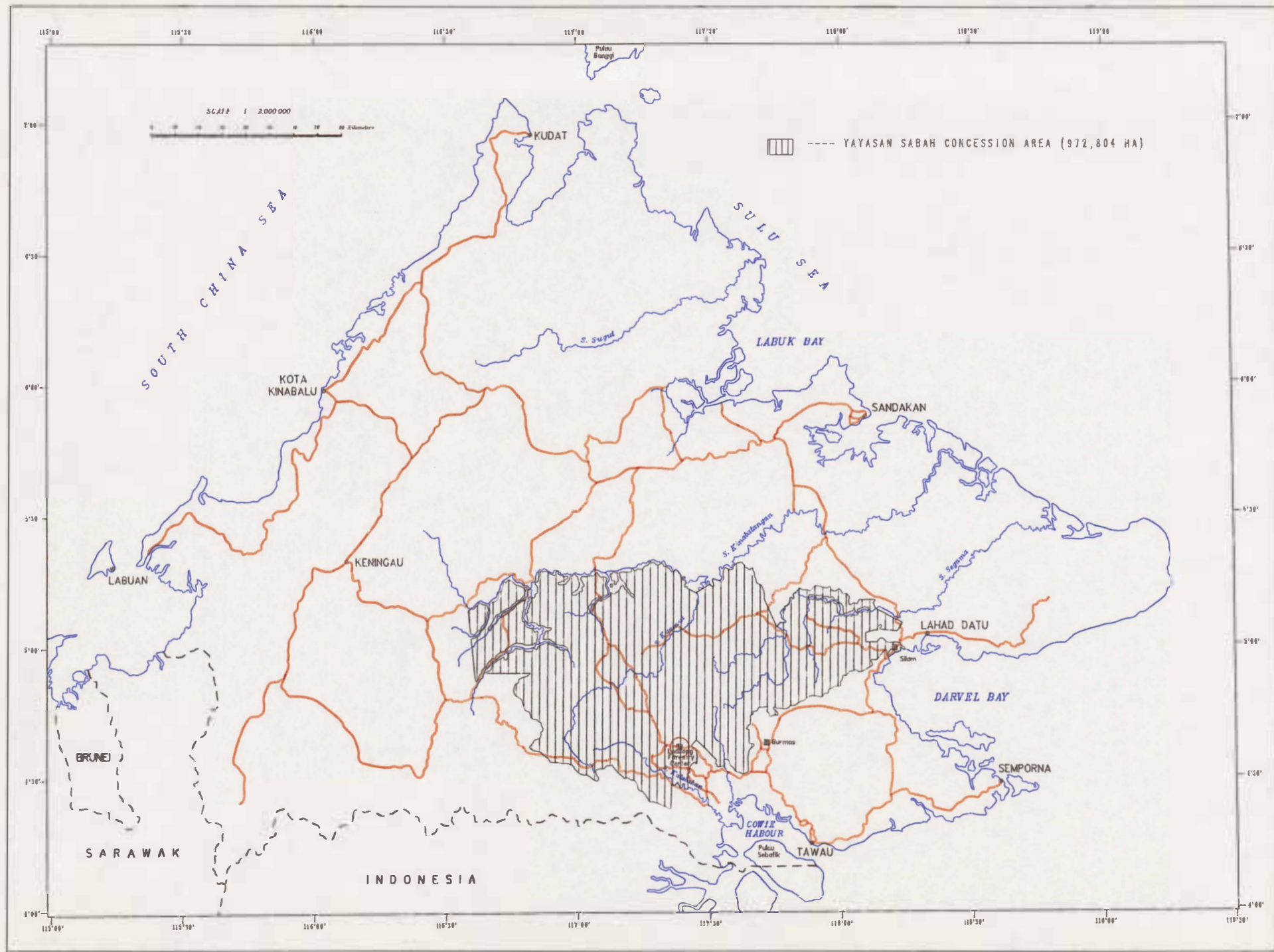
Fig III. 1 : Yayasan Sabah Concession Area

Projects of new methods of logging

Usual logging activities with tractors cause much damage on the residual forest stand and lessen the regeneration possibilities of the forest. An attempt is made now to improve the quality of harvesting with new methods such as pre-planning of skid-trails or directional felling. Two projects have been launched locally, to test these methods of Reduce Impact Logging (RIL) : one by the New England Power company (NEP) and one by the Swedish University of Agricultural Science (SUAS), (**fig.III.2**).

1.2 Forest Development

The aim of forest development is to improve the value of logged over forests. The most important project currently developed by ICSB is an enrichment plantation of Rattan and high value timber trees based in the Luasong Forestry Center. The aim of the project is to cover 40 000 ha at the rate of 3000 ha /year. 7000 ha have already been planted. The Luasong Forestry Center is also a major center of research for plant improvement and seed production.

ICSB is also developing a project of enrichment planting of logged over areas with local species in collaboration with the FACE Foundation (Forest absorbing carbon dioxide Emission). The aim of this project is to cover 25 000 ha.

Moreover, ICSB intends to undertake an important project of development based on the Taliwas center in the region of Lahad Datu. The target is mainly to implement enrichment plantation or large scale plantation on poorly stocked area and to develop tourism activities. Finally, there are some possibilities of large scale forest plantation in the Ulu Segama Forest Reserve (10,000 ha) and in Bongaya Forest Reserve (30,000 ha).

1.3 Conservation

More than 80,000 ha of virgin forest have been set aside as forest conservation area: Danum valley and Maliau basin. A camp established on the boundary of Danum Valley , the Danum Valley Field Center, provides accommodations and basic laboratory facilities for scientists and other visitors. Furthermore, other areas are set aside in the concession: riparian reserves and water catchment areas to cut back on erosion and siltation risks, virgin jungle reserves and other special reserves for such heritage as waterfall, Rafflesias etc.

The extent of the Yayasan Sabah concession has led to share all the forest activities between 4 regions : Tawau, Lahad Datu, Sandakan and Keningau. Moreover, most of the information are centralized in the Headquarter of RBJ in Kota Kinabalu. The main management decision are made in this last mentioned office.

11

KENINGAU

S. Kinabatangan

S. Segama

LAHAD DATU

S. Kuamut

DVFC ▲

DANUM VALLEY

A

Silam

MALIAU BASIN

DARVEL BAY

Burmas

B

COWIE HABOUR

Pulau Sebatik

TAWAU

INDONESIA

|		YAYASAN SABAH CONCESSION AREA		CONSERVATION AREA
		REDUCED IMPACT LOGGING SITES		FACE PROJECT AREA
A = RBJ/NEP	B = RJB/SUAS			LUASONG PLANTATION PROJECT AREA

10   20   30   40   50   60   70   80 Kilometers
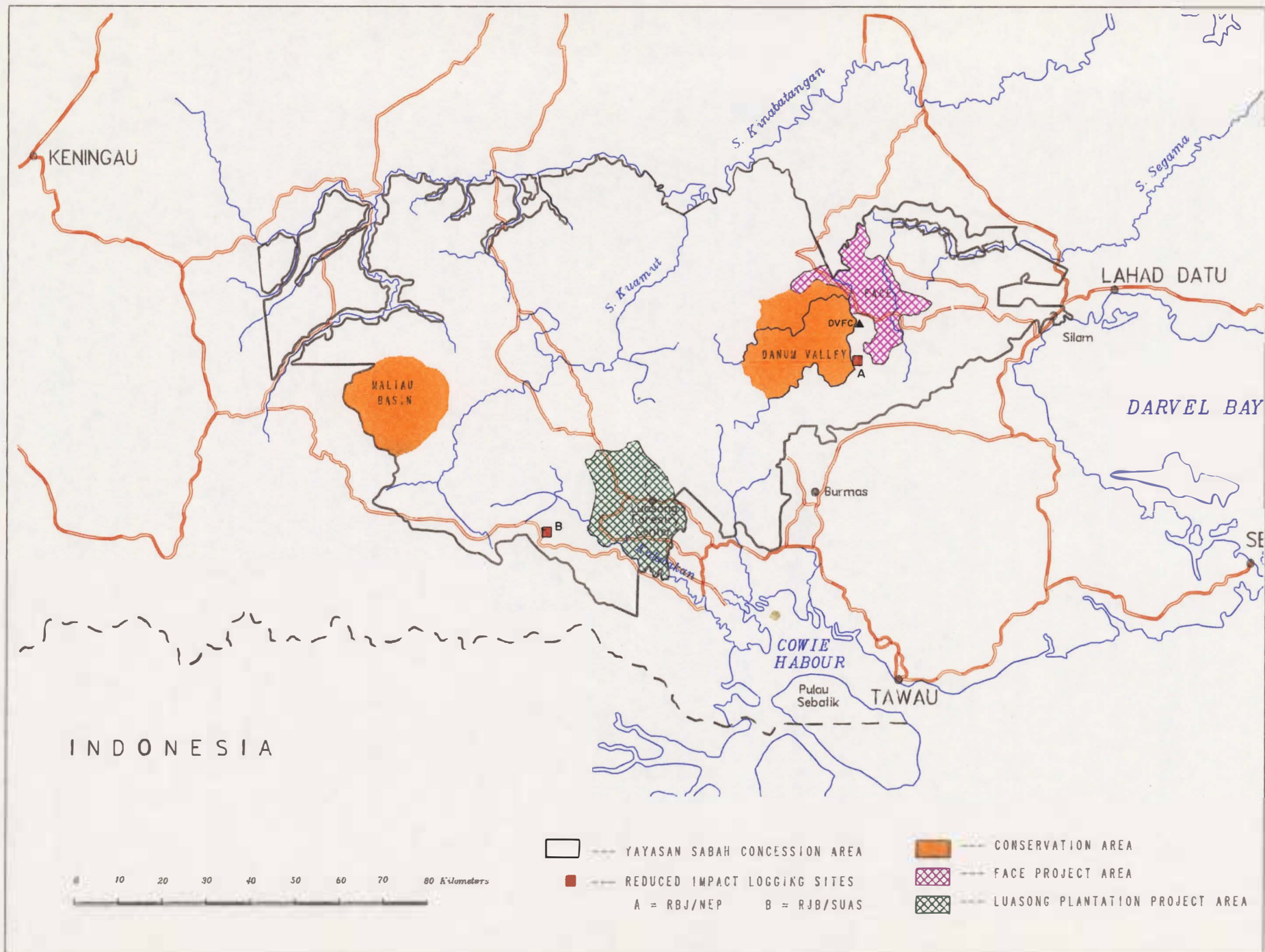
Fig III 2 : Forest Management Activities

2. Identification of GIS applications

As mentioned by S. ARONOFF[1], there is a tendency for the principal use of an information system to evolve. New technology tends first to be used to perform the tasks in the "old" way. Later, as familiarity is gained, new ways of providing the same functions are developed and finally, new functions are found that take full advantage of the new technology.

At this level of the project we can, thus, give suggestions of objectives and applications, and guidelines for the organization of the GIS but we can expect that progressively, new needs and objectives will arise as the familiarity with the GIS possibilities is acquired.

All the activities of ICSB previously described are summarized in 3 major areas: natural forest management, forest development and conservation. The conservation activities do not involve many geographic information and no GIS application is envisaged for the moment. **Natural forest management** and **forest development** can represent 2 main domains of applications. They involve the management of 3 different forest areas : primary forest, secondary forest and plantations. In that way, we can propose the following applications.

2.1 Natural forest management and planning.

A. General Consultation

The first interest of the GIS is merely to provide an instant picture of the whole concession. The GIS must provide an up-to-date progress map with all the characteristics of the logged over areas, the remaining virgin forests, the reserves and conservation areas,... It involves the basic functions of retrieval and display of the GIS. This is a basic but fundamental tool of monitoring and management of the concession. An important aspect of map production is required. Especially, an efficient and **fast production of up-to-date map** is expected from the GIS. At this level, the GIS could be used moreover for a purpose of **demonstration** to present the concession.

The following points are particularly important to be taken into account in the GIS:
- *Block and compartment*
The annual area of coupe is divided in blocks or coupes of approximately 1000 ha and each block is subdivided in compartments of approximately 200 ha. All the area logged by ICSB is therefore shared in blocks and compartments. The compartment is the basic forestry unit.

Many descriptive data are available for each; the GIS would be interesting to provide only a summary, especially for the following data:

> *Identification data*: : these are basic information such as area, block or compartment number, coupe permit number, contractor's name, year of coupe, etc. They are fundamental references for the management.

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[1] ARONOFF S. : Geographic Information Systems : a management perspective

Logging data : before logging, a pre-felling inventory is undertaken to assess the number of trees, the expectable volume, by species and by diameter class for each compartment. After logging, data for number of logs volume actually extracted by species and grades can be obtained for a particular time interval and for each compartment.

- *Road network* :

The road network is another fundamental point in the management of the concession, since it influences the access to the resource. Information on the quality of the network is important for the maintenance: road class (main, secondary or feeder road), date of construction, and of the last maintenance, number of bridges, their location and their type (wood, concrete or steel), number of culverts. This kind of information will be also essential to re-use and renew the abandoned network for a second harvest for example. Another interesting aspect is the road status (private or government road) and permission or approvals required to use them. For that reason, it would be interesting to take into account the road network outside the concession up to dumping sites on rivers (Pangkalan) or mills. The GIS will be very useful to gather and monitor all these information which have been so far stored in different files.

Remote sensing should be an interesting mean to support the management of these points. Especially, we can expect of it accurate limits on harvesting progress and a fast updating of the road network. Remote sensing could be used moreover to monitor shifting cultivation in. the concession or the extent of fires. Otherwise , the **GPS** is also very interesting to provide accurate location and would be helpful to support survey activities.

B. Forest management and planning

The following applications involve more particularly the capabilities of a GIS for analysis and modelisation.

- In primary forest

- *Classification of areas according to their slope* by means of a Digital Terrain Model (DTM) is fundamental. Common logging operations with tractors cannot be achieved if the slope is too steep. If this is the case other methods such as skyline can be recommended. Otherwise the area can be classified as unworkable with the present logging methods.

- *Delimitation of buffer zones* is required around roads and rivers in the logging areas to prevent erosion and subsequent pollution or degradation.

- *Calculation of areas* : Area is the key-parameter in forestry.The remaining area to be logged is the basis of forestry planning, the actual exploitable area is the basis of calculation for volume estimation.

The GIS, by taking into account all this geographic entities, (unworkable areas, reserves, bufferzones, watercatchment, ...) should be interesting to monitor the concession space, and particularly to delimit and locate the annual allowable coupe (AAC). In the new methods of logging promoted by the NEP and the SUAS project, the harvest is inadvisable below a certain slope in order to avoid erosion. Moreover the skid-trail network is designed to minimize the density and to avoid river crossing : the GIS might be utilized to prepare the coupe or to plan skid-trails if these methods are applied on large scale.

- *Calculation of distance* : The distance involves the economical component of the logging; the distance from the coupe to pangkalans or mills determines directly the transportation costs. It influences the choice of the grade or the species to be harvested so that the logging is profitable.

- In logged-over forest

Primary forests can be considered homogeneous without having important impacts on the production but the secondary forest is a mosaic of degraded, high stocked areas and many different intermediate situation according to the initial stock of the area and the equipment used for the logging. To prepare a coupe planning or to decide of appropriate treatments to be given to this type of forest, it is thereby important to be able to distinguish the different stands and to know their quality in terms of remaining stock and potential production.

- *LRS inventory data* :

Currently, the main information on the logged over forest come from the LRS inventory. This LRS inventory estimates the remaining stock of the forest after logging, taking into account the importance of seedlings and saplings and the volume of remaining trees. Moreover an algorithm has been established to modelise the growth of this stock versus time. The estimation of the potential volume is calculated until 80 years after the inventory is done.

The LRS inventory is carried out to know whether silvicultural input is needed to enhance the future yield of the compartments if this one is below the average yield of 70 m3/ha. But the LRS estimation can also be used as a basis to plan a second coupe by giving priority to the blocks according to the expected yield. Nevertheless, LRS data are only available as an average of a whole coupe and sometimes only by compartment. It does not take into account the different stands, hence the two projects to delimit stands from aerial photo interpretation.

- *Remote sensing* :

There are still few information on the logged over area and the existing information are rather rough. The use of GIS cannot be envisaged on large scale for the time being but there is most probably a very good potential of management for a GIS, especially if completed with remote sensing. If the distinction of stands in secondary forests proves satisfactory with satellite imagery then, it will be very interesting to alleviate the lack of up-to-date photos and to provide a more accurate analysis. Moreover, remote sensing could follow the growth of the stands and, linked to a GIS provide a very accurate coupe planning of logged over forests. The RADAR technology has also been mentioned as a very efficient tool for remote sensing, especially in cloudy areas. It could be particularly interesting for this country where clear satellite images are difficult to obtain. Nevertheless, this technology is still of the domain of research.

2.2 Forest Development

The GIS can be helpful for the management of vast plantation areas. It is interesting for different purposes.

- *Consultation*

The manager must have at its disposal all the characteristics of the plantation. On one hand, the spatial component - again the GIS must include the limits of the plots planted and provide up-to-date information on the road network-, on the other hand, the descriptive component which includes plantation data such as species planted, number of plants, date of plantation, loss.....

- *Planning* :

The plantations must be maintained regularly by silvicultural treatments such as row slashing, weeding or shade adjustment. These treatments must be carried out at a particular moment in the growth of plants and regularly. They are theoretically planned in advance. The GIS can monitor the date and the location of all these operations. Moreover, the GIS can plan the production. This is especially straightforward for the rattan: rotation is about 15 years for big canes or about 8 years for small ones and the growth rate is known approximately. With these data, the GIS can be used easily to estimate the production expected and prepare a coupe planning.

- *Location of the most suitable areas to be planted* :

The plantation projects have started recently and many other areas still remain to be planted. It could be interesting to locate the most suitable areas for this purpose or to give recommendation for the most suitable species in an area. A GIS is an appropriate tool for that, providing that a correlation can be established between plantation performance and some geographic parameters, and providing that the maps representing these parameters can be accurate enough at the plantation scale. Research are currently carried out on that purpose but no correlation are available yet.

- *Support to research* :

For the establishment of the correlations ; the GIS could provide localized information for different kinds of map (soils, land capabilities, slopes,...) or complex maps by overlaying these information.

OBJECTIVES	OUTPUTS
1-Demo concession	Map showing the concession and its main components at different scales.
2-Demo Reduce Impact Logging	Maps of skid-trail network and showing the strategy of design according to site - condition parameters. Comparative maps of spatial distribution of residual stands, skid-trails and landings. Graphs and charts of results for both methods.
3-Concession progress consultation	Progress map. Descriptive table including production, inventory, identification, account data,... summary form.
4-Road network management	Map of the network, past and present. Computation of distance and density. Descriptive table on bridges and road status.
5-Preparation of coupe in primary forest	Recommendation map to optimize the profit Location and delimitation of the coupe. Design of roads or skid-trails.
6-Logged-over forest management	Map of the stands. Inventory table. Projection of yield. Establishment of a coupe planning.
7-Plantation management	Progress map. Descriptive table. Yield prediction. Establishment of a harvest schedule and maintenance planning. Location of suitable areas for plantation.
8-Support to research	Complex maps by overlaying. Delimitation of areas corresponding to special criteria.

Fig III.3 : Objectives and expectable outputs

. 3. Objectives and expectable outputs

According to the needs and the possible applications described, we can propose the following objectives with the corresponding outputs (**fig. III.3**).

Besides **objectives of management** and **planning**, an **objective of demonstration** has been requested to be a part of the GIS : on one hand a demonstration to present at different scales the concession and locate the projects or activities carried out. On the other hand, a demonstration at the scale of a project is also expected to display main results of research. In that way, The RIL is a project for which many data are available and a good "demo" can be built.

The objective of support to research must be considered for the long-term only.
The objective of logged over forest management, however important, can be considered only for medium to long term since few data are available at the moment.

4. Users and organization of the GIS

Once the objectives proposed, the problem is to know what detail is needed and what data must be captured or not. It depends obviously on the user to whom the GIS will provide the information : the data captured on the rattan plantation will not be the same if they are used in the Headquarter for a purpose of general management or if they are used by a local team based in Luasong. The identification of the users is thereby a very important step for the implementation of the GIS.

The following system can be imagine for the GIS in ICSB, (**fig.III.4**). Three levels of users are distinguished :

- One **main system**, based in the headquarter of RBJ, handled by a GIS team and providing information for any forest manager or officer on :

    road network management,
    coupes in virgin forest,
    logged-over forest management
    general consultation.

- An **Executive Information System**, proposed to be handled separately by senior management. This system, partly supplied by the main system, should provide :

    Progress information in a summary form.
    Demonstration modules.

- A **local implementation level**, in Luasong and Taliwas in the future. This system should be supported by an independent database and provide information for local management

    Plantation management
    support to research.

This 3 levels can be considered as an ideal organization of the GIS but the implementation of such a system depends obviously on the availability in equipment and staff. For a first step, priority must be given to the main system.
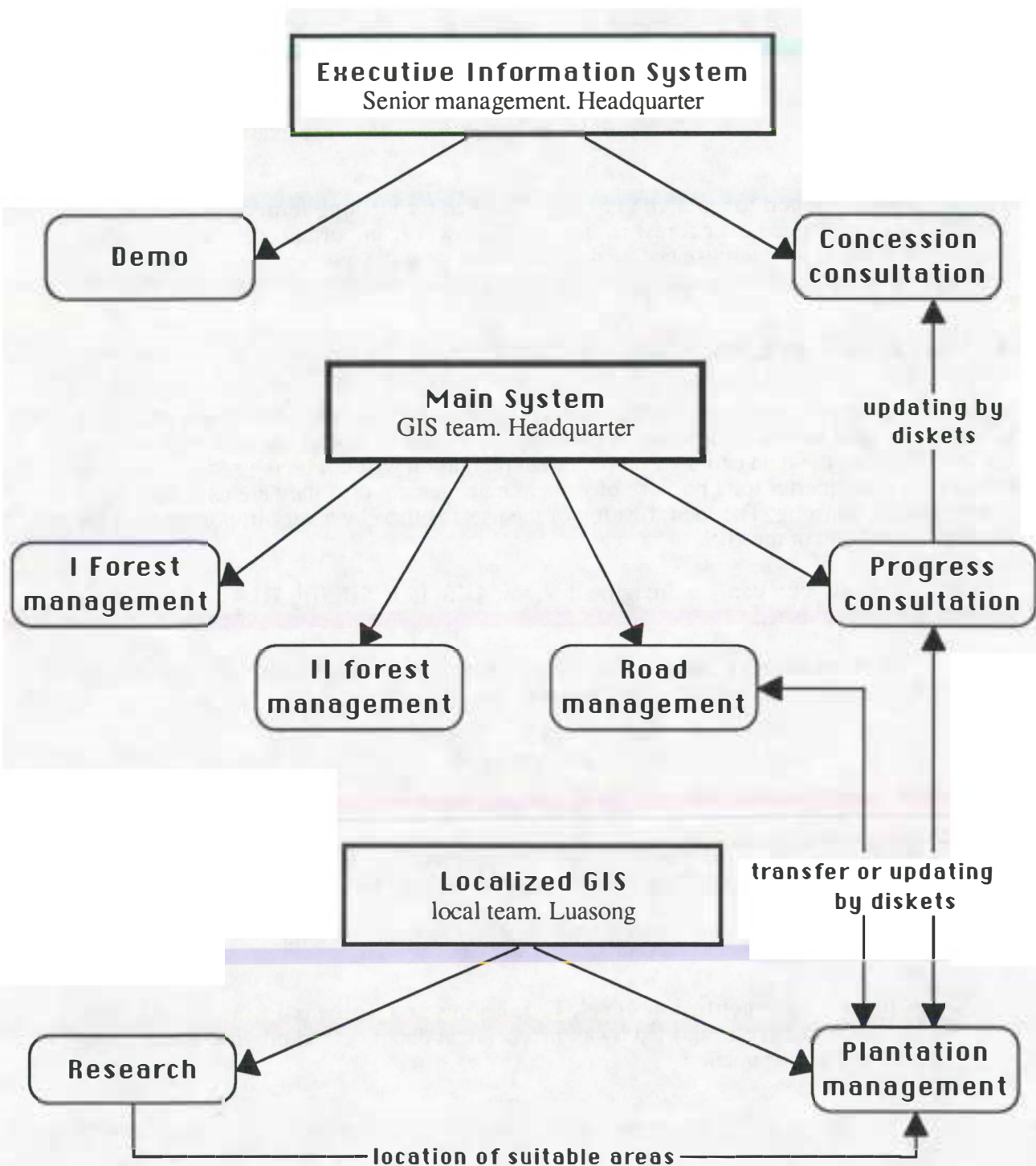
Fig.III.4 : Organization of the GIS

5. Data available and data quality

5.1 Descriptive data

- *Logging data* :

All the data concerning the logging i.e. pre felling inventory data and log flow data are stored in digital form. Special application programmes have been developed for that purpose.

- logflow data are captured under a system developed under REVELATION (**App.1**).

- the inventory data base has been written under dBASE (**App.2**)

So far, these data have been captured in each branch and transferred afterwards to the HQ of RBJ in Kota Kinabalu. These logging data include all the identification data of the blocks and compartments.

It must be noted that the logging activities on the YS Concession have been carried out for more than 20 years. The first figures of production and inventory were captured manually and would be available most probably with difficulties.

- *Rattan plantation* :

For rattan plantation also, the records are captured through a special application programme developed with REVELATION. The rattan plantation has started recently (1989) and thereby all the data were captured in this program and they are easily available (**App.3**).

- *LRS inventory* :

LRS inventory data with the stand table projection are available in spreadsheet (Lotus). They have been gathered in the branch office of Sandakan (**App.4**).

The LRS inventory has two main drawbacks :

> The LRS data are most often only an average on a whole coupe (1000 ha) and thereby embrace possible differences between stands. The projected yield, based both on these data and on assumptions from literature is obviously very rough.

> Undertaken since 1984, only a few coupes are covered by this inventory.

- *Road network information*

All the information related to the status of the road, approval reference, duration, etc, are available in the HQ in different files, but few information have been recorded on the bridges, locations, quality,etc. One census is being undertaken on main roads (**App.5**).

All the data captured in files could be easily transferred to the GIS. A programme would have to be developed to extract and transform them into ARC/INFO format.

TABLE A : PROGRESS OF ARC/INFO DATA ENTRY (DEC 1993)

Coverage	Scale 1:250 000		Scale 1:50 000
	Map sheet no NB50-11	Map sheet no NB50-15	Map sheet no 4/117/6 (FD.104)
River	completed		completed
Contour	-	in progress	-
Boundary	-		-
Spot height	-		-
Grid (15 Geo-co)	-		-
Road	-		-
Township	-	-	-
Coupe	in progress		in progress
Final topography map	completed		completed
Soil	-		completed on LFC
Final soil map	-		completed
LCC	-		-
Final LCC map	-		-

5.2 Spatial data

- *Progress map*

The progress map is drawn by the mapping unit of RBJ and displays all the coupe and compartment limits as well as concession boundaries or any boundaries of reserves, unworkable areas,... The progress map includes also the main road network with main roads and secondary roads but does not represent the road network at the scale of a coupe (feeder roads, logging roads). Progress maps are available at 1:50 00 or 1:250 000 scale (**fig.IV.2**).

All these limits have been surveyed on the ground in terms of bearings and distances,which is a certain guarantee of accuracy. Coupe and compartment limits are surveyed by prismatic compass, the limits of the concession by theodolite, which is more accurate. Finally, the use of GPS recently acquired by ICSB should allow to get a very good level of accuracy and improve much the survey of all the limits of the concession.

- *Topographic Map* :

ICSB has purchased 26 topomaps at 1:50 000 scale and 4 at 1:250 000 scale to cover the whole concession. The contour interval depends on the topography, on the major part of the concession, it is 250 feet (75 m) which is quite rough. Ten maps of the east part of the concession has a contour interval of 100 feet (30 m). Moreover, all the area on the east side of Ulu Segama river is covered by 50 feet (15 m) contour interval topomap at 1:25 000 scale, provided by Pacific Hardwoods. These maps have been enlarged to 1:12 500 scale in order to display the road network up to logging roads.

- *Thematic Map* :

Apart from the two previous kind of map immediately useful for the GIS, some thematic maps covering the concession are available in the mapping unit. They could be used if necessary:

- rainfall distribution	1:1 000 000	
- elevation classes	1: 250 000	
- geology	1: 500 000	
- pedology	1: 50 000	& 1:250 000
- land capabilities	1: 50 000	& 1:250 000
- forest cover	1: 50 000	

- *Aerial photos* :

ICSB has at its disposal 2 sets of aerial photos :
- 1971, covering the whole concession
- 1986, covering only the east part

5.3 Data under ARC/INFO

ARC/INFO was purchased 3 years ago by ICSB. From that time, many spatial data have been digitized; at 1:50 000 scale on the Luasong area and at 1:250 000 scale from 1 of the 4 maps covering the concession, (**Table A**).
Moreover, a topomap at 1:5 000 scale covering the RIL project has been digitized as well as an overview map at 1:1,000,000 scale showing the YS Concession in Sabah with road network and rivers.

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6. Requirements for the implementation of the GIS

6.1 Equipment

ICSB has already purchased the following equipment

Equipment already available

Hardware:

.1 unit M386/XP7 Olivetti RC, 25 MHz, RAM 4MB, HD 383 MB

.1 unit calcomp 95 480 digitizer

.1 unit calcomp 23 180 digitizer

.1 unit calcomp Artisan 1025 plotter

Software:

.2 sets of PC ARC/INFO vers 3.4 D$^+$

.1 set of ARC View 1.0 under WINDOWS

Moreover, ICSB has now at its disposal

.2 sets of GPS Magellan 5000 PRO

.1set of GPS Tremble Ensign

The option ARC/INFO under PC is sufficient for a first step of implementation of the GIS. However, the afore mentioned list reveals a lack of hardware ; ICSB has at its disposal 2 sets of the latest version of ARC/INFO under PC for only 1 PC whose capacities prove limited to manage an important database. Thereby, to start the implementation, it has been chosen to complete the hardware possibilities by the purchase of the following units

Equipment expected

Hardware :

.2 units of olivetti M4-66, intel 80 486 DX 2/66, 16MB RAM

.1 unit pinnacle 5.25 optical disc system 600 MB

Subsequently, a functional GIS covering the whole concession will require to upgrade the system to **workstation** so as to manage easily the important database. Moreover, the purchase of an **image processing package** can be envisaged at this level.

6.2 Staff

One of the most important step in the implementation of the GIS is to form an independent GIS team. For an optimal work, the team should be composed of the following people

Quantity	Designation	Job description	Time allocation
1	**senior forest officer** (GIS coordinator)	.Link between the technical team and the needs in term of forestry. .Definition of output and checking of data quality.	≥ 50 %
1	**forest officer** (GIS officer)	.Implementation of the GIS. .Data manipulation and analysis	full time
1	**system analyst**	.Design and organization of the database.	50 %
4	**technician**	.Digitizing and capture of data.	full time

7. Choice of a pilot area

Before implementing the GIS on a such a big concession, it is important to start the project on small scale. A pilot project should allow first to get familiarity with the system and train people to the technology. Moreover, it must allow to test the efficiency and the interest of the system in different areas of activity. This might lead to make the objectives more accurate or to propose new areas of application.

Criteria:

The choice of the pilot area is done on one hand according to the priority of the objectives. Particularly, a strong aspect of demonstration is expected from this pilot project. On the other hand, the pilot project must be as representative as possible of the future applications it is supposed to carry out.

Two pilot areas :

In that way, the plantation site of **Luasong Forestry Center** has been chosen for its strong interest for ICSB and since many geographical data have already been digitized in ARC/INFO. Moreover, another area has been proposed in the **Ulu Segama Forest Reserve** next to the Danum Valley conservation area. This area includes the NEP and the FACE projects and allows to display new methods of logging in primary forests, secondary forests areas and plantation activities.

In order to facilitate the digitizing, the 2 areas chosen correspond to the limits of the corresponding topographic map at 1:50,000 scale (**fig. III.5**)

> map sheet   4/117/6 (104) for the Luasong area
> map sheet   4/117/4 (92) in the Ulu Segama Forest Reserve

They represent each an area of approximately 77,000 ha. However the actual area concerned by the activities described covers 10,000 ha in Luasong and approximately 25,000 ha in Ulu Segama forest reserve.

8. Planning

The **pilot project** should be achieved quickly : from **6 month to 1 year** after the acquisition of the equipment, according to the staff available.

The subsequent **phase of implementation** on the whole concession could be carried out in **2 years** with a complete and trained GIS team, according also to the possible availability of new equipment.

Finally, a third phase could be imagined to develop more specifically some models or research aspects.
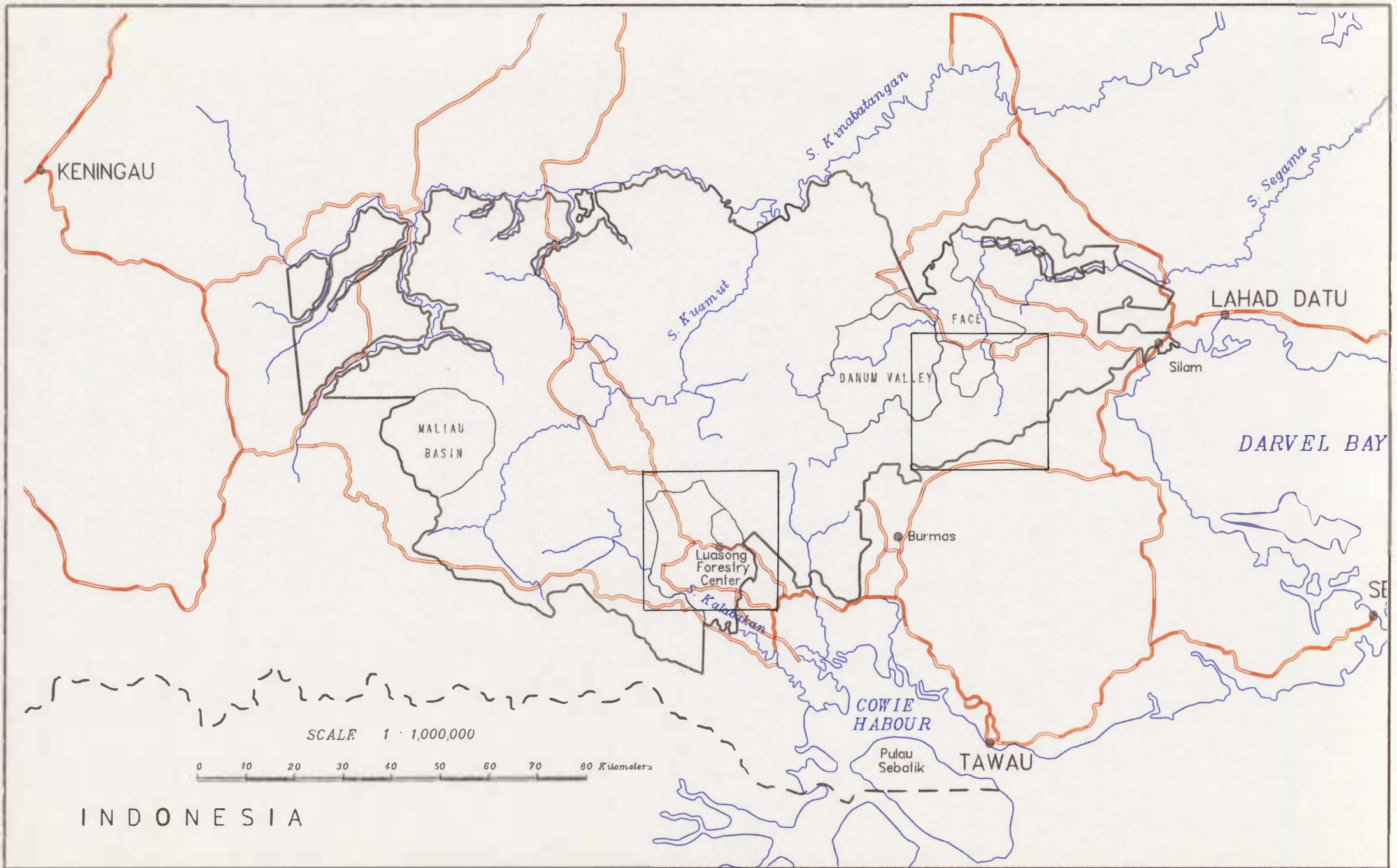
Fig III. 5: Location of the Pilot Areas

CHAPTER IV

DETAILED STUDY
FOR
THE PILOT PROJECT

IV. DETAIL STUDY FOR THE PILOT PROJECT

A. Luasong area.

1. Context of implementation

The area chosen for the pilot project is the map sheet 4/117/6 (104). It was previously harvested by the North Borneo Timber Company (NBT). Since the attribution of this area to the YS the logging has been carried on and nowadays it is totally logged over. The previous forest camp of NBT has turned in the actual Luasong Forestry Centre (LFC) which is nowadays a major base of development in the YS concession.

The main activity carried out from Luasong is enrichment planting of rattan. The aim of the project is to cover 40 000 ha with an annual planting target of 3000 ha. Moreover, for 10% of this area, the rattan plantation is supposed to be mixed with high value timber trees such as Swietenia, Pterocapus, Khaya. The planting started in 1989 and so far, more than 7000 ha have been covered.

To support the plantation activity, a research component has been developed in the Luasong Forestry Centre, especially with the implementation of the PISP project (Plant Improvement and Seed Production). The aim of the research is genetic improvement, rattan growth monitoring, improvement of the methods of multiplication, and plantation trials of new species both native (Dipterocarpus) or exotic (Khaya, Teak).

All the activities of plantation and research have been concentrated so far in an area of 10,000 ha beside the LFC (**fig. IV.1**).

2. Domain of application of the GIS

2.1 Plantation management

The GIS should be used very efficiently to support the management of a plantation, for basic consultation and planning purpose. The following points are particularly important:

Limits :
The plantation area is divided into compartments, which are sub-divided into several sub-blocks of approximately 40 ha each. The sub block is the basic plantation unit.

Census :
Two census are undertaken after the plantation. One after 3 or 4 month to check the number of seedlings alive which is the basis of payment of the contractor and to assess the needs of refilling. Another census is carried out after 1 or 2 years to check whether the stock of plants alive is important enough or whether it needs to be completed by new plantings (threshold value 80%). Apart from these assessments, the census are supposed to integrate in the future shade measurements. These one will be used as a basis for operations of shade adjustment and could be used for a purpose of research so as to establish relations between growth and light or stand quality.

Maintenance
Maintenance operations are to be carried out on the plantation. Especially slashing but also circle weeding. These operations must be achieved theoretically within steady intervals during the first two years after the plantation. There is a "planned date" for which rangers are sent on the field to make sure of the necessity of the operations and an "actual date" if these ones are postponed. The following operations will be adjusted according to this new date.

Fig IV. 1 : Luasong Development Project Area

Harvesting
An important aspect of the plantation activities is to foresee the production. Thereby it would be very interesting to integrate in the GIS the corresponding model to establish a coupe schedule. The rattan harvest is done when canes are considered mature i.e. after approximately 8 years for small canes and 12 years for big ones. Moreover, measurements are carried out as part of the PISP project to establish production table, that is relation between the age of plantation and yield for the different species.

Plantations :
Ideally, the production tables should be established according to site condition parameters such as slope, soils, light or quality of the remaining stand. Research is currently undertaken in that way. It could lead in the future to locate the most suitable areas for the plantation or the most suitable species in an area, the GIS is particularly adapted to this task.

Account system
The Luasong Forestry Centre has its own account system. Some of the data could be associated to the GIS.

2.2 Support to research

The PISP project has two kinds of experimental plots. On one hand, small **plots** (400 sq.m) **in rattan plantation** to follow the growth and establish the production table. On the other hand **plots for high value timber trees** to test the growth of different species and provenances. These ones are gathered in the specific area of Tiagau (225 ha). The project of opening 2 other areas of 225 ha each in the LFC area is being submitted to the Forest Department.

The GIS was expected to provide local information at the scale of a plot for correlation establishment purpose. As mentioned previously, ICSB has its disposal thematic maps such as land capabilities, geology, soils, etc. Topography is also a key parameter. Nevertheless, it turns out that the maps presently available do not have a sufficient accuracy to be used in an interesting way. The contour interval in the LFC area, for example, is 250 feet (75 m), which is really too rough compared to the size of experimental plots. No reliable correlation could be carried out in these conditions. Field measurements should be probably more adapted for this task.

Although applications for support to research are presently difficult to implement, more accurate information or other applications might be found later on.

3. Objectives summary and outputs

The objective on this pilot area is to implement a semi-functional GIS managed from the Headquarters in Kota Kinabalu. It is a way to test the technical feasibility of the GIS for plantation management purpose before a possible implementation in Luasong.

The expected outputs are as follows:

> progress map of the block or sub-block planted
> table and map of the plantation characteristics
> map of road network
> map for maintenance operations planning
> table and map of production expected
> map for harvest schedule
> map for locations of experimental plots
> table for main research results

4. Data and Requirements

4.1 Attribute data

- *plantation data* : All the plantation data are gathered and updated in the Luasong Forestry Centre in a program developed under the revelation system. A special application will have to be developed to extract and transfer easily the necessary data.

- *PISP results* : The research results from the PISP plots are available in a spreadsheet form (lotus).

A suggestion of data to be captured for the pilot project is given in **Appendix 6**.

4.2 Spatial data

- *topomap* : The topomap of Luasong at 1:50000 scale has already been digitized in ARC/INFO. It includes the following coverages: contours, rivers, different boundaries, spot height, grid, township and road network.

   The road network digitized is not up to date and an important part of it even remains to be surveyed before digitizing.

- *coupe limits* : The limits of all the compartments and some of the sub-blocks have already been digitized in ARC/INFO.

   A first set of limits has been digitized from surveyed limits. But the main drawback is that these limits have no tie points, which means that they are not geographically referenced. However accurate is this set of surveyed limits, it is not possible to overlay it with a georeferenced map such as topomap, LCC, soils,...
   A second set of limits has thus been digitized from rough limits based on photo interpretation and simply drawn on the topomap. This set of limits can be overlaid with referenced map but they have no accuracy.

   The first set of limits, accurate, is obviously more important for the reliability of the GIS. A solution to the lack of spatial references should be brought with the GPS.

- *PISP* :   The plots created in the rattan plantation are too small to be a fully represented.
  plot limits   A simple point on the topomap is enough to locate them. On the Tiagau area, the main limits have been surveyed but not the limit of the different plots. This operation will have to be carried out if an accurate representation of these plots is needed.

   -Remote sensing data : One SPOT scene was used for the project "Mapping from SPOT image data in tropical rain forest in Sabah-Malaysia" carried out in 1987 on the Luasong area. The CCT can be obtained if necessary.

5. Conclusion

On the Luasong area, almost all the geographic data are already captured. Moreover, all the attribute data are gathered in digital form and in the same files. The implementation of the GIS should not encounter major problem and be achieved quickly.
The remaining things to do are as follows :
   - creation of the database.
   - limits adjustment by means of the GPS.
   - Survey of the road network.

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B.Ulu Segama area

1. Context of implementation

The area chosen to be a pilot area for the GIS project is the topographic map sheet 4/117/4 (92).

The area located on the boundary of the YS Concession area is subdivided into several parts,
(Fig IV.2):

A part of the *Danum Valley* conservation area, where the forest is protected. The map sheet includes the DV Field Center (DVFC), a camp for scientific activities and tourism.

An area that was already logged over by the North Borneo Timber forest company when the concession was attributed to the YS.

- A part of the *Ulu Segama Forest Reserve*. This area was logged after the concession was attributed to the Yayasan Sabah. Until 1990, this area was logged by Pacific Hardwoods (PH) in joint venture with ICSB, and from 1991 onwards the remaining coupe were harvested by ICSB. The whole area is logged over now.

An area kept as water catchment.

Two main projects are carried out on the areas:

- *RIL* : The aim of this project is to develop a method to reduce the damages and soil disturbance that occur with current logging activities. This project is carried out on a 430 ha area included in the 1993 coupe.

- *FACE* : The aim is to undertake large scale rehabilitation of logged forest by enrichment planting and reclamation of degraded area using native tree species. The project was initiated in 1993 on 300 ha; 2000 ha should be covered in that way over 3 years for a pilot phase and 23 000 ha afterwards over 23 years.

2. Domain of application of the GIS

2.1 RIL project

Background

The RIL project covers 8 different sub-blocks in the coupe 1993. Four of them are logged under RIL methods and the 4 others under conventional logging in order to compare the results of the 2 methods. The RIL method is supposed to extract essentially the same volume of harvest timber as usual (8-12 trees/ha; 70 m3/ha), using conventional yarding technology (bulldozer). However RIL involves distinct modifications:

a hundred percent inventory is carried out before logging. The location of all commercial species is recorded on a large-scale topographic map (1:5000) or stock map.

pre-planning of skid-trails, at scale 1:5000 to achieve optimum alignments, minimizing steep slopes and stream crossings. The RIL tries to reduce the density of skid trail to 150 m/ha. Moreover the RIL tries to limit the number of landings and to reduce their area.

riparian reserves are left along streams according to their width.

Field techniques such as climber cutting 1 year before felling so that felled trees would not drag other trees down with them.

Skid trail and tree marking

Directional felling towards skid trail and away from potential crop trees.
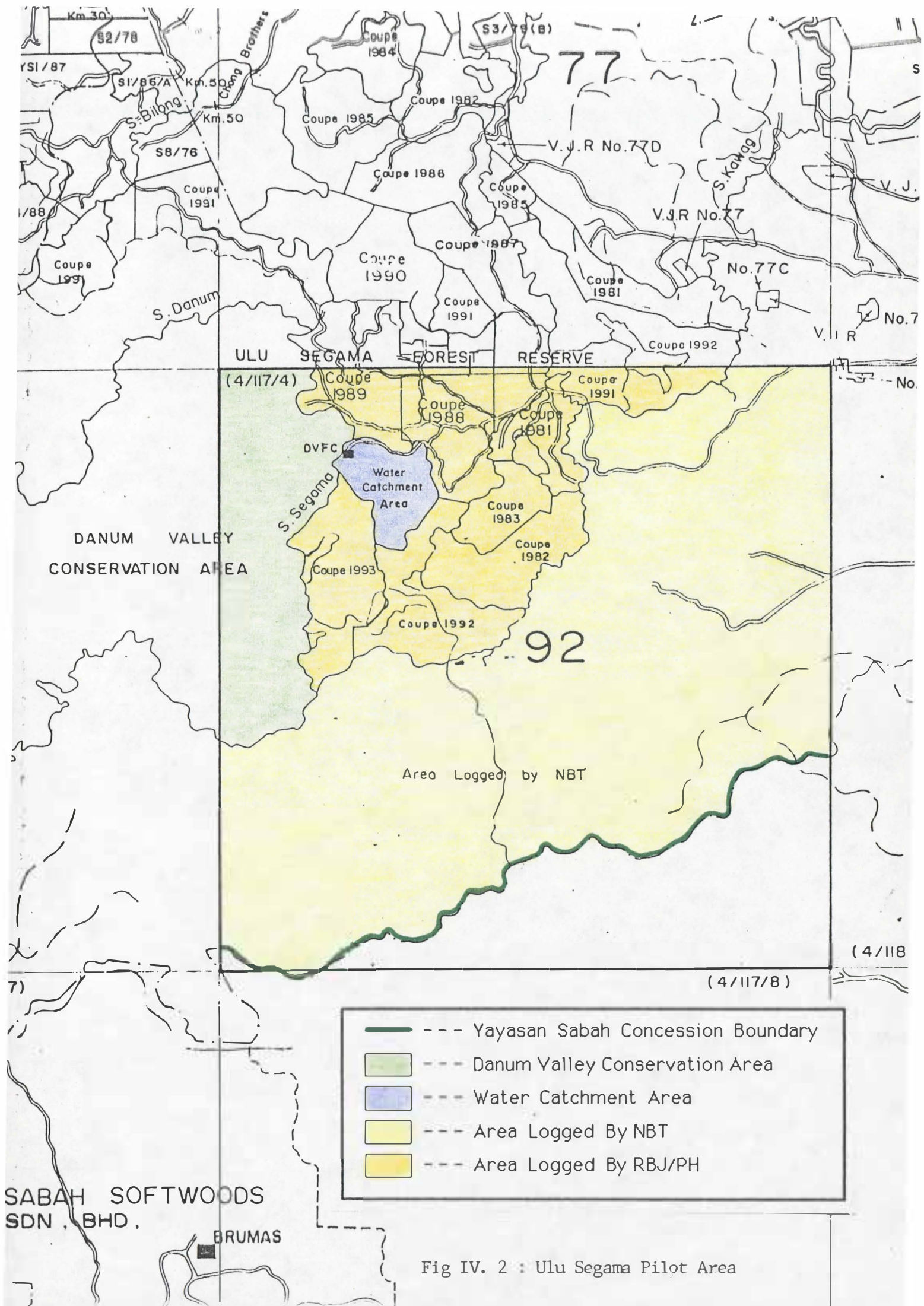
Fig IV. 2 : Ulu Segama Pilot Area

Applications :

The RIL project area should be logged over by the end of 1993 i.e. before the implementation of the GIS. Thus no GIS application could be implemented on this project except for a purpose of "Demo". Nevertheless, suggestion can be made if this method is used on large scale, on the whole concession.

The RIL project involve mostly field techniques for which the GIS cannot be used. But the GIS could be an interesting tool for the map preparation and skid trail planning, especially with its capacity to calculate the slope. With the RIL method, the logging must be achieved for slope below 35°. The distribution of slope on the area to be harvested by means of a DTM could thereby be used very efficiently for planning purpose. Finally, GIS can be used to monitor length or density of the trails network.

Nevertheless, such a planning on the RIL was made at large scale (1:5000) with contour interval of 50 feet (15m). This detailed map was made by the contractor, by enlargement of the 1:50 000 scale topomap in which contours have been completed and redrawn by hand from field observations. On the whole concession, only 1:50 000 scale map are available with contour interval up to 250 feet (75 m). These maps are too rough to do a detailed planning at the scale of a skid trail. With the present accuracy, only a general planning can be envisaged. The final question is to know whether it is really interesting.

Otherwise, it was suggested to use the GIS on the RIL project for a purpose of "demo". Many detailed information are available on the RIL project. The "demo" can demonstrate the optimization of the skid-trail network according to slopes, rivers, contours, stocking map with the RIL method and to compare it with the common method of logging. Moreover, the "demo" can display the main results of research such as damage caused with the 2 methods, remaining stock volume extracted.

2.2   FACE project

Background :

The pilot phase of the FACE project aims at planting 2000 ha over 3 years. Almost 1800 ha have already been planted. This first phase of the project relies on a strong research component that should provide the guidelines for the plantation of the balance of 23 000 ha. On that purpose, trials are made to test the performance of stands versus different parameters such as age of logged forest, degree of disturbance, site conditions or fertilizers, spacing, size of planting hole..

Hence, the 300 ha of the first year of plantation have been divided in 6 separate plots of approximately 50 ha each in order to cover different types of logged over areas: different ages, different topography, different method of logging (tractors or highlead). In that way, the 700 ha corresponding to the 2nd year of the program are divided in 8 different plots. Moreover each plot is planted with different species corresponding each to a line or a group of lines of plantation.

Applications :

- *Plantation management* :

25 000 ha of plantation are planned as a long term objective. It is foreseeable that soon will arise the need for a management of the area planted. Just as for the rattan plantation in Luasong, the GIS could be used to monitor the plantation data of the Face project. Without going into the matter, we can already point out the importance of data such as area planted, and year of plantation, species planted and survival or growth rate. The GIS should be able to provide all the necessary information for the planning of coupe and possible silvicultural treatments.

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- Assistance to the plantation :

Using as a basis that the enrichment plantation in logged over areas must be done where the remaining stand is the most degraded, the GIS can be used to locate these areas with simple parameters:

> LRS Inventory Data: These data are interesting to provide a first idea of the regeneration of the blocks and their potential production after 60 years.

> Method of Logging used: Two different methods of logging are used: tractor logging or high lead. The latter is particularly destructive for the remaining stand. The areas logged with this method are appropriate for enrichment planting. The exact places where high lead were installed are located on the topomap at scale 1:12 500 used by contractors. At a smaller scale a map shows more simply which method was used by sub-block only.

> Finally the year of coupe can be an interesting parameter to take into account. Regeneration is more advanced in oldest coupes and the lack of light in these areas lessen the growth of young plantation.

All these parameters can be easily captured in the GIS. All combined can provide a first logic to assist the location of plantation area, which can be improved afterwards.

Moreover, the GIS could be used to assist the choice of the species to plant:

> Production and / or inventory figures give information on the main species harvested or present in a place, which represent probably the most suitable species for this place. These figures recorded by the contractors are available at large-scale, even by logging areas of 50 acres.

> The research conducted on the FACE project might establish correlation between the growth of species with parameters such as soil, topography, land capabilities. Then, the GIS could be used to locate the most suitable area for a species or conversely the best species in an area provided that the maps available (soil, topography) are detailed and accurate enough.

- Support to research

It was suggested to use the GIS as a support for research in order to establish the correlation previously mentioned. The GIS would not be used as a statistical package but as a tool to display and overlay information at large scale. Topographic maps at 1:12 500 scale with contour interval of 50 feet are available and at this scale, the lines of plantation and even the location of the plants can be displayed.

Numerous information can be associated to each:

> Soil and land capabilities: The maps available at 1:50 000 scale are too rough to be used in an interesting way at this scale. A detailed survey has been undertaken on the first year of the FACE project and one is planned for the whole 25 000 ha.

> Light: a grade of light is attributed to each point of plantation

> Slope: by means of a DTM

> Growth: plants will be divided in growth class.

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2.3 logged over area

The GIS will have first to integrate all the identification data of the coupes such as, coupe number, area, permit number, contractor, volume extracted,etc. Moreover, it was pointed out that the GIS could integrate detailed information on the road network.The road network is a fundamental item of the concession since it influences the access to the forest. It seems particularly important to keep a record of this network in case it should be re-used. This is the case on the Ulu Segama reserve since the area is within the 25 000 ha planned for the FACE project. The network will have to be re-used and improved for plantation purpose. So far, only main roads (roads of permanent usage) and secondary roads (usage over 5 years) have been surveyed and reported on the progress map. The whole network up to the logging roads is available on the large scale topomap 1:12 500 provided by Pacific Hardwood. But on this map, the network is not surveyed which means not accurate or reliable.

The interest of the GPS was mentioned previously to get easy and fast survey. Moreover Remote sensing would be the best and easiest way to get a fast, reliable and up to date road network. Otherwise, even if this network cannot be surveyed in the time of implementation of the pilot project, it could be interesting all the same to digitize it to keep the records. Information concerning the number of bridges or culverts, their location and their quality have not been recorded by ICSB. Nevertheless we must mention a current work undertaken by the survey team of ICSB, and which consists in recording the detailed information on all the bridges and culverts on the main roads.

3. Objectives summary and outputs

An important objective of demonstration is expected with the RIL project. Moreover, this area will be interesting to test the technical feasibility of other objectives, less demonstrative but representative of the future GIS. The objectives and outputs proposed for the pilot project are described as follows. An increasing order of priority is given according to the interest and the difficulty of implementation.

1- **Demo RIL**	Topomap showing river network, areas with slopes beyond 35°, stocking-map and skid-trail design.
	Map comparing the skid-trail density for both methods of logging.
	location of experimental plots.
	Graphs and charts for descriptive results.
2- **Concession consultation**	Progress map with grid of sub-blocks.
	Table of descriptive data : identification, production, account data.
3- **Road network management**	Map of road network.
	Location of bridges and culverts.
	Descriptive table of road status.
4- **Plantation management**	Limits of FACE project plots.
	Descriptive data such as species planted, year of plantation.
5- **Location of suitable areas**	Delimitation of priority blocks or sub-blocks to be planted

The 2 last objectives could be merge together.

The assistance to research previously described should be considered more as a long-term objective and not suitable for pilot project. It is thus not proposed as an objective on this area, all the more since a GIS should be implemented by a local team of research.

4. Data required and available

4.1 RIL demo

Spatial data :

- *Stocking map* : to display the location of the commercial trees . The stocking map is only available for the sub-blocks under RIL method.

- *Topo map* : The topomap at scale 1 : 5000 is digitized for the 4 sub-blocks under the RIL method but not for the 4 others. the sub-blocking is necessary to be add to distinguish the eight different areas of the project. The area with a slope above 35° will have to be displayed as well as the streams network.

- *Skid trail network* : All the skid-trails are supposed to be surveyed.

- *Experimental plots location*

Attribute data :

Production figures by sub-block
Inventory figures
Forest Cover figures especially density
Figures on the defects
Figures of carbon offset

All the data from the experimental plots are captured in a special application programme developed under REVELATION.

4.2 Concession consultation, road network, plantation management

Spatial data :

Topomap : The topographic map, digitized under ARC/INFO has been obtained from UKM Sabah Campus. It includes the following coverage: vegetation, contours, rivers and roads settlement. The accuracy of the contours remains to be checked.

Progress map : At 1:50,000 scale, it will allow to digitize the coupe limits, the main roads and unworked areas. The sub-blocking is not represented and will have to be added separately.

Road network : The complete but unsurveyed road network is available at the scale 1:12 500 from the map provided by PH.

FACE limits : The limits of the first two years of the project have been surveyed and already digitized in ARC/INFO.

RIL limits : Requires to digitize at least the sub-block limits in the 1993 coupe.

The 1:50 000 scale could be sufficient to display the features corresponding to this objective.
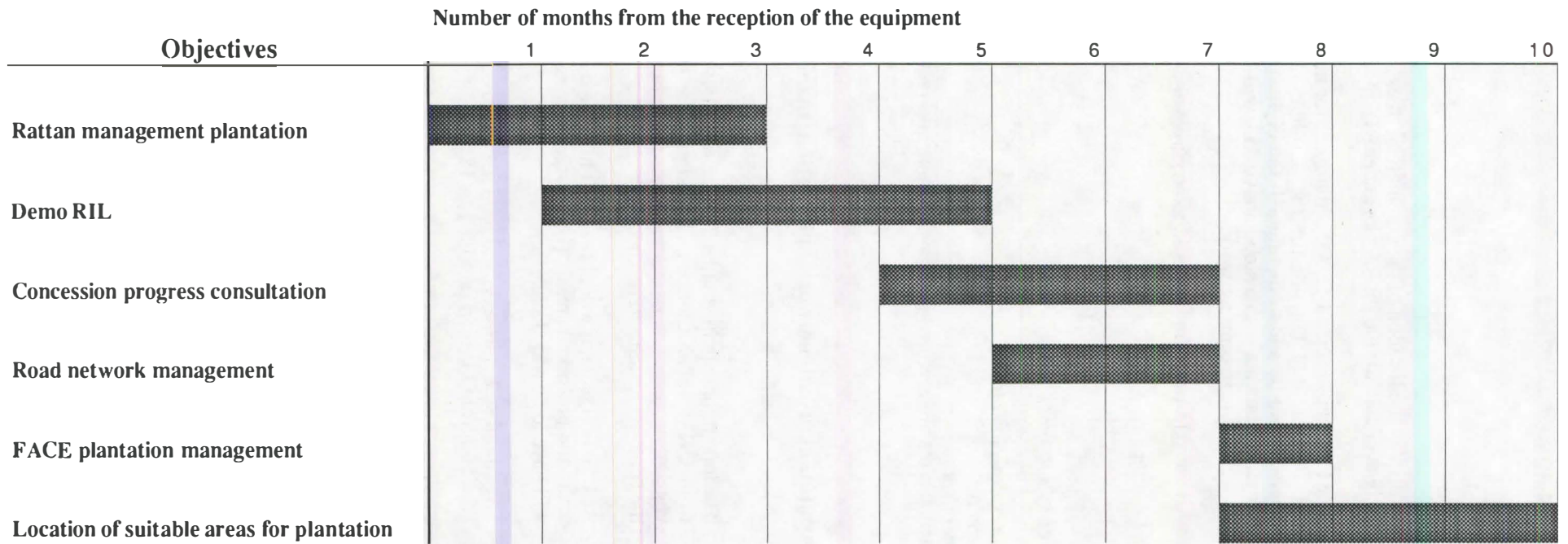
Fig IV.3 : Proposed planning of implementation for the pilot project

Attribute data

On the area previously harvested by North Borneo Timber, no data are available. On the area harvested since the attribution of the concession to the Yayasan Sabah, two periods can be distinguished.

Until 1990 PH was responsible for the logging activities in the Ulu Segama reserves. All the figures have been stored by PH, manually.

From 1991 onwards, ICSB was responsible for the logging through contractors.
The logging data are stored in digital form in KK.

Identification data :	block number, coupe permit number, area, year of coupe contractor, volume extracted.
Road network :	road type, hauling distance,...A census is being undertaken on the main road to assess the number of bridges and culverts, quality, length, year of construction, location,...
Plantation data :	mainly year of plantation and species planted. The data are available from the FACE project.

4.3 Location of suitable areas

Spatial data :

The topomap and the progress map; The sub-blocking is necessary to display detailed information.

Attribute data :

- LRS inventory data	Remaining volume of big trees, number of trees in advance growth, number of seedlings. Projected volume of trees above 60 cm dbh after 60 years, class of projected yield. The LRS data are available on all the coupe of the area except 89,92 and 93 coupe.
- Production and/or inventory data :	Volume predicted/harvested by main species and by sub-block.

- Method of logging used available by sub-block.

5 . Conclusion

This pilot project is characterized by more objectives and more ambitious propositions compared to Luasong. Still few data are available in ARC/INFO and the implementation phase will probably have to face a problem of data collection because of the many different origins of the data. Moreover, the creation of the database from data captured manually will certainly prove long and tedious. The implementation of this pilot project should be thereby more time consuming.

However, the objectives of concession consultation, road network and plantation management should be achieved quickly. The abundance of data for the RIL project allow to expect a very interesting "demo". Only the last objective is more hazardous.

Finally, a planning of implementation is proposed for the pilot project (**fig. IV.3**). It does not take into account the possible difficulties of staff availability.

GENERAL CONCLUSION

GIS is a new technology and few experiences of implementation exist for forestry management purpose. It is thereby difficult to be fully aware of the GIS capabilities and it is not so easy to express needs.

However, through visits to the different activities of the concession, discussions and meetings, some objectives have been identified and an organization imagined for the GIS. It could evolve in time. A first set of objectives should be carried out in less than 1 year during the pilot project. The implementation phase on the whole concession will allow to approach more long-term objectives, requiring either an important work because of the abundance of data (Progress consultancy) or the needs for models or special technology (logged over forest management). The possibility of data exchange with a GIS carried out by the Forestry Department could alleviate the work and increase the speed of implementation.

The equipment expected will allow to start the project on PC. The key parameter is now to constitute an independent GIS team since the availability of staff for the GIS will influence the efficiency and speed of the work. The question of the premises needed must not be neglected.

Subsequently, the upgrading of the system to workstation will be necessary, which will allow to create independent modules of GIS for local management. Additionally, a remote sensing package could be envisaged.

Finally, the implementation of this Forestry GIS should allow to approach the forestry management by a very interesting way. Moreover, the framework of ICSB and its dynamism is a very favorable context of implementation and much can be expected from the project.

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APPENDIX

REPORT ID   CFF.2A
REPORT DATE 23 JUL 1993
PAGE NO

CIRCLE   TAWAU   BLOCK NO   YT7/92   CONTRACTOR   340 LEGA UTAMA SDN.BHD.

	FAQ		SSQ		SQ		MQ		SH/SSH		MQL		REJECTED		BRIDGE TIMBER/CO.USED		
S P E C I E S	Log/s	m3	Log/s	m3	Log/s	m3	Log/s	m3	Log/s	m3	Log/s	m3	Log/s	m3	Log/s	m3	Log/s
BALAUNG HITAM																	
KAPUR					229	1,588.45	16	99.76	59	173.16	17	66.69					321
GAGIL						19.40					1	4.38					5
KEMBANG/TANAS																	
KELUBONG						16.28		8.05									
KEMBANG/KEMBULANG																	
KERUING					181	1,065.38	20	119.93	38	119.20	15	70.11					254
KAPAI																	
KEKELANG SEKANGKOI						43.55		6.54				1.64					8
BAKAS																	
KEMBUE						17.06											
MENGGELAS																	
MENGGELAS/TUALANG																	
MELAPI		51.33		44.08	46	270.80		33.57	10	34.65	16	76.09					92
UTSEBEH						33.38			1	1.73	1	4.84					6
PENGIRAN						7.19											1
PEDARI HUTAN								20.59	1	4.65							2
BENGERIS																	
RED SERAYA	65	672.65	69	540.13	663	4,335.03	126	766.70	171	589.12	117	610.16					1,257
SELANGAN BATU						16.36		12.71									4
SELANGAN BATU II					15	81.66		27.09	2	6.05							21
SIMPOR																	
SEPAYAO						35.17						5.84					
TANGUS						8.07											
WHITE SERAYA	40	314.36	30	196.57	194	1,285.09	53	425.09	30	193.44	102	583.50					460
YELLOW SERAYA	13	145.42		60.00	57	471.86	8	68.97	15	58.52	33	237.83					131
T O T A L	150	1,185.36	111	640.78	1,519	9,276.32	236	1,591.45	326	1,075.41	336	1,661.10	0	.00	0	.00	2,571
PERCENTAGE		7.48		5.43		58.80		9.29		6.78		11.73		.00		.00	
PERCENTAGE SQ +						71.50											

FORESTRY DIVISION (RBJ), INNOPRISE CORPORATION SDN. BHD.
SUMMARY OF 10% PRE-FELLING INVENTORY
TABLE C NET VOLUME PER HA AND TOTAL NET VOLUME BY SPECIES GROUPS AND DBH CLASSES (GROSS TO NET VOL. FACTOR = 0.60)

(DEFECTS = 0.15 INACCESSIBILITY = 0.15)
(BREAKAGE = 0.10 SOUND VOLUME = 0.60)

[redacted] : SANDAKAN COUPE YEAR : 1993 COUPE/COMP. NO : Y51/93 AREA(ha)Prel : 1076 SAMPLE AREA(ha) : 97.5 INVENTORY START : 18/03/91 TALLY RECEIVED : DISKETTE SENT TO K.K. :
[redacted] RESERVE : SUNGAI PINANGAN CONTRACTOR : TO BE DETERMINED FINAL : 985 SAMPLE INTENSITY : 9.90 END : 06/04/91 PREPARED ON : 12/03/92 ARRIVED K.K. :

05

[redacted] CIES	DBH CLASS (CM)																								TOTAL		% OF	% OF
[redacted] P	20 < 50		50 < 60		60 < 70		70 < 80		80 < 90		90 < 100		100 < 110		110 < 120		120 < 130		130 < 140		140 < 150		150 +		(60 CM+)		6	
	Y/HA	T.VOL	Y/HA	T.VOL	Y/HA	T.VOL	Y/HA	T.VOL	Y/HA	T.VOL	Y/HA	T.VOL	Y/HA	T.VOL	Y/HA	T.VOL	Y/HA	T.VOL	Y/HA	T.VOL	Y/HA	T.VOL	Y/HA	T.VOL	Y/HA	T.VOL	(6	
	0.53 - 2.05		3.25		4.94		7.12		9.52		12.50		17.50		19.35		24.70		30.70		37.25		45.90 - 64.10					
1. [redacted] CARP																												
[redacted]	NR	NR	0.00	0.00	6.64	6540.40	5.34	5441.70	7.54	7426.90	5.62	4744.70	2.42	2383.70	2.50	2462.50	4.15	4087.75	2.95	2905.75	1.56	1536.60	1.32	1300.20	40.64	40030.40		
[redacted]	NR	NR	0.00	0.00	0.71	677.35	0.77	758.45	1.03	1014.55	0.34	336.50	0.63	620.55	0.71	679.35	0.59	581.15	0.00	0.00	0.00	0.00	0.00	0.00	5.34	5259.90		
[redacted]	NR	NR	0.00	0.00	0.50	492.50	0.97	955.45	1.03	1014.55	1.20	1182.00	0.95	935.75	0.60	591.00	0.44	433.40	0.18	177.30	0.00	0.00	0.28	275.80	6.16	6067.60		
[redacted]	NR	NR	0.00	0.00	0.33	317.55	1.07	1053.95	1.77	1743.45	1.20	1182.00	0.74	728.90	0.24	236.40	1.04	1024.40	0.37	364.45	0.45	443.25	0.00	0.00	7.71	7594.35		
[redacted]	NR	NR	0.00	0.00	0.24	236.40	0.07	68.95	0.27	265.95	0.28	275.80	0.11	108.35	0.36	354.60	0.44	433.40	0.35	344.75	0.00	0.00	0.00	0.00	2.38	2344.30		
[redacted]	NR	NR	0.00	0.00	0.74	728.90	0.60	591.00	0.63	620.55	0.28	275.80	0.42	413.70	0.24	236.40	0.15	147.75	0.00	0.00	0.00	0.00	0.00	0.00	3.08	3033.80		
[redacted]	NR	NR	0.00	0.00	0.27	265.95	0.38	374.30	0.46	453.10	0.15	147.75	0.21	206.85	0.12	118.20	0.00	0.00	0.00	0.00	0.00	0.00	0.33	325.05	1.92	1891.20		
[redacted]	NR	NR	0.00	0.00	1.66	1635.10	2.75	2708.75	3.66	3605.10	3.08	3033.80	3.36	3309.60	3.22	3171.70	2.52	2482.20	2.21	2176.85	1.12	1103.20	0.93	916.05	24.71	24339.35		
[redacted]	NR	NR	0.00	0.00	0.00	0.00	0.00	0.00	0.06	59.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	59.10		
[redacted] DIPTS.	NR	NR	0.00	0.00	0.62	610.70	0.64	630.40	0.06	59.10	0.08	78.80	0.11	108.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.51	1487.35		
[redacted] DIPTS.	NR	NR	0.00	0.00	12.21	12026.85	14.02	13809.70	16.53	16282.05	12.23	12046.55	8.75	8315.75	7.97	7370.15	9.33	9170.05	6.26	6166.10	3.13	3083.05	2.35	2317.20	93.51	92107.35		
2. [redacted]-DIPTS.																												
[redacted]	NR	NR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
[redacted]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
[redacted]	NR	NR	0.00	0.00	0.06	59.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12	118.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.18	177.30		
[redacted]	NR	NR	0.00	0.00	0.03	29.55	0.00	0.00	0.06	59.10	0.08	78.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.17	167.45		
[redacted]	NR	NR	0.00	0.00	0.15	147.75	0.26	256.10	0.23	226.55	0.15	147.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.79	778.15		
[redacted]	NR	NR	0.00	0.00	0.03	29.55	0.00	0.00	0.29	285.65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.32	315.20		
[redacted] NON-DIPTS	NR	NR	0.00	0.00	2.57	2531.45	1.45	1428.25	1.37	1347.45	0.30	295.50	0.11	108.35	0.36	354.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.26	6166.10		
[redacted] NON-DIPTS	0.00	0.00	0.00	0.00	2.84	2797.40	1.71	1684.35	1.95	1920.75	0.53	522.05	0.11	108.35	0.48	472.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.72	7604.20		
3. [redacted]TECTED SPECIES																												
[redacted]	NR	NR	0.00	0.00	0.15	147.75	0.47	462.95	0.29	285.65	0.45	443.25	0.53	522.05	0.12	118.20	0.15	147.75	0.00	0.00	0.00	0.00	0.00	0.00	2.16	2127.60		
[redacted] TREES	NR	NR	0.00	0.00	0.36	354.60	0.17	167.45	0.34	334.90	0.23	226.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.10	1083.50		
[redacted] PROTECTED	NR	NR	0.00	0.00	0.51	502.35	0.64	630.40	0.63	620.55	0.68	669.80	0.53	522.05	0.12	118.20	0.15	147.75	0.00	0.00	0.00	0.00	0.00	0.00	3.26	3211.10		
4. [redacted]TAL																												
a. [redacted]	0.00	0.00	0.00	0.00	[illegible]	14722.75	15.73	15494.05	16.49	16202.30	12.76	12568.60	7.06	6724.10	8.47	8347.95	9.33	9190.05	6.26	6166.10	3.13	3083.05	2.26	4501.45	101.23	99711.35	94.42	94.42
b. [redacted] COMM.	NR	NR	0.00	0.00	[illegible]	247.10	0.77	758.45	0.46	453.10	0.08	78.80	0.21	206.85	0.12	118.20	0.00	0.00	0.00	0.00	0.22	216.70	0.00	0.00	2.72	2677.20	2.54	2.54
c. [redacted]ECTED	NR	NR	0.00	0.00	0.51	502.35	0.64	630.40	0.63	620.55	0.68	669.80	0.53	522.05	0.12	118.20	0.15	147.75	0.00	0.00	0.00	0.00	0.00	0.00	3.26	3211.10	3.04	3.04
d. [redacted] SPECIES	0.00	0.00	0.00	0.00	16.52	16272.20	17.14	16882.90	17.57	17276.45	13.52	13317.20	7.77	7653.00	8.71	8579.35	9.48	9337.80	6.26	6166.10	3.35	3299.75	2.36	4501.45	107.21	105601.85	100.00	100.00
[redacted] OF VOLUME		0.00		0.00		15.41		15.99		18.25		12.61		9.14		8.12		8.84		5.84		3.12		4.25		100.00		

* [redacted] = Not recorded
** [redacted] of Volume calculated base on 60 cm & above

FORESTRY DIVISION (RBJ), INNOPRISE CORPORATION SDN. BHD.

TABLE 1. SUMMARY OF 1993 COUPE DETAILS

REGION	FOREST RESERVE	COUPE NO.	COUPE AREA (HA)		COMPARTMENT NO.	TOTAL AREA	WORKABLE (HA)		UNWORKABLE (HA)	
			PREL.	FINAL			PREL.	FINAL *	AREA	REASON(S)
Sandakan	Pinangah	YS1/93	1,026	985	122	89	92	89		
					125	169	176	169		
					126	211	220	211		
					127	198	206	198		
					128	159	166	159		
					129	159	166	159		
		Sub-total	1,026	985	6	985	1,026	985	0	0
Sandakan	Pinangah	YS2/93	1,058	1,045	117	205	208	205		
					118	134	136	134		
					119	157	158	157		
					120	146	148	146		
					121	221	224	221		
					121A	182	184	182		
		Sub-total	1,058	1,045	6	1,045	1,058	1,045	0	0
Sandakan	Pinangah	YS3/93	794	710	119A	199	223	199		
					119B	124	138	124		
					119C	180	201	180		
					119D	207	232	207		
		Sub-total	794	710	4	710	794	710	0	0
Sandakan	Pinangah	YS4/93	1,970	2,070	170	282	268	282		
					533	237	226	237		
					553	198	188	198		
					554	256	244	256		
					555	193	184	193		
					556	240	228	240		
					565	208	198	208		
					566	265	252	265		
					567	191	182	191		
		Sub-total	1,970	2,070	9	2,070	1,970	2,070	0	0
Keningau	Pinangah	YK1/93	929	1,105	304	281	236	281		
					305	264	222	264		
					308	277	233	277		
					317	283	238	283		
		Sub-total	929	1,105	4	1,105	929	1,105	0	0
Keningau	Pinangah	YK2/93	985	930	306	206	218	206		
					307	260	276	260		
					318	238	252	238		
					319	226	239	226		
		Sub-total	985	930	4	930	985	930	0	0
Sandakan	All FRs		6 762	6 845	33	6 845	6 762	6,845		

TABLE 3 : SUMMARY OF NET VOLUME (m3) PER HA FOR 60CM DBH AND ABOVE BY SPECIES GROUP.

REGION	FOREST RESERVE	COUPE NO.	PREL. AREA	COMPARTMENT NO.	PREL. AREA(ha)	RS	WS	YS	OS	CR	KR	MP	SB	MGL	BE	NY	OT	NC	TOTAL
Sandakan	Pinangah	YS1/93	1.026	122	92	63	7	2	6	7	4	0	24	0	0	1	15	3	132
				125	176	36	3	7	6	3	3	4	26	0	0	0	13	3	104
				126	220	31	3	7	6	1	4	1	27	0	0	1	12	2	95
				127	206	52	6	6	12	3	2	0	20	0	0	0	12	3	116
				128	166	32	4	7	11	1	3	4	31	0	1	1	10	4	109
				129	166	42	10	7	6	3	2	1	20	0	2	2	10	3	108
				6	Wtd. Mean	41	5	6	8	2	3	2	25	0	0	1	11	3	107
Sandakan	Pinangah	YS2/93	1,058	117	208	43	20	2	0	10	6	1	7	0	0	0	9	1	99
				118	136	58	27	4	0	10	10	1	9	0	0	0	11	1	131
				119	158	35	20	5	1	10	12	0	4	0	1	0	13	1	102
				120	148	32	12	3	0	21	23	0	7	0	1	0	11	2	112
				121	224	54	14	2	2	9	7	4	19	0	0	0	10	1	122
				122A	184	57	29	2	0	12	5	1	0	0	0	0	15	1	122
				6	Wtd. Mean	46	20	3	0	12	10	1	8	0	0	0	11	1	112
Sandakan	Pinangah	YS3/93	794	119A	223	44	11	4	2	29	10	2	8	0	0	1	20	7	138
				119B	138	73	7	6	7	34	5	1	12	0	0	2	13	1	161
				119C	201	54	8	1	2	30	15	1	8	0	0	0	28	10	157
				119D	232	61	6	6	4	33	6	1	8	0	0	0	17	4	146
				4	Wtd. Mean	57	8	4	4	31	10	1	9	0	0	1	17	6	148
Sandakan	Pinangah	YS4/93	1,970	170	268	58	18	7	4	9	6	2	7	0	3	0	15	5	134
				533	226	45	9	6	2	4	4	0	4	0	6	0	16	3	99
				553	188	61	5	7	4	7	10	8	10	0	2	0	24	3	141
				554	244	50	11	6	2	6	3	2	5	0	2	0	12	4	103
				555	184	43	6	8	8	2	6	5	4	0	4	0	14	2	102
				556	228	45	13	2	0	8	4	3	0	0	5	1	26	2	109
				565	198	40	9	6	10	15	3	1	1	0	0	0	21	6	112
				566	252	46	10	8	3	13	7	0	3	0	3	1	20	8	122
				567	182	58	13	4	10	10	12	1	1	0	4	1	15	4	133
				9	Wtd. Mean	50	11	6	4	8	6	2	4	0	4	0	19	4	118
Keningau	Pinangah	YK1/93	929	304	236	41	16	8	3	3	9	2	49	0	2	0	10	7	150
				305	222	51	5	3	1	3	7	1	56	0	0	0	8	12	147
				308	233	31	22	3	1	1	2	3	31	0	0	0	9	2	105
				317	238	29	5	5	2	5	2	5	34	0	0	1	18	1	107
				4	Wtd. Mean	37	12	5	2	3	5	3	41	0	1	0	11	6	125
Keningau	Pinangah	YK2/93	985	306	218	34	15	6	5	2	4	3	27	0	0	1	15	0	112
				307	276	29	13	4	3	4	4	2	14	0	0	0	8	2	83
				318	252	21	1	1	1	1	3	1	41	0	2	0	11	1	84
				319	239	34	6	9	4	2	4	3	28	0	1	0	12	3	106
				4	Wtd. Mean	29	7	5	3	2	4	2	27	0	0	0	13	2	94
Sandakan	All FRs	6	6,762	33	Wtd.Mean	43	11	5	3	10	6	2	19	0	1	0	14	4	117

Appendix 3   Rattan plantation data

CENSUS REPORT

COMPARTMENT NO : 200   SUB-BLOCK : A
SPECIES : RS   '' ROTAN SEGA
CENSUS COMMENCED : 02/25/92   CENSUS COMPLETED : 02/28/92
UNPLANTED AREA (STONY)   . 3.21 PLANTED AREA (HA) :   21.22
NO SEEDLING CENSUSED :   14132   RANGER/NAME : BASAR TARIB
PAGE : 1
DATE : 05 AUG 1993   '' PRELIMINARY ''

LINE NO	HEALTHY PLANT	PESTS/ DISEASES	DISTURBANCE	LIFE	HOLE/NO SEEDLING	EMPTY/BUT PLANTABLE	DEAD	EMPTY POINT
1	422	20	16	458	2	3	95	100
2	404	19	64	487	9	11	84	104
3	415	7	10	432	3		110	120
4	417	2	6	425	0	4	100	104
5	233	12	35	330	0	0	117	117
6	370	74	7	451	3	0	95	98
7	351	54	28	433	3	0	99	102
8	327	53	61	441	2	2	91	95
9	377	19	28	424	0	4	102	106
10	331	24	40	395	2	9	136	147
11	271	30	69	370	3	2	99	104

PLANTATION UNIT - LUASONG FORESTRY CENTER

PLANTING RECORD REPORT

COMPARTMENT NO : 200   SUB-BLOCK : A
SPECIES :. RS   '' ROTAN SEGA
PLANTING DATE : 11/05/91
UNPLANTED AREA (STONY)   3.21
SURVEY AREA (HA) :   31.00
PLANTED AREA (HA)   21.22
NO SEEDLING CENSUSED   14132
NO SEEDLING DISPATCHED   3100
PLANTING DENSITY :   666
PLANTING SPACING (M) : 2.5M X 12M
RANGER/NAME : IBGEH MOBIN
CONTRACTOR : SOON   '' SOON SANG PLANTING CONTRACTOR
REPORT DATE : 05 AUG 1993

CIRCLE WEEDING FOR THE MONTH OF 09/91

COMPT/NO	SUB/BLK	CONTRACTOR	RND DUR.	COMMIT	ACTUAL	PLAN
206	E	SAWANG DEVELOPMENT SDN BHD			09/91	09/91
206	G	PENGURONG KURNI			09/91	09/91
206	H	AJUKO SDN. BHD.			09/91	09/91

Appendix 4   LRS inventory

Status of sampled coupes/compartments projected 60-65 years after logging by forest reserves

FOREST RESERVE	COUPE/ COMPT	AREA (ha)	YEAR OF LOGGING	YEAR OF LRS	PROJECTED NET VOL/HA (M3)	YEAR	TOTAL HARVESTABLE VOLUME	STOCKING CLASS
GN KARA	T5/84/1&2	376	1984	1986	147.51	2016	55.364	
	T5/84/3&4	378	1984	1986	125.71	2016	47.518	
	T5/84/5&6	330	1984	1986	153.81	2016	50.757	
KALABAKAN	Compt 215	162	1981	1987	128.24	2012	20.775	
	Compt 233	245	1982	1988	101.54	2013	24.877	
	Compt 221	146	1982	1987	101.63	2012	14.838	
	Compt 240	210	1982	1988	113.05	2013	23.741	
	Compt 232	248	1981	1988	109.36	2013	27.121	
	Compt 225	228	1982	1988	80.95	2013	18.457	
	Compt 195	224	1975	1991	82.42	2036		
	Compt 219	220	1981	1987	112.89	2012		
	Compt 250	220	1983	1988	101.01	2013		
	Compt 214	290	1982	1987	113.29	2012	32.854	
	Compt 223	270	1982	1988	133.77	2013	36.118	
	Compt 241	178	1982	1988	103.55	2013	18.432	
	Compt 218	372	1981	1987	89.02	2012	33.115	
	Compt 229	200	1981	1988	112.89	2012	22.578	
	Compt 224	405	1982	1988	81.74	2013	33.105	
	Compt 251	228	1978	1988	80.47	2038	18.347	
	Compt 196	210	1975	1991	92.01	2036	19.322	
	T2/78/B27	813	1978	1985	81.51	2040	66.268	
	T2/83/B30A(1)	423	1983	1986	104.32	2041	44.127	
	T2/84/B30B(2)	300	1984	1988	82.34	2013	24.702	
	T2/84/B30B(3)	255	1984	1988	101.15	2013	25.793	
	T4/82/B12B(1)	322	1982	1986	100.54	2011		
	T4/82/B12B(2)	345	1982	1986	94.58	2011	32.630	
	T4/83/B13(1)	430	1983	1986	124.40	2011	53.492	
	T4/83/B13(2)	479	1983	1986	130.37	2011		
	T4/83/B13(3)	690	1983	1986	121.40	2011	83.766	
	T6/75/B2(1)	704	1975	1984	152.05	2034	107.043	
	T6/75/B2(2)	712	1975	1984	170.63	2034	121.489	
	YT1/88	932	1988	1989	122.74	2049	114.396	
	YT1/89	398	1989	1991	83.35	2051	33.174	
	YT2/86A	360	1986	1989	96.81	2014		
	YT2/87	1,951	1987	1989	88.60	2049		
	YT2/88	1,722	1988	1989	89.86	2049	154.742	
	YT17/88	1,214	1988	1990	85.67	2050	101.001	
	YT17/89	780	1989	1991	90.86	2051	70.874	

[illegible]

Table A

LRS SUMMARY BY TOTAL STOCKING, TREATMENT TYPES, DOMINANCE AND SIZE CLASSES

LOCATION

1. REGION : Sandakan
2. F. RESERVE: Malua
3. BLOCK : 1972 4. AREA(HA) 846
5. SUBBLOCK/COMPT: 6. AREA(HA):

DETAILS OF SAMPLING WORK

DATE OF SAMPLING
7. START : 5.2.97
8. END : 27.2.97
9. TEAM LEADER : AMU.SALEH
10. TOTAL SAMPLING LINE : 31
11. TOTAL LENGTH : 39720
12. TOT. QUADRATS : 3972
13. TOT. SUBQUADRATS : 14060
14. SAMPLE AREA (HA) : 39.72
15. TOTAL AREA (HA) : [illegible]
16. S.INTENSITY (20x20m)% : [illegible]
17. S.INTENSITY (10x10m)% : 4.7

WORKRATE AND COSTS

18. TOTAL WORKING DAYS : [illegible]
19. NO. OF MEN : 17
20. TOT.EFF. WORKING DAYS : 45
21. TOTAL MANDAYS/HA : 2.50
22. ACTUAL MANDAYS/HA : [illegible]
23. TOTAL COST : $
24. DIRECT COST : $ [illegible]
25. DIRECT COST/HA : $ [illegible]

CATEGORY	SPECIES	SUB QUADRAT (2x2m) SEEDLINGS <10cm DBH (percentage of stocked quadrats)										MAIN QUADRAT (10x10m) ADVANCE GROWTH 10<60cm DBH (Stocking % = No. of stocked quadrats per ha)															BIG TREES (PER HA) 60cm dbh and above							
		Size Class					Treatment Type					Size Class						Dominance				Treatment Type					Quality 1		Quality 2		Quality 3		TOTAL	
		H1 <0.5m	H2 <1.5m	H3 <3.0m	H4 <10cm	TOTAL	1 None	2 G	3 CL	4 GCL	TOTAL	10<20	20<30	30<40	40<50	50<60	TOTAL	1 D	2 CD	3 S	TOTAL	1 None	2 G	3 CL	4 GCL	TOTAL	No. Tree	Cumul. (BA)	No. Tree	Cumul. (BA)	No. Tree	Cumul. (BA)	No. Tree	Cumul. BA
26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
[illegible] SS CROP TREES	R.SERAYA	[illegible]	17	31	35	84	68	[illegible]	15	0	84	202	161	73	37	28	501	34	452	[illegible]	501	269	0	232	[illegible]	501	2	11.57	48	352.25	56	158.40	110	523.57
	W.SERAYA	[illegible]	5	31	25	65	55	0	10	0	65	55	51	26	19	[illegible]	125	14	106	5	125	73	0	53	[illegible]	126	6	31.82	25	155.75	40	139.57	[illegible]	326.95
	Y.SERAYA	0	1	2	1	4	4	0	0	0	4	32	34	14	8	5	93	[illegible]	90	[illegible]	93	45	[illegible]	47	[illegible]	93	1	1.31	8	56.25	[illegible]	3.05	10	54.63
	KAPUR	1	10	20	11	32	22	0	10	0	32	16	3	8	10	5	42	5	34	3	42	25	0	17	0	42	1	4.94	7	29.25	[illegible]	1.35	18	45.53
	KERUING	[illegible]	22	20	25	66	30	0	16	0	65	20	18	14	15	11	78	[illegible]	61	[illegible]	78	51	[illegible]	25	[illegible]	75	[illegible]	14.24	20	112.16	17	56.66	38	183.02
	S.BATU	[illegible]	7	9	10	27	22	0	5	0	27	7	5	5	8	5	25	[illegible]	25	[illegible]	25	15	0	10	[illegible]	26	0	0.00	10	85.80	17	118.70	27	[illegible]
	BELIAN	0	[illegible]	1	3	7	5	0	2	0	7	1	0	[illegible]	0	0	2	0	[illegible]	[illegible]	[illegible]	1	0	[illegible]	0	2	0	0.00	5	36.57	11	59.07	20	95.64
	BINUANG	0	6	3	2	5	5	0	0	0	5	[illegible]	[illegible]	15	15	5	45	[illegible]	35	0	45	30	[illegible]	10	0	46	1	7.12	4	19.75	[illegible]	10.37	[illegible]	37.25
	NYATOH	0	0	0	0	0	0	0	0	0	0	0	2	[illegible]	0	0	[illegible]	0	5	0	[illegible]	[illegible]	0	0	0	[illegible]	0	0.00	0	0.00	[illegible]	3.25	[illegible]	3.25
	SEPETIR	0	1	0	0	1	0	0	1	0	1	1	0	2	0	0	[illegible]	0	3	0	[illegible]	[illegible]	[illegible]	0	0	3	0	0.00	[illegible]	19.55	1	2.06	2	21.60
	KEMBANG S	0	4	1	0	5	2	0	3	0	5	1	[illegible]	[illegible]	1	[illegible]	[illegible]	[illegible]	6	0	7	6	[illegible]	[illegible]	0	[illegible]	0	0.00	[illegible]	4.94	[illegible]	51.45	[illegible]	56.39
	MERBAU	0	0	0	0	0	0	0	0	0	0	2	[illegible]	[illegible]	[illegible]	0	[illegible]	0	4	0	4	1	[illegible]	3	0	4	0	0.00	0	0.00	[illegible]	22.02	[illegible]	22.02
	MELAPI	1	1	1	1	4	5	0	1	0	4	5	2	[illegible]	0	[illegible]	9	2	7	0	9	5	0	3	0	9	0	0.00	0	0.00	0	0.00	0	0.00
	OTHERS	0	[illegible]	4	1	7	6	0	1	0	7	12	11	[illegible]	[illegible]	[illegible]	38	0	35	3	38	25	[illegible]	[illegible]	0	38	0	0.00	[illegible]	2.35	[illegible]	14.37	[illegible]	16.92
a.	TOTAL	3	77	113	112	308	243	2	63	0	308	337	281	172	112	73	975	75	853	47	975	556	6	426	0	975	13	45.45	139	592.25	187	[illegible]	329	[illegible]
b.	% OF TOTAL	1.9	25.0	36.7	36.4	100.0	78.9	0.5	20.5	0.0	100.0	34.5	28.8	17.6	11.5	7.6	100.0	7.8	87.4	4.8	100.0	57.0	0.6	43.6	0.0	100.0	4.0	2.65	39.2	35.76	56.8	[illegible]	100.00	100.00
NON-SS CROP TREES	OBAH	0	[illegible]	0	0	0	0	0	0	0	0	3	2	2	0	0	10	0	10	0	10	5	0	5	0	10	0	0.00	0	0.00	[illegible]	2.06	[illegible]	2.05
	KAYU MALAM	0	0	0	0	0	0	0	0	[illegible]	0	3	7	[illegible]	[illegible]	0	15	4	11	0	15	[illegible]	0	10	0	15	[illegible]	1.11	1	1.11	[illegible]	[illegible]	[illegible]	2.22
	LARAN	0	[illegible]	0	0	0	0	0	0	[illegible]	0	0	45	62	35	14	[illegible]	34	130	[illegible]	164	128	0	35	0	156	[illegible]	2.13	15	40.26	[illegible]	54.96	[illegible]	99.11
	MENGARIS	0	0	[illegible]	0	0	0	0	[illegible]	[illegible]	0	0	0	0	[illegible]	0	[illegible]	[illegible]	9	0	[illegible]	0	0	[illegible]	[illegible]	[illegible]	[illegible]	12.51	[illegible]	31.23	[illegible]	1.03	[illegible]	44.65
	KARAI	0	0	0	0	0	0	0	0	0	0	12	8	[illegible]	0	0	22	0	18	[illegible]	21	14	[illegible]	7	[illegible]	[illegible]	0	0.04	[illegible]	0.30	[illegible]	0.00	[illegible]	3.00
	RENGAS	0	0	0	0	0	[illegible]	0	0	0	0	1	0	0	0	0	[illegible]	[illegible]	[illegible]	0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1	0	0.00	0	0.00	[illegible]	0.00	[illegible]	2.00
	BAWANG H	0	0	0	[illegible]	0	0	0	0	0	0	0	[illegible]	[illegible]	1	0	2	[illegible]	2	0	[illegible]	1	0	[illegible]	0	2	[illegible]	0.00	0	0.00	[illegible]	4.56	[illegible]	4.56
	OTHERS	0	0	0	0	0	0	0	0	0	0	179	207	172	81	16	675	43	597	35	675	393	[illegible]	281	0	675	7	11.50	50	163.92	58	235.65	[illegible]	411.11
a.	TOTAL	0	0	0	0	0	0	0	0	0	0	196	295	248	122	30	891	73	769	43	891	541	[illegible]	346	0	591	11	28.30	56	240.57	75	277.03	[illegible]	546.70
b.	% OF TOTAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	22.2	32.9	27.8	12.7	3.4	100.00	8.5	86.3	4.8	100.00	61.2	0.1	39.2	0.0	100.00	7.1	5.06	40.2	44.35	45.7	52.40	100.00	100.00
TOTAL ALL CROP TREES	TOTAL	6	77	113	112	308	243	2	63	0	308	505	574	420	234	104	1857	[illegible]	1622	90	1857	1097	[illegible]	769	0	1867	24	67.90	197	1075.93	262	1307.23	[illegible]	2481.06
	% OF TOTAL	1.9	25.0	36.7	36.4	100.0	78.9	0.5	20.5	0.0	100.0	26.7	30.7	22.3	12.5	5.6	100.0	8.3	86.9	4.8	100.00	58.8	0.1	41.2	0.0	100.00	5.0	5.55	40.8	43.37	54.2	52.69	100.00	100.00

SEEDLINGS: 0

YIELD PER HA : m3

Rs ______ % Cr ______ % Mp ______ %

Ws ______ % Kr ______ % [illegible] ______ %

Ys ______ % Sb ______ %

NEXT LRS : ______

TREATMENT YES | NO

DETAILS OF TREATMENT :

OFFICER IN-CHARGE

DATE:

STAND TABLE PROJECTION
(DATA INPUT FROM LINEAR REGENERATION SAMPLING)

REGION : SANDAKAN   BLOCK NO. 1968A   COMPT NO.:   ARE ASAMPLED (HA) : 32.4   COUPE YEAR : 1968
F.RESERVE : MALUA   AREA(HA) : 684   AREA(HA) : N/A   SAMPLING INTENSITY : 4.75%   YEAR OF LRS : 1985

		ADVANCE GROWTH (10<60CM DBH)											OTHER BIG TREES (>30CM DBH)										TOTAL SUMMARY					
		10<20	20<30	30<40	40<50	50<60	60<70	70<80	80<90	>90	10<60	>60	30<40	40<50	50<60	60<70	70<80	80<90	90<100	>30	>60	GROSS			NET		
1.DBH (cm)																						>10	>30	>60	>60cm		
2.D.M.A.I. (cm/yr)		0.5	0.5	0.5	0.5	0.5	0.4	0.3	0.2	0.1			0.5	0.5	0.5	0.4	0.3	0.2	0.1								
3.TRANSITION PROBABILITY		0.25	0.25	0.25	0.25	0.25	0.20	0.15	0.10	0.05			0.25	0.25	0.25	0.20	0.15	0.10	0.05								
4.MEAN ANNUAL MORTALITY %		4	2	2	2	2	1	1	0	0			2	2	2	1	1	0	0								
5.RECRUITMENT (no.of trees)		5																									
6.MEAN CLASS G.VOLUME(m³)		0.4	0.53	1.11	2.05	3.25	4.94	7.12	9.52	12.5			1.11	2.05	3.25	4.94	7.12	9.52	12.5								
7.STAND AT YEAR OF LRS																											
	a. Trees/ha	16.40	16.71	12.52	5.39	5.73					56.75		0.00	0.00	0.00	1.88	1.42	0.89	0.34	4.53	4.53	61.28	28.17	4.53			
	b. G.vol m³/ha	6.56	8.86	13.90	11.05	18.62					58.99		0.00	0.00	0.00	9.29	10.10	8.51	4.24	32.13	32.13	91.12	75.70	32.13	19.28		1985
8.PROJECTED STAND TABLE (Growing Stock)																											
YEAR 5	a. Trees/ha	14.02	14.96	12.32	6.63	5.07	1.43	0.00	0.00	0.00	53.00	1.43	0.00	0.00	0.00	1.41	1.51	1.02	0.43	4.37	4.37	57.37	29.82	5.80			
	b. G.vol m3/ha	5.61	7.93	13.67	13.60	16.48	7.08	0.00	0.00	0.00	57.29	7.08	0.00	0.00	0.00	6.97	10.75	9.63	5.36	32.76	32.76	90.05	83.59	39.84	23.90	4.12	1990
YEAR 10	a. Trees/ha	12.71	13.23	11.75	7.39	4.96	2.34	0.29	0.00	0.00	50.03	2.63	0.00	0.00	0.00	1.06	1.49	1.14	0.53	4.22	4.22	54.25	30.94	6.85			
	b. G.vol m3/ha	5.08	7.01	13.04	15.15	16.10	11.57	2.04	0.00	0.00	56.39	13.61	0.00	0.00	0.00	5.23	10.61	10.87	6.63	33.34	33.34	89.73	91.24	46.95	28.17	4.11	1995
YEAR 15	a. Trees/ha	11.59	11.78	10.94	7.74	5.07	3.00	0.70	0.04	0.00	47.52	3.74	0.00	0.00	0.00	0.79	1.40	1.25	0.64	4.09	4.09	51.61	31.58	7.33			
	b. G.vol m3/ha	4.80	6.24	12.15	15.87	16.47	14.80	4.97	0.41	0.00	55.52	20.17	0.00	0.00	0.00	3.92	10.00	11.91	8.06	33.88	33.88	89.41	98.54	54.06	32.44	4.14	2000
YEAR 20	a. Trees/ha	11.60	10.65	10.46	7.77	5.23	3.51	1.16	0.14	0.00	45.30	4.82	0.00	0.00	0.00	0.59	1.23	1.34	0.77	3.93	3.93	49.28	31.85	8.80			
	b. G.vol m3/ha	4.64	5.65	11.16	15.92	17.00	17.36	8.24	1.36	0.05	54.36	27.02	0.00	0.00	0.00	2.94	9.13	12.73	9.62	34.41	34.41	88.73	105.51	61.43	36.86	4.19	2005
YEAR 25	a. Trees/ha	11.38	9.82	9.20	7.56	5.34	3.94	1.63	0.30	0.02	43.30	5.89	0.00	0.00	0.00	0.45	1.14	1.40	0.90	3.89	3.89	47.19	31.89	9.78			
	b. G.vol m3/ha	4.55	5.21	10.21	15.50	17.36	19.43	11.60	2.88	0.23	52.83	34.13	0.00	0.00	0.00	2.20	8.15	13.28	11.29	34.93	34.93	87.76	112.18	69.11	41.47	4.24	2010
YEAR 30	a. Trees/ha	11.26	9.23	8.44	7.22	5.36	4.29	2.09	0.52	0.05	41.50	6.95	0.00	0.00	0.00	0.33	1.00	1.43	1.04	3.81	3.81	45.31	31.77	10.76			
	b. G.vol m3/ha	4.50	4.89	9.36	14.79	17.43	21.20	14.89	4.92	0.60	50.93	41.61	0.00	0.00	0.00	1.65	7.15	13.59	13.04	35.43	35.43	86.41	118.63	77.04	46.23	4.30	2015
YEAR 35	a. Trees/ha	11.19	8.81	7.79	6.80	5.29	4.56	2.53	0.73	0.10	39.83	7.97	0.00	0.00	0.00	0.25	0.87	1.44	1.19	3.74	3.74	43.63	31.59	11.71			
	b. G.vol m3/ha	4.48	4.67	8.65	13.94	17.19	22.53	18.02	7.41	1.21	48.92	49.13	0.00	0.00	0.00	1.24	6.20	13.67	14.82	35.93	35.93	84.85	124.85	85.10	51.06	4.36	2020
YEAR 40	a. Trees/ha	11.16	8.53	7.27	6.37	5.14	4.74	2.94	1.03	0.17	38.45	8.93	0.00	0.00	0.00	0.19	0.75	1.42	1.33	3.69	3.69	42.14	31.39	12.62			
	b. G.vol m3/ha	4.46	4.52	8.07	13.05	16.70	23.43	20.91	10.29	2.13	46.80	56.75	0.00	0.00	0.00	0.93	5.32	13.54	16.61	36.40	36.40	83.20	130.57	93.16	55.59	4.43	2025
YEAR 45	a. Trees/ha	11.14	8.33	6.86	5.96	4.93	4.84	3.30	1.41	0.27	37.21	9.82	0.00	0.00	0.00	0.14	0.64	1.39	1.47	3.64	3.64	40.85	31.20	13.46			
	b. G.vol m3/ha	4.45	4.42	7.61	12.21	16.03	23.92	23.43	13.45	3.37	44.71	64.22	0.00	0.00	0.00	0.70	4.52	13.26	18.39	36.87	36.87	81.58	136.93	101.09	60.65	4.51	2030
YEAR 50	a. Trees/ha	11.12	8.20	6.54	5.58	4.69	4.86	3.61	1.77	0.40	36.14	10.63	0.00	0.00	0.00	0.11	0.54	1.35	1.61	3.60	3.60	39.74	31.05	14.24			
	b. G.vol m3/ha	4.45	4.35	7.26	11.45	15.26	24.03	25.65	16.32	4.97	42.76	71.49	0.00	0.00	0.00	0.52	3.82	12.84	20.13	37.31	37.31	80.07	142.77	108.80	65.28	4.59	2035
YEAR 55	a. Trees/ha	11.12	8.11	6.30	5.26	4.45	4.82	3.86	2.13	0.55	35.24	11.36	0.00	0.00	0.00	0.08	0.45	1.29	1.75	3.57	3.57	38.81	30.95	14.93			
	b. G.vol m3/ha	4.45	4.30	6.99	10.79	14.45	23.82	27.47	20.29	6.93	40.99	78.50	0.00	0.00	0.00	0.39	3.21	12.32	21.32	37.74	37.74	78.72	148.43	116.24	69.74	4.67	2040
YEAR 60	a. Trees/ha	11.12	8.05	6.12	5.00	4.21	4.73	4.05	2.50	0.74	34.49	12.01	0.00	0.00	0.00	0.06	0.38	1.23	1.87	3.54	3.54	38.04	30.88	15.56			
	b. G.vol m3/ha	4.45	4.27	6.80	10.24	13.67	23.36	28.84	23.77	9.24	39.43	85.21	0.00	0.00	0.00	0.29	2.68	11.73	23.44	38.14	38.14	77.56	154.06	123.35	74.01	4.76	2045
YEAR 65	a. Trees/ha	11.11	8.01	5.99	4.78	3.99	4.60	4.19	2.85	0.95	33.88	12.59	0.00	0.00	0.00	0.04	0.31	1.17	2.00	3.52	3.52	37.40	30.87	16.11			
	b. G.vol m3/ha	4.45	4.25	6.65	9.80	12.95	22.71	29.81	27.17	11.90	38.09	91.60	0.00	0.00	0.00	0.22	2.23	11.09	24.98	38.52	38.52	76.61	159.51	130.11	78.07	4.85	2050
YEAR 70	a. Trees/ha	11.11	7.99	5.90	4.60	3.78	4.44	4.27	3.20	1.19	33.39	13.10	0.00	0.00	0.00	0.03	0.26	1.10	2.11	3.50	3.50	36.89	30.89	16.60			
	b. G.vol m3/ha	4.44	4.23	6.55	9.44	12.30	21.95	30.39	30.43	14.38	36.96	97.66	0.00	0.00	0.00	0.17	1.85	10.43	26.43	38.87	38.87	75.84	164.62	136.53	81.92	4.93	2055
YEAR 75	a. Trees/ha	11.11	7.97	5.83	4.47	3.61	4.28	4.30	3.52	1.45	32.99	13.55	0.00	0.00	0.00	0.03	0.21	1.03	2.22	3.49	3.49	36.48	30.95	17.04			
	b. G.vol m3/ha	4.44	4.22	6.47	9.16	11.74	21.14	30.64	33.49	18.13	36.03	103.40	0.00	0.00	0.00	0.12	1.52	9.76	27.80	39.21	39.21	75.24	169.97	142.60	85.56	5.02	2060
YEAR 80	a. Trees/ha	11.11	7.96	5.78	4.36	3.46	4.11	4.30	3.81	1.73	32.68	13.95	0.00	0.00	0.00	0.02	0.19	0.95	2.33	3.49	3.49	36.16	31.05	17.44			
	b. G.vol m3/ha	4.44	4.22	6.42	8.94	11.26	20.31	30.61	36.23	21.62	35.23	108.82	0.00	0.00	0.00	0.09	1.33	9.09	29.06	39.60	39.60	74.87	175.04	148.42	89.05	5.11	2065
9.MAI OVER 80 – YEAR PERIOD (m³/ha/annum)											1.18	1.36								0.09	0.09	-0.20	1.24	1.45			

10. STAND AT YEAR 60 (CALENDER YEAR : 2030)

- a) Adv.growth (10<60cm DBH)/ha : 37.21 trees   44.71 m³
- b) Adv.growth (>60cm DBH)/ha : 9.82 trees   64.22 m³
- c) Big trees (>30cm DBH)/ha : 3.64 trees   36.87 m³
- d) Big trees (>60cm DBH)/ha : 3.64 trees   36.87 m³
- e) Merchantable trees (>60cm DBH = Big trees + Advance growth)
  - i) Gross/ha : 13.46 trees   101.09 m³
  - ii) Net mб/ha (60% of gross)   60.65 m³   4.51 m³/tree
- f) Coupe/compt classification : CLASS 2 (60<80 m³/ha; Adequately stocked)

g) 10% Inventory – Malua FR
- i) 15.28 trees/ha
- ii) 83.27 m³/ha
- iii) 5.45 m³/tree

ASSUMPTIONS :

- a) 4% mean annual mortality in 10<20cm, 2% in 20–60cm 1% in 60–80cm classes and 0% in 80cm dbh
- b) Equal rate of growth for 10–60 dbh classes (growing stock) and constant declining rate from 60 cm.
- c) Recruitment of 5 trees into the 10<20 cmdbh class for each 5–year period.
- d) No outgrowth for dbh class of 90 cm and above.
- e) Tree volume based on Standing Tree Volume Table of Sabah Forest Department.
- f) Reduction factor from gross to net volume is : 40%

NAME _____

SECTOR _____

CARRIAGEWAY WIDTH _____

ROAD LENGTH _____

		CULVERT						BRIDGES					
DATE	LOCATION	3 LOGS CULVERT	BOX CULVERT	NUMBER OF LOGS	LENGTH	WIDTH	YEAR CONSTRUCTED	COVER WITH EARTH	TIMBER PLANKS EXPOSED	NUMBER OF LOGS	LENGTH	WIDTH	CTED

by _____

_____

Appendix 5 : Census on road characteristics

Appendix 6 : Proposed data to be captured on the pilot project of Luasong

1. Rattan plantation data

a.	identification	- compartment n^o - compartment area - sub-block n^o - sub-block area
b.	plantation	- species planted - cane type [small or big] - planting date - contractor - planting density (Dp) - planted area (Ap)
c.	1st census & 2nd census	- date of census - survival rate - net planted areas - shade class

d.   Maintenance

- planned date   ⎤   Row slashing
- actual date   ⎬   Circle weeding
- contractor   ⎦   (Shade adjustment)

e.   Harvesting

- planned date
- growth rate of species ((Rg)
- yield expected (=Rg. dp. Sp)

2. PISP results

a.   Plots in
       comm. plant

- plot n^o or sub-block n^o
- species
- survival rate
- length/plant.   mean and STD
- nb of sucker/plant. mean and STD
- length/sucker

b.   plantation trials

- n^o of plots
- location
- species or provenance
- growth rate