PREFACE

I finish my assignment as an expert on agricultural development for The Remote Sensing Engineering Project Phase II on 1 June 1994. This report describes a summary of my activities in Indonesia.

Since July 1991, I have been trying to get appropriate way for application of remote sensing and GIS for the scheme of Indonesian agricultural development planning. It is rather difficult for me to evaluate how far my trial could contribute on improvement of agriculture development in this country. However, I have a confidence that all of my counterparts in PUSDATA will succeed my trial and in the near future, PUSDATA will play an significant role in the field of agricultural development by using remote sensing and GIS.

Finally, I would like to express my gratitude and most sincere appreciation to PUSDATA which has provided assistance with smooth implementation of my works, and also to the relevant Indonesian and Japanese agencies who have cooperated with PUSDATA and the Remote Sensing Engineering Project II.

Jakarta, June 1991

Ken-ichiro KAMIMURA
JICA Expert
The Remote Sensing Engineering
Project Phase II
Center for Data Processing and Mapping
Ministry of Public Works

FINAL REPORT
on
AGRICULTURAL DEVELOPMENT

1 Introduction

This report summarizes the activities of long term expert on agricultural development of THE REMOTE SENSING ENGINEERING PROJECT PHASE II FOR THE DEVELOPMENT OF AGRICULTURAL INFRASTRUCTURE IN THE REPUBLIC OF INDONESIA (hereinafter referred as the R/S Project II), assigned from 25 July 1991 until 5 June 1994.

1-1 Purpose

The activities of each expert should be adjusted with the target of the R/S Project II. The R/S Project II involved the following objectives in order to achieve its target, namely, "Promotion of efficient application of remote sensing technology for the planning of development of agricultural infrastructure":

1) production of thematic maps and evaluation maps,
2) establishment of guideline,
3) establishment of database,
4) training.

Among these objectives, expert on agricultural development has mainly charge of 'establishment of guideline'. The purpose of his activities shall be defined as follows:

The purpose of the expert on agricultural development is to realize *the target of project by means of establishment of guideline that promotes application of remote sensing technology for the efficient planning of agricultural development.*

1-2 Scope of Works

In order to achieve the above purpose, the following activities are implemented:

1) To investigate the existing scheme of land evaluation for agricultural development so as that the guideline should be in accordance with actual planning of agricultural development,
2) To select the thematic maps and evaluation maps which are fit with scheme of agricultural development and to fix the specification of those maps,
3) To describe the specifications of thematic and evaluation maps in the guideline.

2 Activities

2-1 Process of activities

The activities of the author can be divided into four stages as below:

1st stage : August 1991 ~ December 1991
Identification of policy for establishment of the guideline.

2nd stage : January 1992 ~ July 1992
Investigation on the actual scheme of agricultural development planning and making of framework of the guideline.

3rd stage : August 1992 ~ October 1993

Selection and examination on material of the guideline such as thematic maps and evaluation maps.

4th stage : November 1993 ~ May 1994

Fixing of specifications of maps and description of the guideline.

2-2 Identification of policy for establishment of the guideline

On the occasion of the visit of the mission team on November 1991, the full discussion and detail designing on the specifications such as purpose, usage, making procedure and management of the guideline, including the map production and the database between Japanese expert team and Indonesian counterparts.

This discussion and designing are made not only on the activities of each field (mentioned in the section 1-1) but also on the role of each field in order to integrate the results of activities under the full consideration of target of the R/S Project II.

2-3 Investigation on the existing scheme of agricultural development planning

In order to gather information of project planning and scheme of land evaluation in the organizations related to agricultural development, 7 times of working group meetings were held as below:

No.	Date	Contents
1	25/NOV/1991	Irrigation and drainage planning
2	22/JAN/1992	General meeting
3	13/FEB/1992	Rural development planning
4	29/APR/1992	Farm land conservation planning

5	1/JUL/1992	Land evaluation in Ministry of Transmigration
6	15/JUL/1992	Land evaluation in KLH
7	28/JUL/1992	Land evaluation in Ministry of Agriculture

The results were compiled into the 1 chapter of the guideline.

2-4 Production of material of the guideline

Production of thematic maps and evaluation maps which are components of the guideline and examination of the specifications of these maps are carried out based on the framework of land evaluation scheme of PUSDATA.

Through the above activity, the following studies (as far as the author concerned) are made:

1) Development of land evaluation system for agricultural development (Activity of short term expert, Mr. Okajima),
2) Water resources management and soil conservation study on Wayrarem dam catchment area(Activity of short term expert, Dr. Miyama),
3) Hydrology and soil erosion study on Jratun Seluna irrigation project area,
4) Study on reforestation site selection on Upper Kampar river basin
5) Study on spatial estimation of water demand potential on Jratun Seluna irrigation project area (Activity of short term expert, Mr. Shiono).

2-5 Description of the guideline

The guideline (DRAFT) was compiled by description of specifications of maps produced through the above studies.

3 Recommendation

1) The guideline, as submitted with this report, is still a draft. The author hopes and requests that the guideline shall be authorized as one of a public guidelines of Ministry of Public Works with efforts of officials concerned.

2) The author recommends that the guideline shall be translated into *Bahasa Indonesia* by hands of Indonesian counterparts in order to help it easy extension to whole Indonesia.

3) The description of the guideline is based on the present technical level of PUSDATA and situation of agricultural development. In case that some other maps can be created by new technical development or case that the specifications of maps should be changed due to the user's requests, the guideline is expected to be revised. the author recommends that PUSDATA shall establish some countermeasures such as administrative rules for revising.

4) The guideline put so much stress on the explanations for the user side about specifications of thematic and evaluation maps that the detail description of procedures on making maps are not written. In order to support engineers for remote sensing and GIS in provincial offices, the author recommends that 'production manual' shall be prepared by hands of all Indonesian counterparts.

4 Conclusion

There are many different opinions for the R/S Project. The author, by himself, has various evaluations on this project from diverse points of view.

Against the opposite opinion for success of this project, the author replies "This project got fruitful results and it can be said that it is successful. Numbers of requests for analyzing remote sensing and GIS from diverse domestic and international organizations proves its great success." On the other hand, against the opinions that applaud its success, he prepares a negative answer: "It is difficult to judge the project to be successful. Even though the name of the project is titled as 'for agricultural development', there is no evidence for improvement of situation of agricultural development.

It should be regarded that the evaluation of the project from short term point of view may not bring desirable consequences. The evaluation whether the project terminated with a great success or not will be determined by the future efforts by all of the personnel concerned with this project.

APPENDIX

In this appendix, the reseach papers of studies made by the autor and his counterparts.

These papers will represent the author's activity on technical transfer.

This appendix includs 5 papers as below:

SECOND SEMINAR ON
THE ROLE OF REMOTE SENSING TECHNOLOGY & G.I.S.
(GEOGRAPHIC INFORMATION SYSTEM)
FOR INFRASTRUCTURAL DEVELOPMENT PLANNING

MONITORING OF FOREST FIRE SITE BY USING LANDSAT TM DATA AND MSS DATA

Kenichiro KAMIMURA
Yumadiati
Kazumi SUWABE

Jakarta, February 26, 1992

PUSAT PENGOLAHAN DATA DAN PEMETAAN (PUSDATA)
In Cooperation With
The JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

Abstract

Forest fire was one of the most serious topics of environmental problem in the world, in 1991. The purpose of this study is to examine the efficiency and propose the necessity of Satellite Remote Sensing data for the monitoring of global environment phenomena such as these forest fires.

Analysing surface temperature by using TM 6 band data and comparing with TM image and MSS image of a study area includes one of the largest forest fires in East Kalimantan, the former was taken after the fire in October 1991 and the latter was taken before it in February 1988, it is concluded as the following:

(1) In the study area, about 33,000ha land burned out was detected from LANDSAT TM data.

(2) Most part of fire site was covered with easy-burning vegetation such as alang-alang.

(3) Landsat MSS data which was taken in 1988 has approximately similar landcover pattern with the forest fire area, and it indicates the possibility of the former forest fire on the same site.

(4) Surface temperature of alang-alang area is rather higher than that of forest area, it can be anticipated that alang-alang area has easy-burning character against fire. And also it indicates that natural forest area has little lower temperature than secondary forest and it has hard-burning character.

I. Introduction

Arising of public opinion for environmental problem is the global trend as we can see in a lot of events such as the Summit for environmental problem in Brazil.The fire of oil fields in the Gulf War and the forest fires in Indonesia and the Malaysia peninsula are the two topical events in 1991 reported frequently by the press as the symbol of these environmental matters.

The field such as the simultaneous and repeatable observation of wide area for global environment monitoring is the very field of Remote Sensing technology. Actually, the Landsat scene of the smoke from oil wells delivered to all over the world through the various mass media promptly is still in our newer memory.

On the other hand, in the matter of the forest fire, when the first Remote Sensing imagery appeared in the paper was November 1991 when the fires had almost died down, even if almost every day forest fire news were reported for several months until then.

The main reason of this delay was considered that we could not identify which Landsat scene included the sites of the forest fires since they were scattered over too much wide area.

In addition, it was also one of the reasons of hard identification of forest fire sites that NOAA data, which covers much wider area than Landsat data and is taken everyday in compensation for low resolution, could not be received in both of Indonesia and Thailand at that time; they are advanced nations in the field of Remote Sensing technology in the Association of South East Asian Nations.

We got the opportunity of analyzing Landsat TM data of East Kalimantan which includes the site of quite large-scale forest

fire under the cooperation of Remote Sensing Technology Center in JAPAN. In this study, at first we classified the land cover and calculated total area of burned site by using TM data.
In addition, Comparing with this TM data and MSS data before the fire which PUSDATA own, we discussed the land cover situation of the forest fire site before and after the fire and the factors of occurrence of the forest fire.

The purpose of this paper is to emphasize the indispensability of Remote Sensing technology for various kind of land monitoring through this study; we expect that this paper shall take some part in the establishment of land monitoring system which is concentrated in acquisition of Remote Sensing data and its application in the Republic of Indonesia.

II. Material

1.Study Area

Analysed area is shown in figure 1. This area is 57km * 57km wide and located 100km apart from to the north-west of SAMARINDA in East Kalimantan. Lower part of study area is covered with vast swampy forest, and upper part is mainly covered with secondary forest. Photographs which were taken from helicopter are shown in photo 1, 2 and 3 near the study area. Based on these photographs it is possible to some extend to estimate the situation of vegetation in our study area.

2.Data

In this study, we used LANDSAT TM data on October 19th 1991 and LANDSAT MSS data on February in 1988. Specifications of used data are shown in table 1.

III. Methodology

1. Processing procedure

Through this study, we investigated and discussed about identification of burned site, characteristics of the land cover and an extent process of the forest fire by means of the following analysis;

(1) Interpretation of color composite imageries composed of visible bands and near infrared band which are taken before and after the fire.

(2) Land cover classification.

(3) Temperature analysis of band 6 in TM data.

The flow of the above analysis is shown in figure 2. Hardware and software system used in this analysis is shown in figure 3.

2. Overlay and Interpretation

In order to compare the two different type and different time data, overlay process was carried out. Although, in general, geometric correction should be processed by using map coordinate, in case of this study the reliable topographic map could not be prepared, only the overlay process which convert the coordinate of MSS data into that of bulk processed TM data was carried out. Overlaying was processed by means of the affine formula whose coefficients were calculated with 24 ground control points which were selected from almost all study area.

MSS imagery taken before the fire was covered with so much clouds that we did not carry out the land cover comparison with TM imagery taken after the fire by digital analysis but by image interpretation. Two kinds of TM color composite image and one MSS false color image are used in the interpretation; whose band combinations are shown in table 2.

3.Land Classification

In order to measure the burned sites of the forest fire, land classification of TM data was processed by clustering. Except short wave band which is suffered easily the influence of the atomosphare, especially smoke of the fire and band 6 whose resolution is different from other 6 bands, we classified land cover into 27 classes by using band 3, band 4 and band 5 of TM data. By means of interpretation of above color composite imageries, classified land cover types were unified into the following 9 categories;

1)burned site, 2)natural forest, 3)secondary forest, 4)alang-alang, 5)water area, 6)cloud, 7)shadow, 8)smoke I (highdensity), 9)smoke II (low density).

4.Temperature imagery analysis

Band 6 of TM data is a sensor which correspond to thermal infrared wave and has high correlation with the surface temperature.

At the present, although there are many kinds of estimation methods for surface temperature by using TM band 6, in this study, we adopted the Horihuchi equation to estimate the surface temperature as the following.

T=206.127+1.0545*DN-0.00371*DN**2+6.606*(10**-6)*DN**3-273.1

T : Surface temperature , DN : CCT count

IV. Result & Discussion

1. Land classification and area of the forest fire site

The result of classification is summarized in Table-3.

The area burned out in this fire totaled 33,110ha.

The largest block of the forest fire amounts to 17,403ha.

2. Image interpretation of the situation of land cover before and after the fire

After the interpretation of MSS imagery before the fire, we found that this imagery had quite similar pattern of a specific land cover with the site of this forest fire. The area is considered to be covered with alang-alang, since it shows lower reflectance intensity than that of surrounding bush or forest area in the near infrared region whose reflectance has strong correlation with the activity of vegetation.

MSS imagery before the fire and TM imagery after the fire are shown in Photo. 4 and Photo 5 respectively.

The yellow doted line on both photos shows the boundary of the area which were interpreted as alang-alang on the MSS imagery before the fire. This alang-alang area corresponds well with the site of the forest fire as shown by the yellow doted line on Photo 5.

Since this area covered very wide area and it didn't have any similarity with catchment, it is hard to consider that the superiority of alang-alang in this area derives from natural and original condition such as a surface water condition, and it neither comes from artificial act because in this area we cannot recognize a special pattern of logging road. In addition, the fact that a quite strong intensity vegetation remains along rivers in this area indicates the possibility of a former fire experience on the same area.

On the other hand, the fire forest site in the east part of study area was interpreted as inundated area from the MSS imagery. Although we cannot say the surface condition of this area in dry season definitely from this MSS data taken in rainy season, it is assumed that this area had been covered with only low intensity vegetation because of surface water condition.

After these interpretation and consideration descried above, we found that in aspect of the loss of forest resources, the damage of this fire did not so terrible as the figure "33,000ha". However, we must memorize the lost natural and secondary forest around these alang-alang area was never negligible amount, although we could not confirm the area quantitatively because of much cloud covered with MSS imagery.

In the matter of the cause of the forest fire, although we cannot say so definitely, the TM imagery indicates the possibility of an artificial cause:
The flames from the comparatively small areas scattered along the river which are seem to be derived from shift cultivation, are considered to leap to the largest fire block and burn out alang-alang dried up by a record-breaking drought.

3.Temperature character

Although the temperature value estimated by Horiguchi's Equation seems to have a general tendency that it is calculated 5 - 10° lower value than true temperature, it is considered the relative temperature difference of the different land cover type is well-expressed.

After the interpretation of temperature map, we led results as the followings:

(1) It is recognized that the distribution of temperature showed the direction of the fire spread was not only from inside to outside;the burning area still remained and kept to burn inside of the burned area. This correspond to the results of interpretation of TM color composite imagery that there were some lines of smoke from center part of forest fire site.

(2) The forest area shows 3°-5° lower temperature than the alang-alang area, and the natural forest area is approximately 1 lower than the secondary forest area. It is assumed that these differences of temperature should be a significant factor of the process of the fire spread.

According to the Japanese survey mission of forest fire, generally, fire in natural forest disappear in natural because of its high humidity; on the other hand, fire in secondary forest which is not well-maintained has a tendency to spread further and further. In this study, we could confirm the same tendency from the aspect of temperature.

V. Conclusion

To summarize our interpretation of the results, we can conclude as the followings:

(1) In the study area, about 33,000ha land burned out was detected from Landsat TM data.

(2) Most part of fire site was covered with easy burning

vegetation such as alang-alang.

(3) Landsat MSS data which was taken in 1988 has approximately similar landcover pattern with the forest fire area, and it indicates the possibility of the former forest fire on the same site.

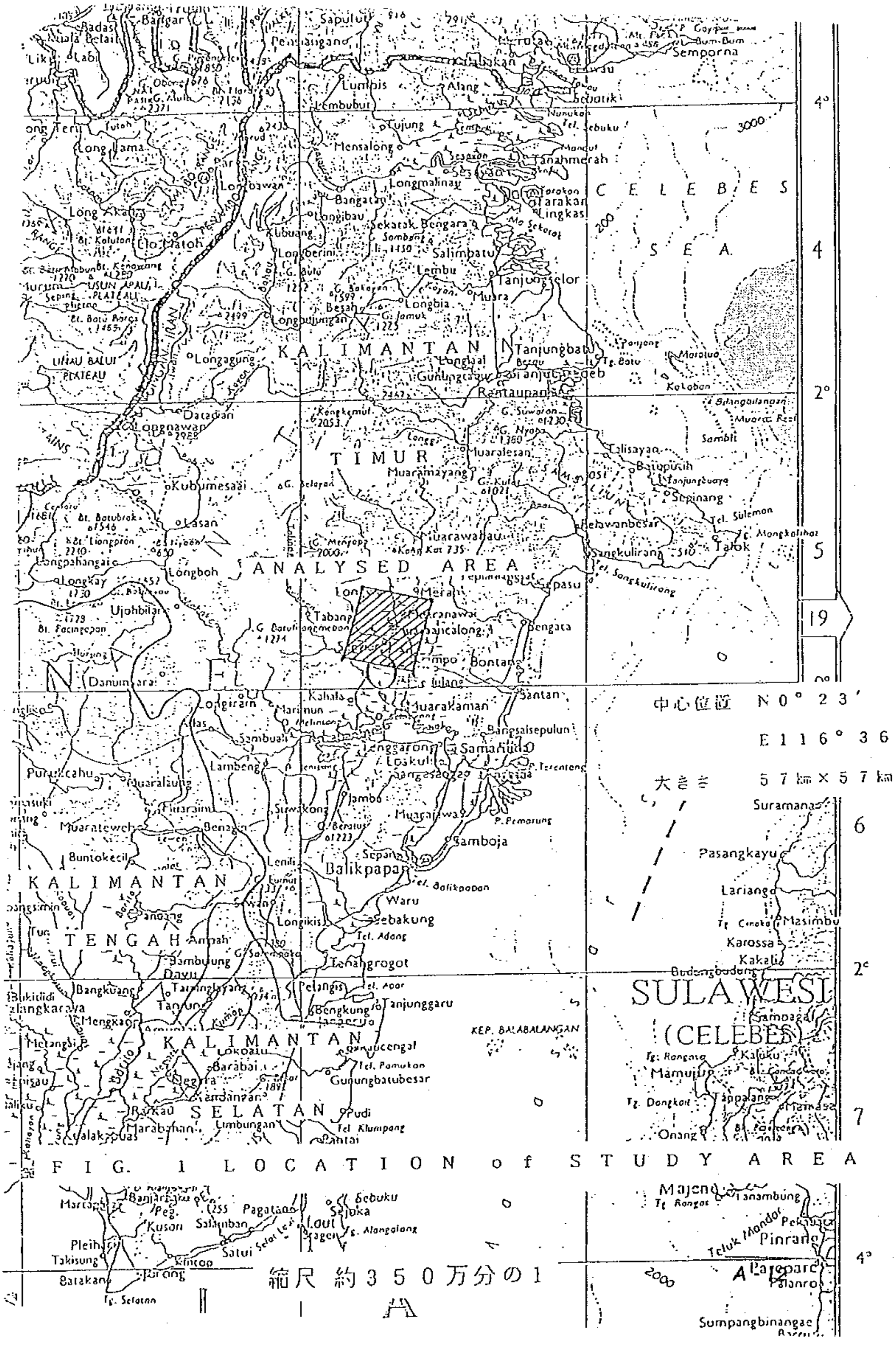
(4) Surface temperature of alang-alang area is rather higher than that of forest area, it can be anticipated that alang-alang area has easy-burning character against fire. And also it indicates that natural forest area has little lower temperature than secondary forest and it has hard-burning character.

Although the study area we analyzed was only one of the forest fire areas which were distributed all over the Indonesia and we could not make those entirety clear, overlaying and comparing the two different type and time data, we could show the possibility to assess the situation and the essence of the forest fire damage quite quantitatively. Considering our original purpose is to emphasize the necessity of Remote Sensing technology for the land monitoring and its efficiency for the plan-making of land conservation, we hope that the results of this report will lead to some useful suggestions for the maintenance of vast land and rich nature of Indonesia.

Acknowledgment

We are indebted to the Remote Sensing Technology Center in Japan for provision of image data, to the members of JICA Tropical Forest Research Project for provision of various information on study area, to members Directorate General of Land

Rehabilitation and Soil Conservation, Ministry of Forestry and JICA expert of Ministry of Forest for provision of information on the forest fire.



F I G. 1 LOCATION of STUDY AREA

中心位置　N 0° 23′
E 1 1 6° 3 6′
大きさ　5 7 km × 5 7 km

縮尺 約３５０万分の１

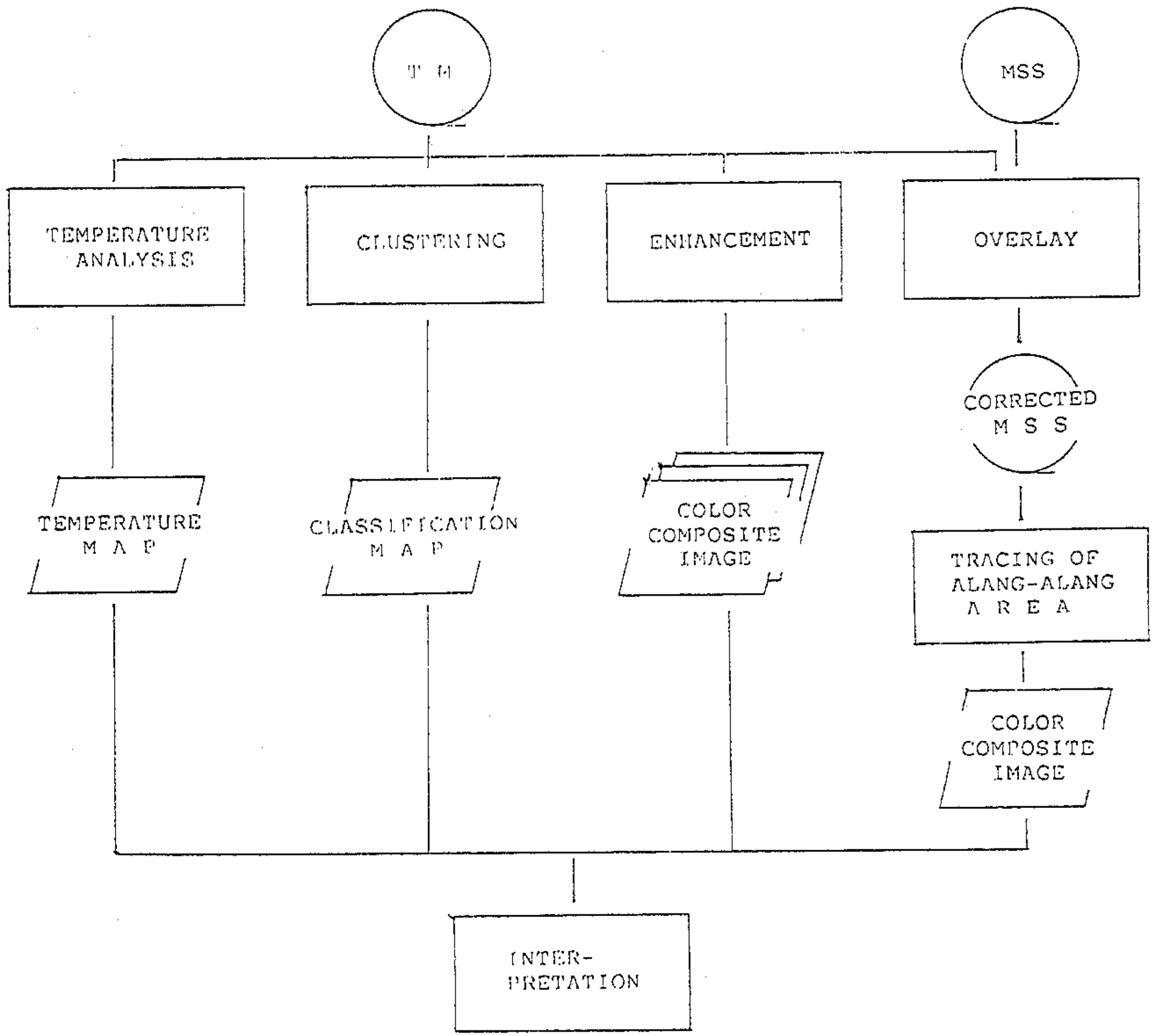


FIG. 2 FLOW OF ANALYSIS

FIGURE 3 HARDWARE and SOFTWARE ENVIRONMENT

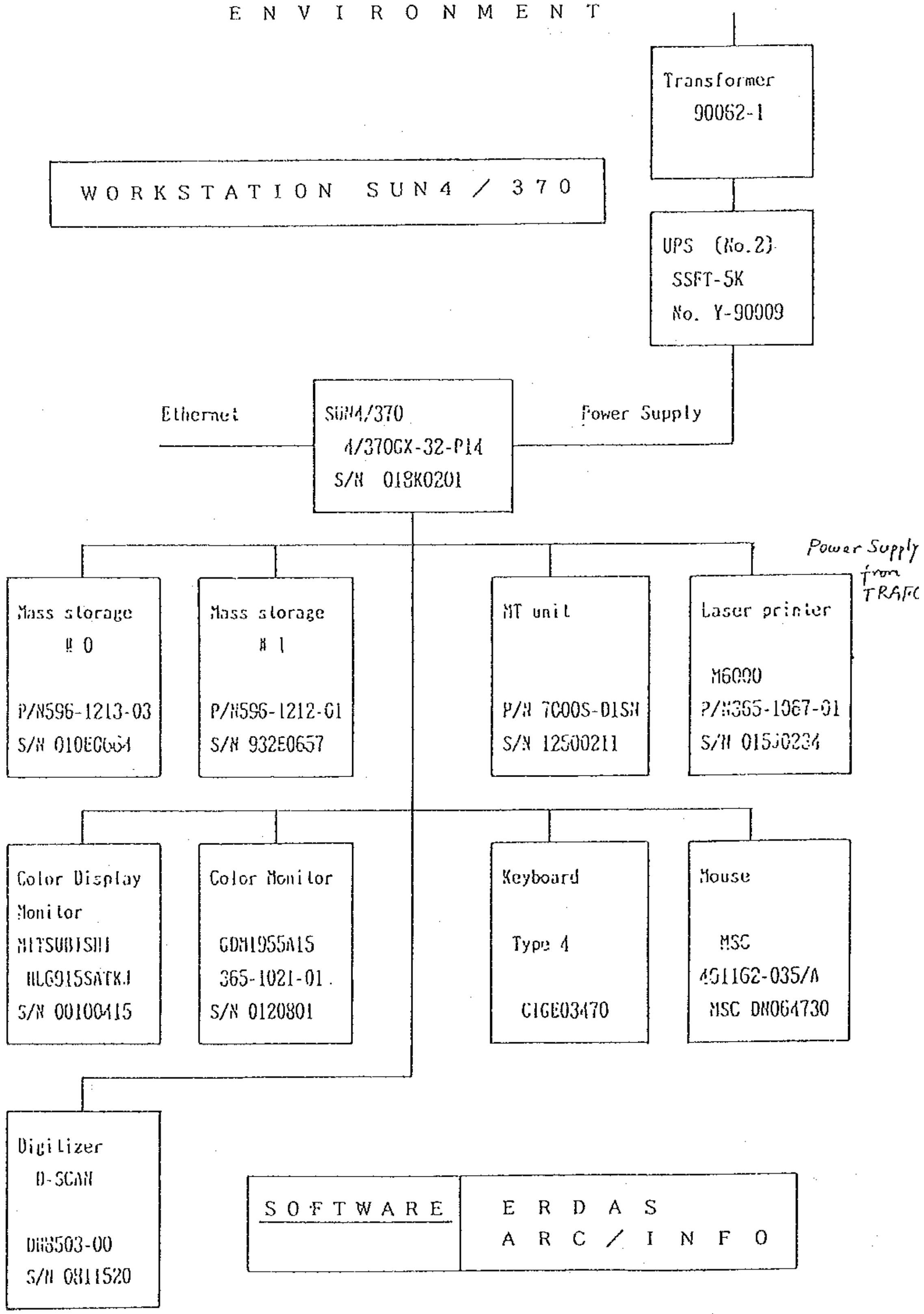


TABLE 1 Specification of Satellite Data

Satellite	LANDSAT 5 TM	LANDSAT 5 MSS
Date	19 Oct. 1991	23.Feb. 1988
Path-Row	116-060	116-060
Recieved Station	Thailand Remote Sensing Center	LAPAN

TABLE 2 Color Composite Imagery

Color	LANDSAT 5 TM			LANDSAT 5 MSS
Red	Band 4	Band 5	Band 5	Band 7
Green	Band 3	Band 4	Band 4	Band 5
Blue	Band 1	Band 3	Band 1	Band 4

<TABLE 3>

RESULT OF CLUSTERING ANALYSIS

CATEGOLY	NO.OF PIXEL	AREA (ha)
BURNED SITE	367,889.	33,110.
NATURAL FOREST	1,020,072.	91,806.
SECONDARY FOREST	859,692.	77,372.
ALANG-ALANG	531,338.	47,820.
WATER AREA	16,321.	1,468.
CLOUD	102,905.	9,261.
SHADOW	95,680.	8,971.
FIRE SMOKE I	172,673.	15,540.
II	443,430.	39,908.
TOTAL	3,610,000.	324,900.

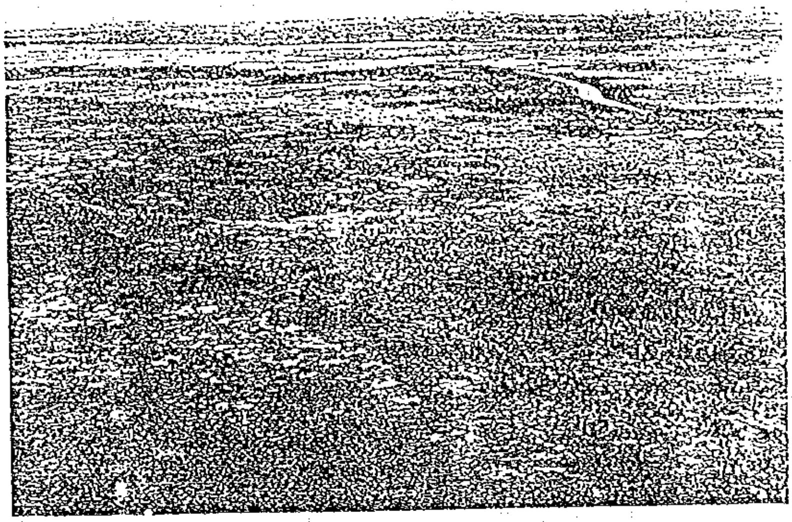


Photo. 1

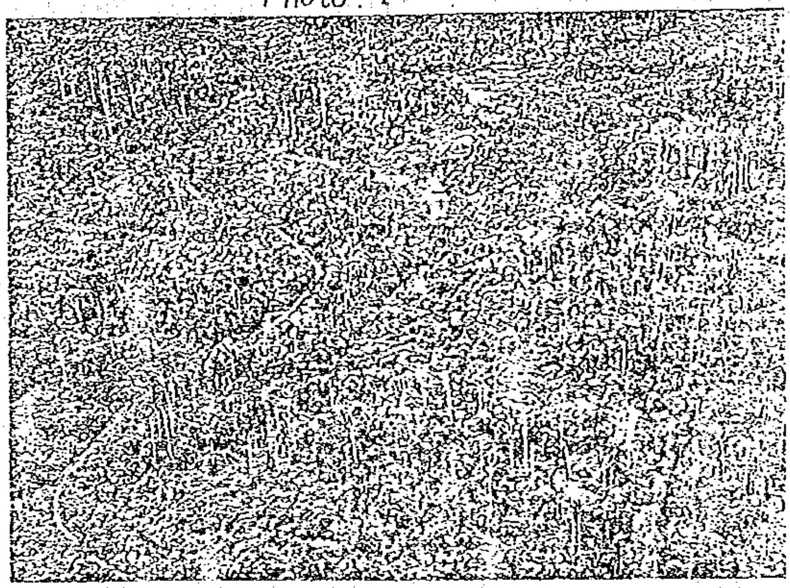
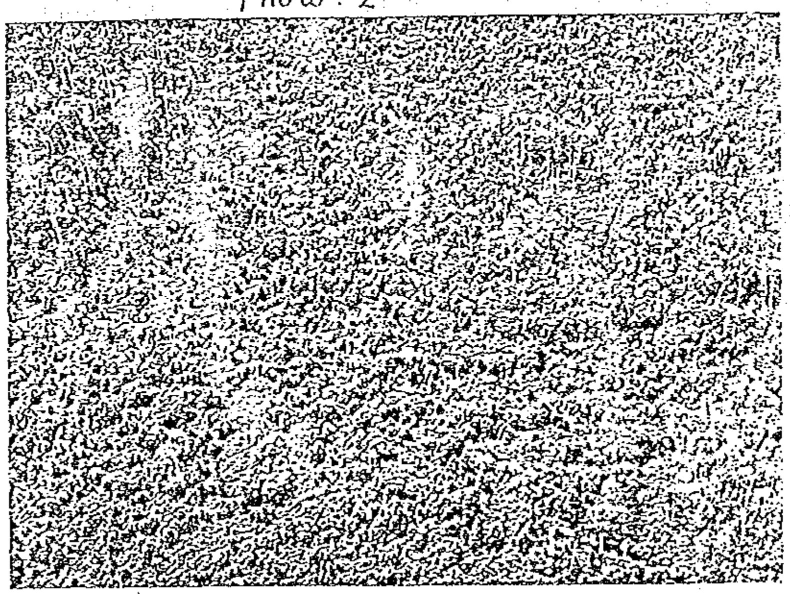


Photo. 2



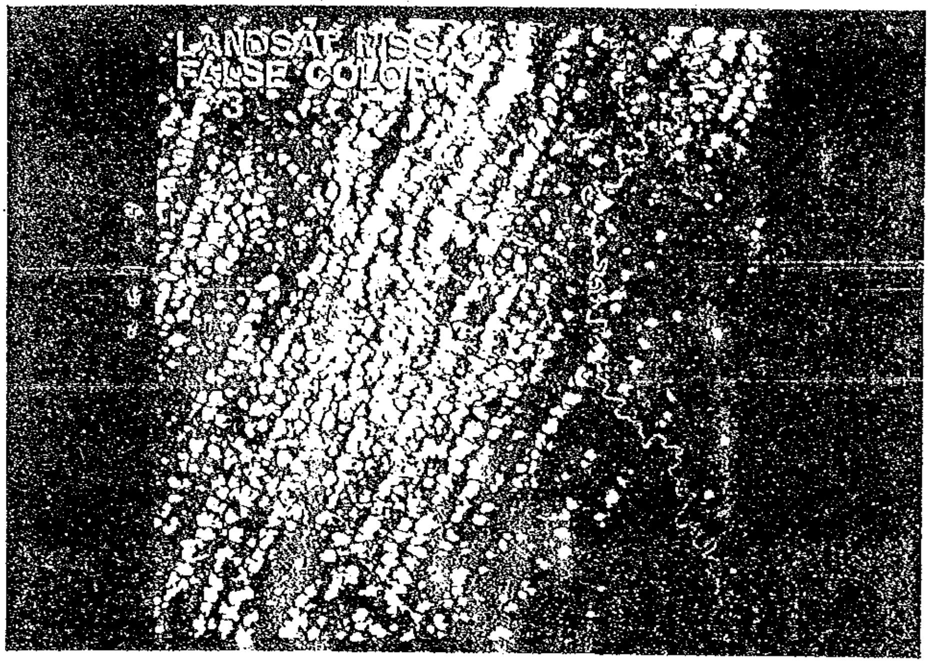


PHOTO - 4

PHOTE - 5

ADVANCES IN AGRICULTURAL ENGINEERING AND TECHNOLOGY

VOLUME I

Proceedings of
JICA-IPB 5th Joint Seminar as an
International Conference
On Engineering Applications for the Development
of Agriculture in the Asia and Pacific Region

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JAPAN INTERNATIONAL
COOPERATION AGENCY

RISTEK

Study on Landcover Changing Caused by "Forest Fire" by Using Satellite Data

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Center for Data Processing and Mapping
Ministry of Public Works

** Experts of Japan International Cooperation Agency

ABSTRACT

"Forest Fire" was one of the most serious topics of environmental problem in the world, in 1991. In this paper, we will discuss the relationship between landcover and forest fire by the time series analysis of satellite remote sensing data.

Comparing with 3 Landsat imageries which were taken before and after the fire in East Kalimantan and analyzing Landsat TM 6 band data,which indicates the temperature of the objects, we obtained the result as follows:

(1) *In our study area, about 33,000ha of land burned out was detected as burned area from LANDSAT TM data.*
(2) *Although the greater part of the fire site was covered with easy-burning vegetation such as alang-alang, at least 800ha of forest resources were lost around alang-alang area.*
(3) *Landsat MSS imageries which were taken in 1988 and 1984 have approximately similar landcover pattern with the forest fire site.*
(4) *Surface temperature of alang-alang area is approximately 3°C to 5°C higher than that of forest area.*

1. INTRODUCTION

Arising of public opinion for environmental problem is the global trend, such as the Summit for environmental problem in Brazil. In particular, the "Forest Fire" in Indonesia and the Malaysia peninsula was one of the most serious problems in 1991 and it was reported frequently by the press as the symbol of these environmental matters.

According to the report by the Ministry of Forestry, up to october in 1991, approximately 48,000ha of forest area, which includes bush and alang-alang area, has been lost by fire in all over the Indonesia. However, this value of fire area is mainly aggregated through field survey; its accuracy may depend on the cost of survey. In addition, in such field survey, The flowchart of the above analysis is shown in figure 2.

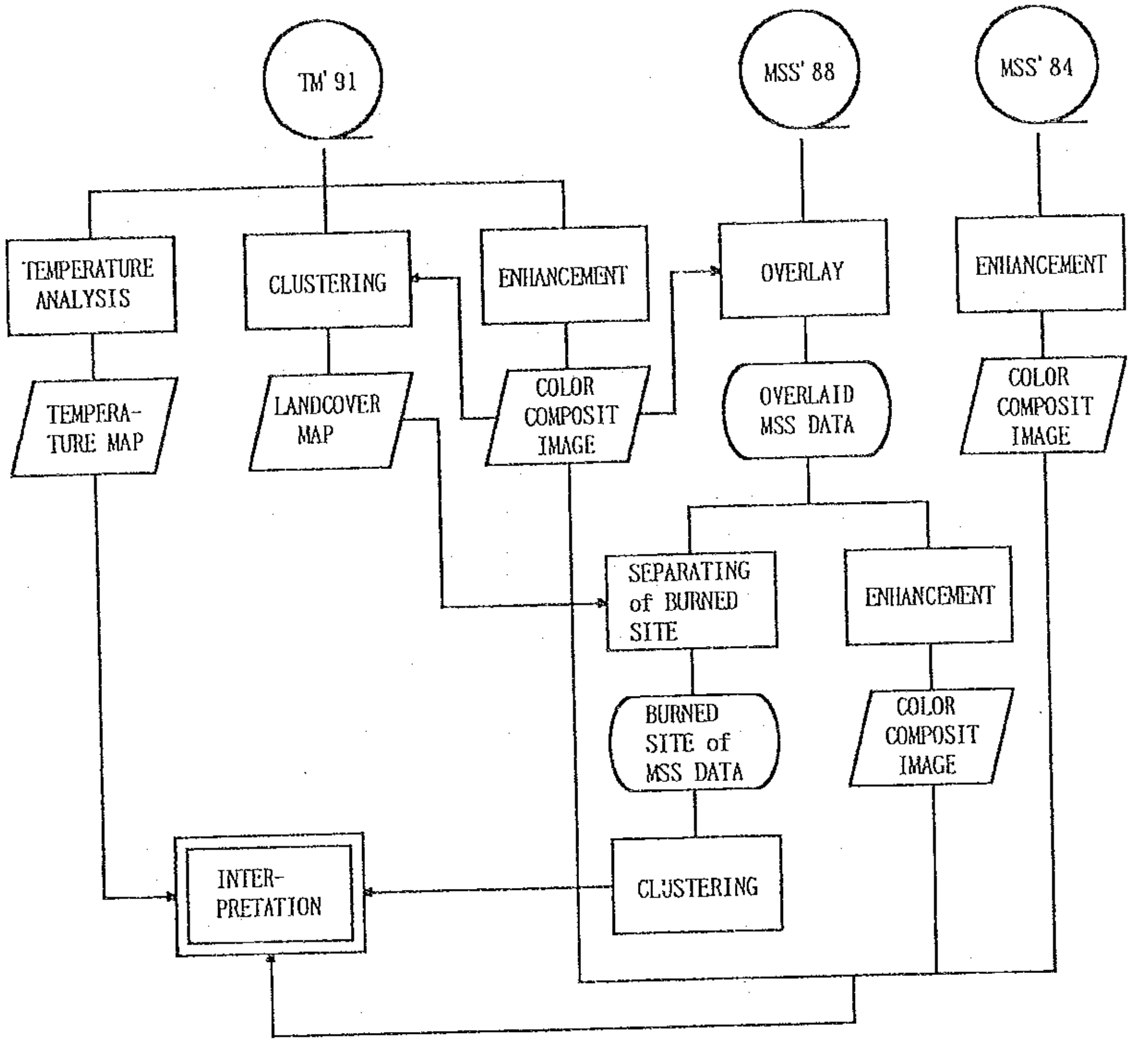

Fig-2 Flowchart of Analysis

3.2. Overlay and Interpretation

In order to calculate the landcover changing by the forest fire quantitatively, overlay process was carried out. In general, however geometric correction should be processed by using map coordinate, in this study we could not find a reliable topographic map in a respect of accuracy; only the overlay process which convert the coordinate of MSS data into that of bulk processed TM data was carried out. Overlaying was processed by means of the affine formula, whose coefficients were calculated with 24 ground control points distributed throughout the study area.

MSS imagery in 1984 was covered with so much clouds that we could not carry out the land cover comparison with other 2 imageries by digital analysis but by image

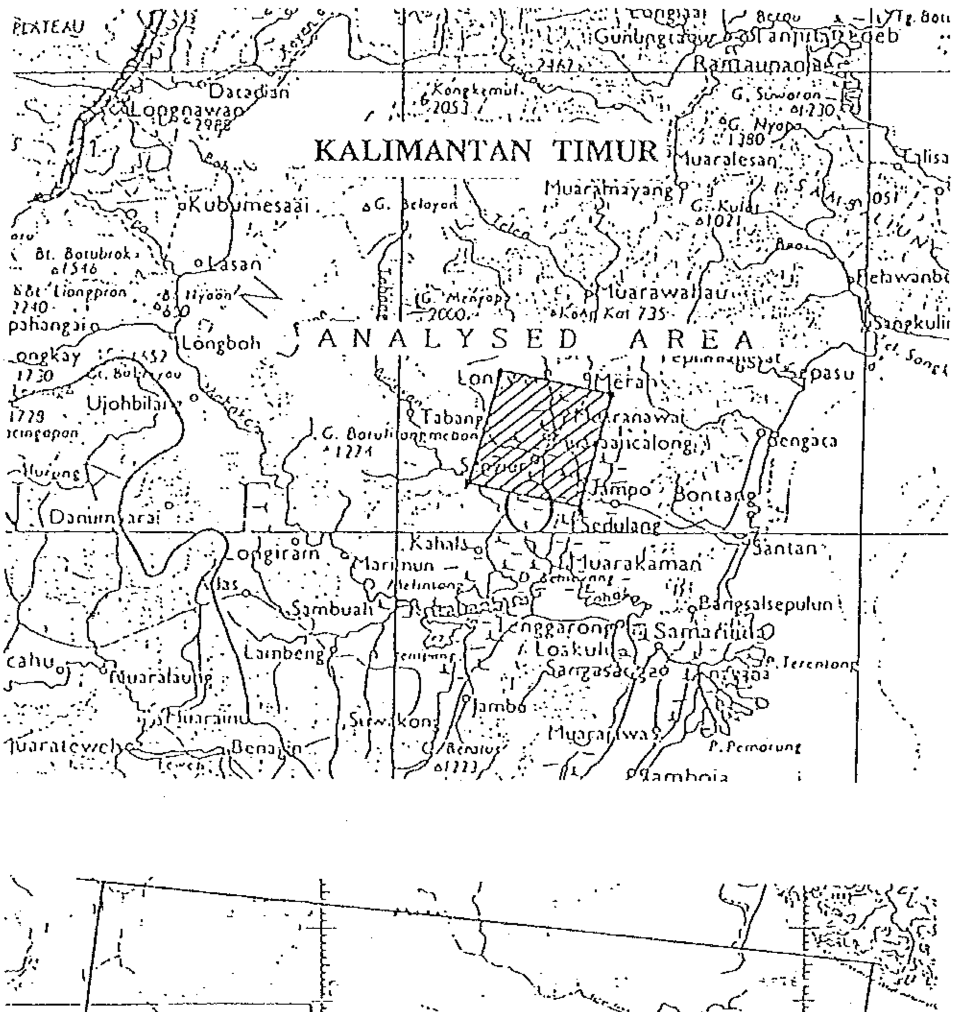

Fig-1 Location of Study Area

it is hard to get detail information about the former landcover of the burned area.

A field such as the simultaneous and repeatable observation of wide area for global environment monitoring is the very field of Remote Sensing technology. We got the opportunity of analyzing Landsat TM data which includes the site of quite large-scale forest fire in East Kalimantan with the cooperation of Remote Sensing Technology Center in JAPAN. In this study, at first we classified the land cover and calculated total area of burned site by using TM data. In addition, Comparing with this TM data and two sets of MSS data before the fire, we discussed the land cover situation of the forest fire site before and after the fire and the factors of occurrence of the forest fire.

The purpose of this paper is to emphasize the indispensability of Remote Sensing technology for various kind of land monitoring through this study; we expect that this paper shall take some part in the establishment of land monitoring system which is concentrated in acquisition of Remote Sensing data and its application in the Republic of Indonesia.

2. MATERIAL

2.1. Study Area

Analyzed area is shown in figure 1. This area is 57km * 57km wide and located 100km apart from to the north-west SAMARINDA in East Kalimantan. Lower part of study area is covered with vast swampy forest, and upper part is mainly covered with secondary forest.

2.2. Input Data

In this study, we used LANDSAT TM data, October 19th 1991 and two sets of LANDSAT MSS data, February in 1988 and August in 1984.

3. METHODOLOGY

3.1. Processing procedure

In this study, we analyzed the former landcover of the burned site and discussed about the relationship between the landcover and the forest fire by means of 3 approaches as the following:

(1) Interpretation of color composite imageries composed of visible bands and near infrared band which are taken before and after the fire.

(2) Land cover classification.

(3) Temperature analysis of band 6 of TM data.

interpretation.

3.3. Land Classification

Overlaid imageries were classified respectively by clustering method. In regard to TM data classification, short wave bands, 1 and 2, which had a close relation with the conditions of the atmosphere and band 6 whose resolution was different from other 6 sensors, were excluded. We classified land cover in 1991 into 27 classes and then integrated them into 9 categories as the following by means of interpretation of color composite imageries.

1)burned site	2)natural forest	3)secondary forest
4)alang-alang	5)water area	6)cloud
7)shadow	8)smoke I (high density)	9)smoke II (low density)

After the identification of the burned site by above land classification of TM data, we separated only the burned site data from MSS imagery in 1988 and classified it into 5 categories as follows:

1)natural forest	2)secondary forest	3)alang-alang
4)cloud	5)shadow	

3.4. Temperature imagery analysis

Band 6 of TM data is a sensor which correspond to thermal infrared wave and has high correlation with the surface temperature of the objects.

At the present, although there are many kinds of estimation methods for surface temperature by using TM band 6, in this study, we adopted the Horiguchi equation to estimate the surface temperature as the following.

$$T = 206.127 + 1.0545 \times x - 0.00371 \times x^2 + 6.606 \times 10^{-6} \times x^3 - 273.1$$

T : Surface Temperature , x : CCT count of TM 6 band

4. RESULT & DISCUSSION

4.1. Land cover classification and landcover changing

The result of classification is summarized in Table-1 and Table-2.

Table-1 Result of Landcover Classification of TM Data

CATEGORY	No. of PIXEL	AREA (ha)
BURNED SITE	367,889	33,110
NATURAL FOREST	1,020,072	91,806
SECONDARY FOREST	859,692	77,372
ALANG-ALANG	531,338	47,820
WATER AREA	16,321	1,468
CLOUD	102,905	9,261
SHADOW	95,680	8,971
FIRE SMOKE I	172,673	15,540
FIRE SMOKE II	443,430	39,908
TOTAL	3,610,000	324,900

Table-2 Result of Landcover Classification of MSS Data

CATEGORY	No. of PIXEL	AREA (ha)
NATURAL FOREST	2,459	221
SECONDARY FOREST	6,452	580
ALANG-ALANG	77,640	6,987
CLOUD	77,141	6,944
SHADOW	29,675	2,671
TOTAL	193,367	17,403

The area burned out in this fire totaled 33,110ha. The largest block of the forest fire amounts to 17,403ha. Around this largest block of fire, we could confirm at least 801ha of forest resource loss by terms of comparison of the results of land classification.

4.2. Image interpretation of the situation of land cover before and after the fire

MSS imagery, 1988, before the fire and TM imagery, 1991, after the fire are shown in Photo. 1 and Photo 2 respectively.

After the interpretation of two MSS imageries before the fire, we found that these imageries had quite similar pattern of a specific land cover with the forest fire sites in TM imagery. The area is considered to be covered with alang-alang, because it shows lower reflectance intensity than that of surrounding bush or forest area in the near infrared region whose reflectance has strong correlation with the activity of vegetation.

These alang-alang area covered very wide region and its boundary had little similarity with catchment boundary. With regard to this point, it is hard to consider that the superiority of alang-alang in this area derives from natural and original condition such as a surface water condition. In addition, comparing 3 different time imageries, the alang-alang area seems to be extended year and year. Although we cannot definitely conclude, these points indicate the possibility of other fire experiences on the alang-alang area.

After these interpretation and consideration descried above, we found that in aspect of the loss of forest resources, the damage of this fire did not so terrible as the figure "33,000ha". However, we must memorize the loss of natural and secondary forest around these alang-alang area was never negligible amount.

In the matter of the cause of the forest fire, although we cannot say so definitely, the TM imagery indicates the possibility of an artificial cause: The flames from the comparatively small areas scattered along the river which are seem to be derived from shift cultivation, are considered to leap to the largest fire block and burn out alang-alang dried up by a record-breaking drought.

4.3. Temperature character

Although the temperature value estimated by Horiguti's Equation seems to have a general tendency that it is calculated 5° C ~ 10° C lower value than true temperature, it is considered the relative temperature difference of the different land cover type is well-expressed.

After the interpretation of temperature map, we led results as the followings:

(1) It is recognized that the distribution of temperature showed the direction of the fire spread was not only from inside to outside;the burning area still remained and kept to burn inside of the burned area. This correspond to the results of interpretation of TM color composite imagery that there were some lines of smoke from center part of forest fire site.

(2) The forest area shows 3° C ~ 5° C lower temperature than the alang-alang area, and the natural forest area is approximately 1° C lower than the secondary forest area. It is assumed that these differences of temperature should be a significant factor of the process of the fire spread.

According to the Japanese survey mission of forest fire, generally, fire in natural forest disappear in natural because of its high humidity; on the other hand, fire in secondary forest which is not well-maintained has a tendency to spread further and further. In this study, we could confirm the same tendency from the aspect of temperature.

5. CONCLUSION

To summarize our study, we can conclude as the followings:

(1) In the study area, about 33,000ha land burned out was detected from Landsat TM data.

(2) Although the greater part of fire site was covered with easy-burning vegetation such as alang-alang, at least 800ha of forest resources were lost around alang-alang area.

(3) Landsat MSS imageries which were taken in 1988 and 1984 have approximately similar landcover pattern with the forest fire area, and it indicates the possibility of the former fores. fire on the same site.

(4) Surface temperature of alang-alang area is rather higher than that of forest area, it can be anticipated that alang-alang area has easy-burning character against fire. And also it indicates that natural forest area has little lower temperature than secondary forest and it has hard-burning character.

The study area we analyzed was only one of the forest fire areas, which were distributed throughout the Indonesia. Although we could show the possibility to assess the forest resources damage by the fire quite quantitatively, th: aggregation of the forest resources damage from world-wide view lies as a future subject.

ACKNOWLEDGEMENT

We are indebted to the Remote Sensing Technology Center in Japan for provision of image data, to the members of JICA Tropical Forest Research Project for provision of land cover information of study area, to members of Ministry of Forestry, Directorate General of nature conservation and JICA expert of Ministry of Forest for provision of information on the forest fire.

REFERENCE

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Application of Geographic Information System to Land Evaluation for Agricultural Infrastructure Development

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ABSTRACT

This paper describes an efficient approach on suitable area selection for agricultural infrastructure development by using Geographical Information System (G.I.S.) that integrates various kinds of land resources information, which are formed on diverse manners of representation. This approach consists of the following 4 steps.

1) *Digitizing existing land resources maps, such as Land System Map, Land Unit Map and topographic map.*
2) *Decomposing digitized land resources maps into component thematic maps.*
3) *Selecting suitable thematic maps for the intended purpose and rebuilding them as Land Capability Map by application of existing criteria.*
4) *Forming Land Suitability Map by screening Land Capability Map with weighted land cover map made from remote sensing data.*

The developed G.I.S. model indicates two remarkable advantages as the following:

1) *An efficient management of land resources information, such as integration of diverse types of information and renewal of data on either format, raster and vector.*
2) *A wide applicability for land evaluation for agricultural development, such as irrigation project and transmigration project.*

1. INTRODUCTION

In the inventry & identification stage of agricultural infrastructure development, such as irrigation and transmigration project, land evaluation is the one of the most significant processes for efficient planning of projects.

In regard to the methodology of land evaluation for agricultural development, a "Framework for Land Evaluation", produced by Food and Agriculture Organizaion of the united nations (FAO) in 1977, is well known and many attempts along the policy of this framefork have been carried out in Indonesia. In particular, among the attempts, Regional Physical Plannig Programme for Transmigration (RePPProT), which was the cooperative project between the Ministry of Transmigration and Overseas Development Administration (UK),

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was the most remarkable project in a respect that results were covered with the whole Indonesia in the almost same intensity level of survey.

However, it is fact that some of the planners of practical regional development projects have critical opinions to the results of RePPProT which is to have more accuracy, especially in delineation of Land System, which is assumed to have homogeneous land conditions. Although some of these opinions are due to exaggerated expectation, such as misapplication in more detail stage of projects, RePPProT maps involve updating and integration with newly acquired information. For instance, we can get more detail soil-information from Land Unit Map produced by Center for Soil and Agroclimate Research (CSAR) in Bogor. In regard to topographic information such as slope and elevation, we can apply Digital Elevation Model (DEM); furthermore, Remote Sensing (R/S) Data has wide applicability and possibility for updating various land resources information.

For the integration of these information, the diverse manners of representation involve a difficult problem; Land System Map by RePPProT and Land Unit Map by CSAR are represented by different delineation of the homogeneous land condition unit; DEM and R/S data are represented by form of grid cell data. In this paper, we will introduce our approach to the integration of various land resources information, which are formed on such diverse manners of representation by using G.I.S.

2. MATERIALS

2.1. Description of the case study area

The case study area for this subject is the rectangle area, where is stretched to between the latitude 0 ° 15 ' - 0 ° 40 ' of south and longitude 101 ° 25 ' - 102 ° of east, in the middle part of Inderagiri river basin in Riau Province, and this covered area is about three hundred thousand hectors. Administratively this area belongs to Kabupaten Inderagiri Hulu in Riau Province, and Geomorphologically most part of this area tends to hilly undulating characteristics excluding back land of Inderagiri river and the maximum elevation point in this area is less than 200m. The characteristics of land use is that a number of settlements are located along the left part of this river and that there are developed transmigrate area in the northeast part of this area and exists a large scale of oil palm plantation at the hilly part in the southern side.

2.2. Input data

The data to be used for input are as follows :

(1) LANDSAT-TM data (Path 126 - Row 60, June 16 1989)

(2) Land System/Suitability Map by RePPProT 1988
(Sheet No.0815, Solok, Scale 1:250,000)

(3) Land unit by Soil Map by CSAR
(Sheet No.0815, Solok, Scale 1:250,000)

(4) Topographic Map

(Sheet No.0815, Solok, Scale 1:250,000) ;

3. METHODOLOGY

The method of this study is shown in flowchart of figure-1. Following is a outline of this method.

3.1. Data input

All data except LANDSAT-TM DATA were digitized by ARC/INFO software in order to construct database of G.I.S.. The data to be used for digitizing are Land system map of RePPProT, Land unit map of CSAR and Topographic map and each layers were arranged in the same coordinate. These original data are converted into grid cell data. The attributions are prepared from every criteria of these materials.

3.2. Preparation of component thematic maps

Preparation of component thematic maps for land evaluation are prepared by decomposing the digitized data. Preparation is easy by searching from this database of GIS, which are extracted by the factor for land evaluation in planning. The following attributions were arranged into 11 items as the component thematic maps that land resources should provide :

(1)	Groundwater quality	* from RePPProT
(2)	Potable water	*
(3)	Inundated land	*
(4)	Dominant soil Texture	** from CSAR
(5)	Depth of soil	**
(6)	Soil drainage	**
(7)	Nutrients	**
(8)	Elevation	***from topographic map
(9)	Slope	***
(10)	Fragmentation	*
(11)	Climate	*

Elevation and slope is processed by digital terrain analysis and are combined as the item.

3.3. Production of Land capability map

3.3.1. Criteria and integrated method

Criteria of this study is applied by that of RePPProT in the Ministry of Transmigration. That is why the purpose is set as planning for site selection of transmigration. Integration method is the process to decide suitability of crops production against each criteria in case of lack information of each criteria. There are sometimes no information in each criteria.

3.3.2. Land Capability Map

Land capability map indicates the information of the capability which land provides for crops production. Land capability are constructed through criteria and integration method by using the database of GIS. In case of site selection for transmigration in this study, Land use are supposed to 3 patterns for cultivation such as paddy fields, upland fields and tree crops. As the first step Land capability map are divided into 3 patterns, based on the purpose of this study.

3.4. Production of Land suitability map

3.4.1. Composing required Land capability map

This is the process of making synthesized Land capability map. The condition of development should be considered about 3 patterns in case of wide applicability in land, in the other case that should be considered one pattern at least. Considering the procedure of these condition for site selection, synthesized Land capability map is produced.

3.4.2. Screening

Screening is the process to produce Land suitability map. Land suitability map is produced by screening with synthesized Land capability map and land cover map that was processed by LANDSAT-TM data, which was extracted the developed area and the possible area for development.

4. RESULT AND DISCUSSION

The result of this study is shown in figure-2 and figure-3 of Land capability maps. These evaluation maps are produced based on the concept to supply many kinds of data information for planner by using G.I.S. system. The merit of construction of G.I.S.system are following things :

(1)Easy to update

Considering the situation that the data become old every year, this system is easy to update the data in real time.

(2)Utilization of data in other relevant organizations

This system provides the function to be able to convert the data from another system in other relevant organizations.

(3)Getting Good accuracy

This system can get good accuracy based on grid cell unit compared with the conventional method by interpretation. Land system and Land unit have the representative value in one mapping unit from point of view to grasp the characteristics in the whole regional area, so there are unreasonable to be lack of detail information in a mapping unit.

(4)Flexible to set up criteria

Criteria is set up flexible for each purpose by using this system. The production of thematic maps which need for evaluation produced easily by the searching from the database of GIS, which purpose is to extract the factor for land evaluation in planning.

(5)Screening with land cover

Land cover map of LANDSAT-TM as the present land use is used for screening method in order to extract detail information as land suitability from land capability map. It is necessary to suppose the future land use in each legend of land cover map for the purpose of screening, which should be considered the soil condition as the land suitability for development.

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3. Yukio YAMAMOTO : Land Evaluation Study for Transmigration area in the middle Inderagiri river basin, Riau Province INDONESIA, JICA report 1991 June

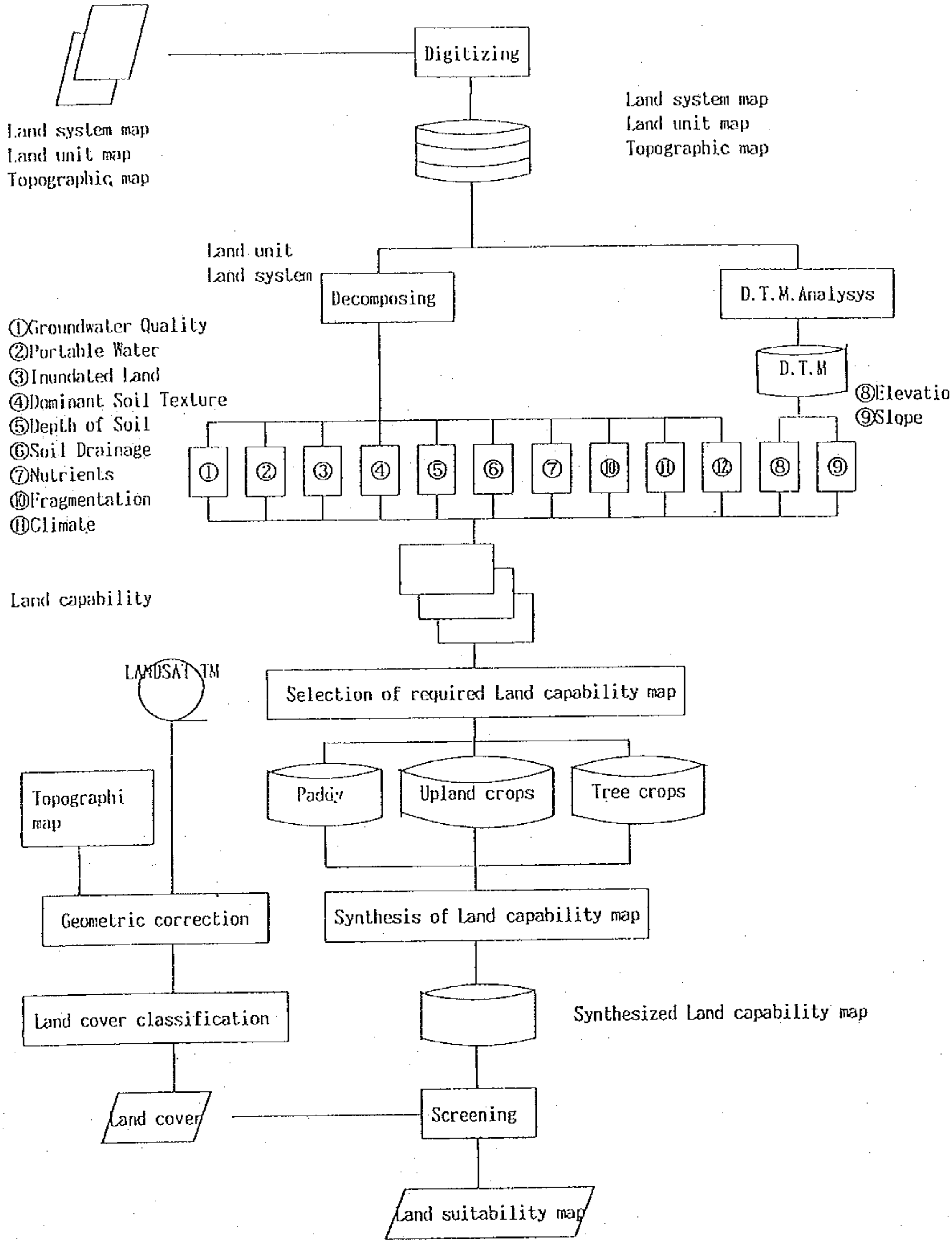

Figure - 1 Flowchart of this study

Land Capability Map for Wetland Arable

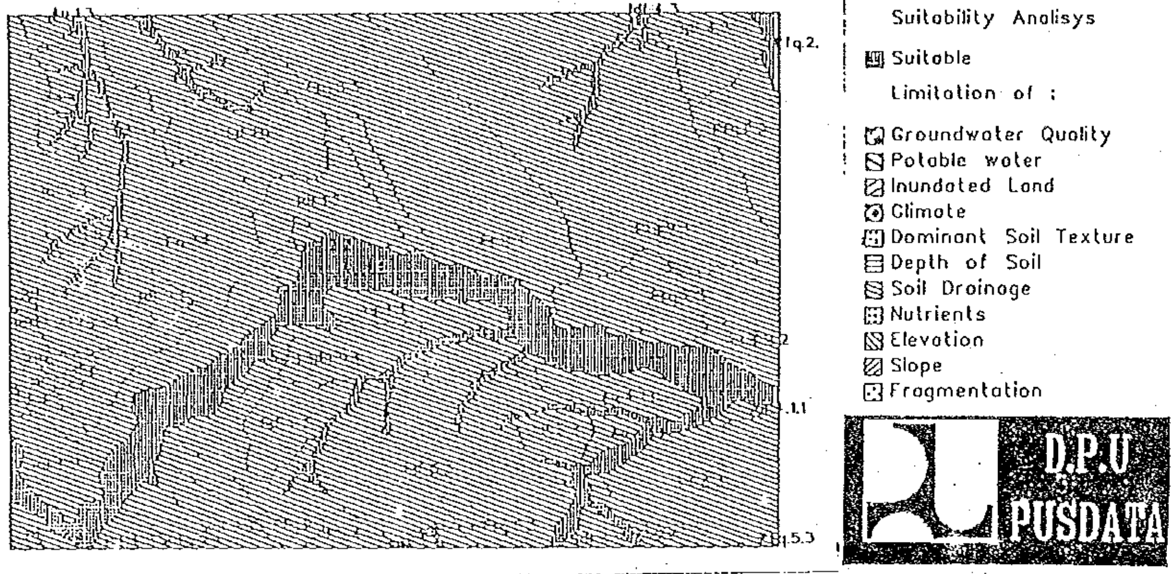

Figure - 2 Ex ample of Land Capability Map.

Land Capability Map for Sago-palm

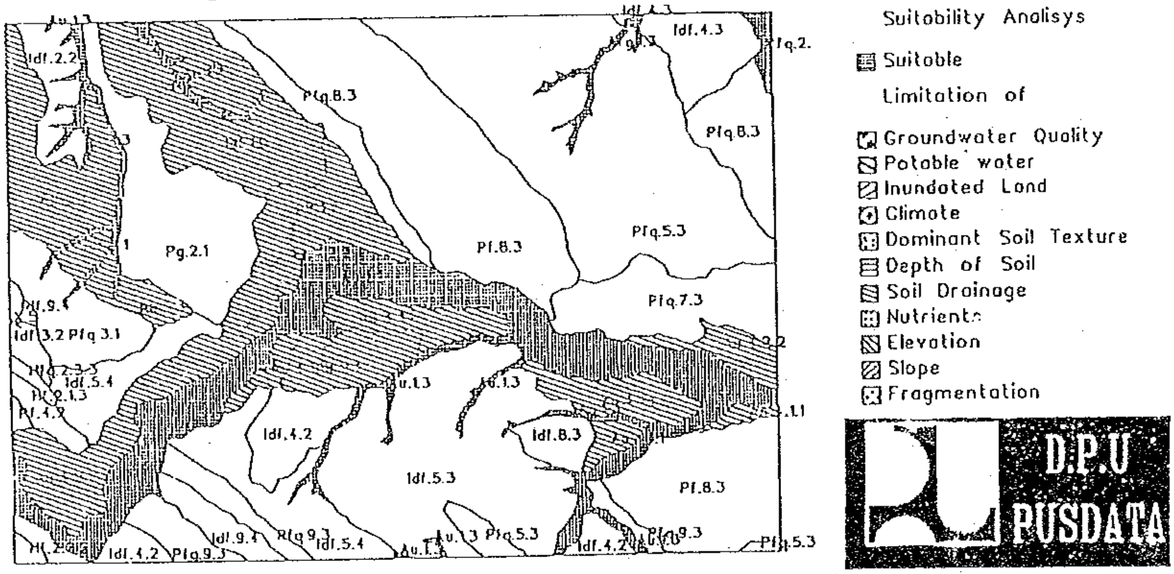

Figure - 3 Ex ample of Land Capability Map

FOURTH SEMINAR ON
THE ROLE OF REMOTE SENSING TECHNOLOGY AND GEOGRAPHIC INFORMATION SYSTEM (GIS) FOR INFRASTRUCTURAL DEVELOPMENT PLANNING

OPTIMASI PEMANFAATAN TEKNOLOGI PENGINDERAAN JAUH DAN SISTEM INFORMASI GEOGRAFI UNTUK PENGINTEGRASIAN PEMBANGUNAN KE-PU-AN MENDUKUNG PENGEMBANGAN KAWASAN ANDALAN

APPLICATION OF REMOTE SENSING AND GIS TECHNOLOGY FOR ESTIMATION OF SOIL EROSION SEDIMENT SOURCE IN KAMPAR RIVER BASIN, RIAU PROVINCE

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JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

APPLICATION OF REMOTE SENSING AND GIS TECHNOLOGY FOR ESTIMATION OF SOIL EROSION AND SEDIMENT SOURCE IN KAMPAR RIVER BASIN, RIAU PROVINCE

by

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ABSTRACT

The study area is located in upperpart Kampar river basin and covered about 330.000 ha. The purpose of the study are to apply remote sensing and GIS technology for estimation of soil erosion and sediment source. In order to achieve the above purpose, the objective of this study is to production maps for land conservation functions (sediment potential map, soil erosion map under diverse land condition). In this study, USLE method was used for estimation soil loss (soil erosion) and analyzed discharge and DEM data for estimation sediment source. Soil erosion was predicted on 3 diverse condition of land cover. Those are soil erosion under present land cover (1992) as amount 70,470,000 ton or 220 ton/ha, soil erosion under depleted land cover as amount 2,132,285,000 ton or 6,649 ton/ha and soil erosion under reforested land cover as amount 20,778,000 ton or 65 ton/ha. By comparatione of soil erosion under reforestation and present land cover can be identified reduction of soil erosion and the result as amount 49,692,000 ton/ha. Those results were presented as a map, it was use for identify soil erosion distribution in order to use as an input for land conservation analysis. According to this result the amount of reduction of soil erosion is 49,692,000 ton or 155 ton/ha. For sediment source analysis, in this study area was distributed generally on sub-watershed no.1-B (Malugiri River Basin). Based on this result, land conservation can be recommended to this area.

I. INTRODUCTION

Located on the upper Kampar River Basin in Central Sumatera, the objective area of this study covers a catchment of Kotopanjang Dam which is now under construction at Kotobaru in Riau Province. Here, Forestry rehabilitation project by Ministry Of Forestry is now planning.

Forestry rehabilitation on this area will contribute not only on conservation of soil and environment, but also on improvement of water resources retaining capacity and extension of the dam's life by control of soil erosion. In order to lead to this effects efficiently, however, delibrate investigations on suitable sites selection for reforestation and methods of regreening are indispensable.

The purpose of this study is to establish investigation method for identification of the sediment source area in dam catchment area by using satellite remote sensin data due to contribute watershed management project such as forest rehabilitation. Needless to say, by only remote sensing analysis, we nefer obtain final resúlt for identification of sediment source area.

Therefore, the aim of this study is to make a field survey efficient by providing quantitative and spatial information in the priliminary stage of investigation.

The Objectives of this study
The objectives of this study are to apply remote sensing and GIS technology for estimation of soil erosion and sediment source.

The Study Area
The study area is located on upper Kampar watershed in Riau Province and covered about 330.000 Ha, it's located on 100°8'23" to 100°54'22" East and 0°30'56" North to 0°4'29" South.

Data Were Used.
1. Landsat TM Scene no. 127-60 dated on June 15, 1992.
2. Topographical map scale 1 : 50.000 and 1 : 250.000
3. Land unit and soil map scale 1 : 250.000

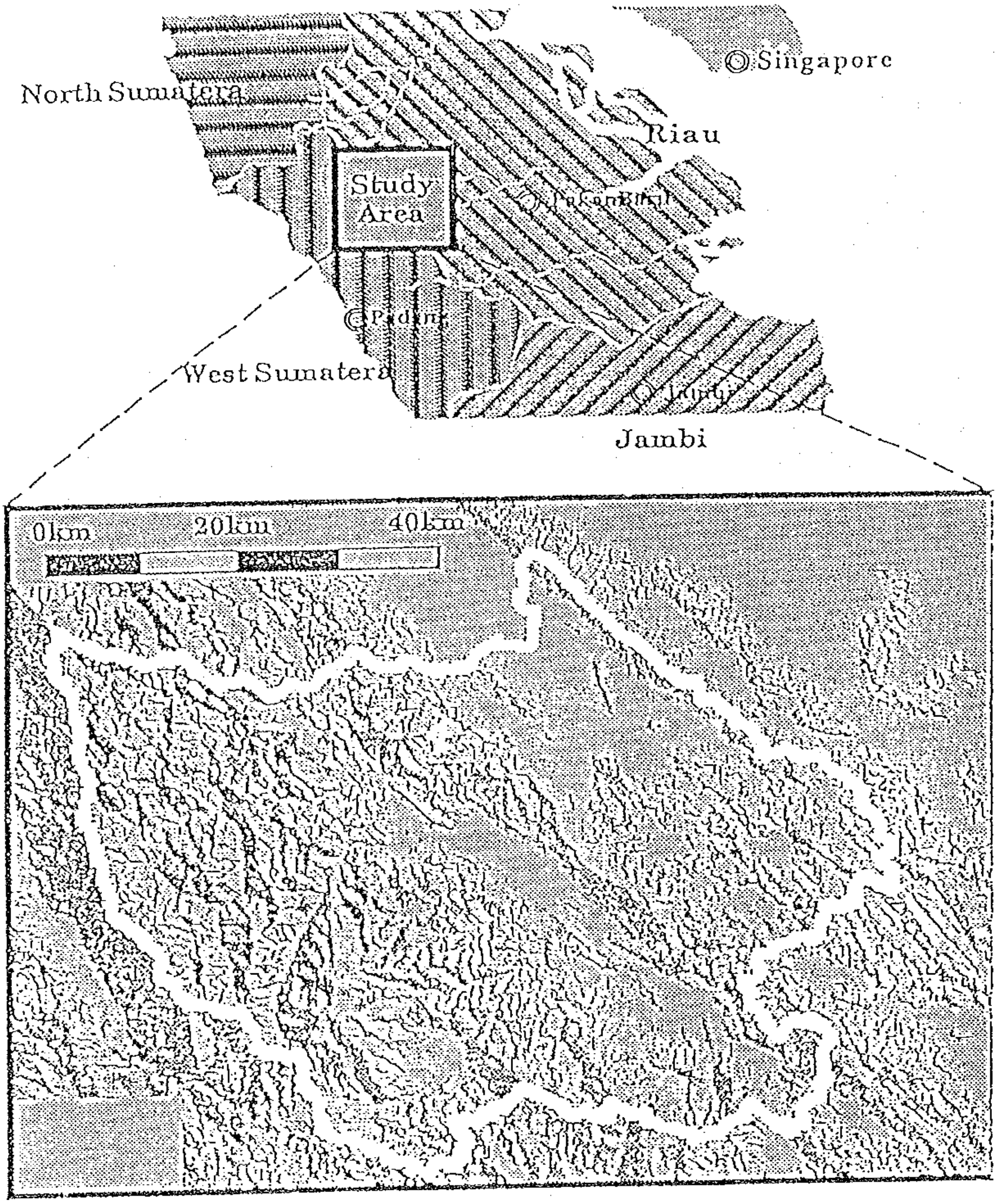

Figure - 1. Location of Study Area

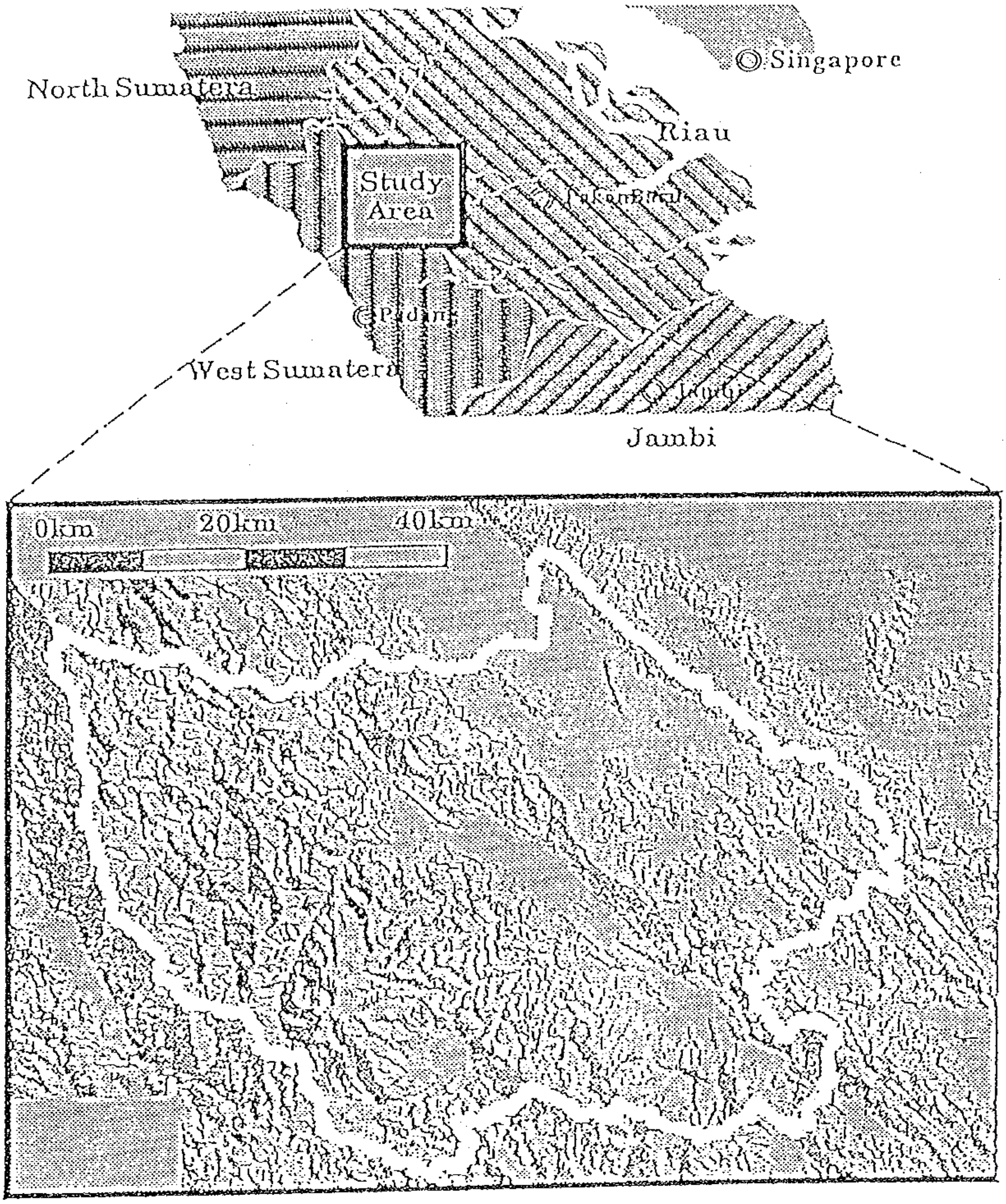

Figure - 1. Location of Study Area

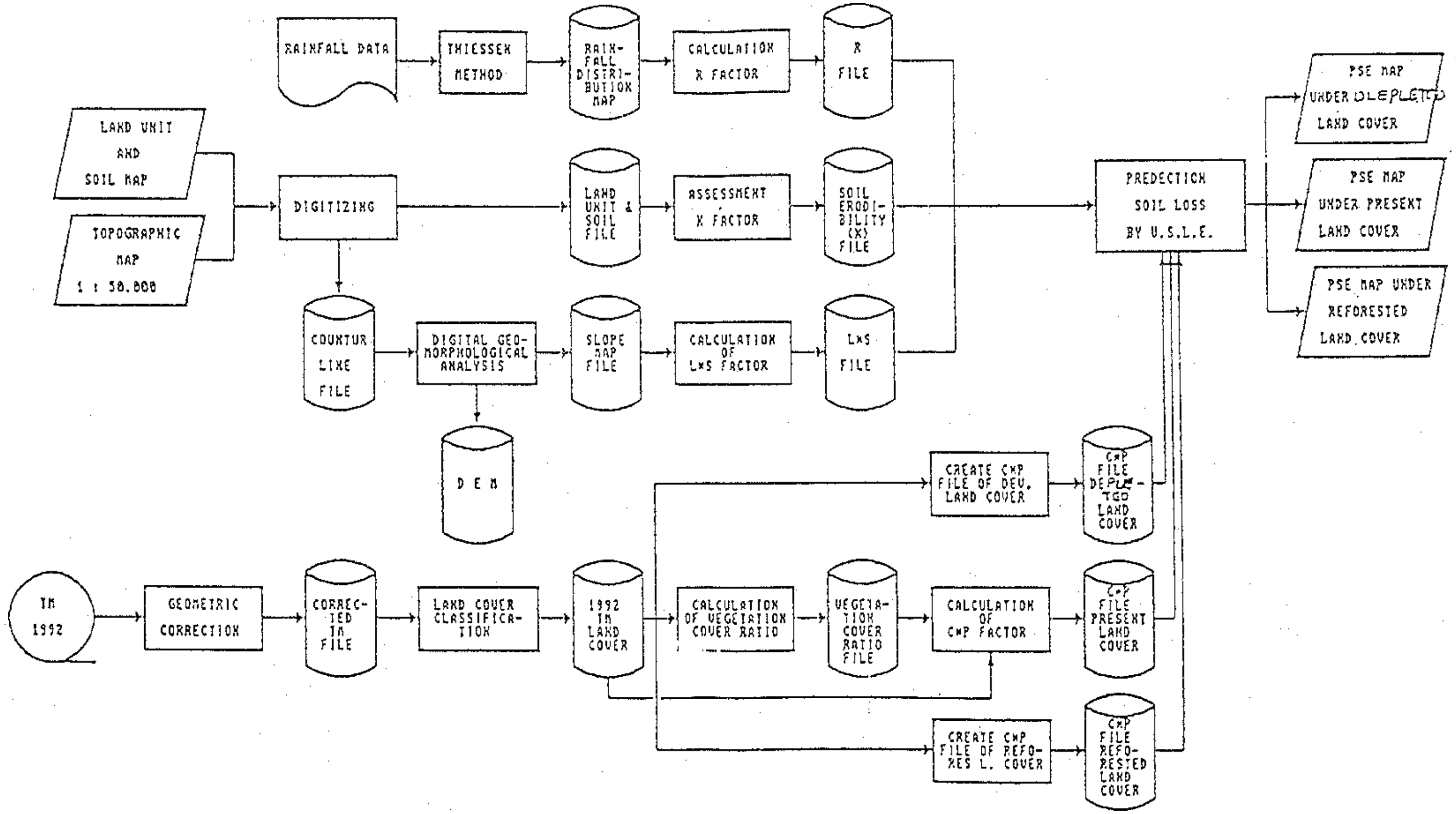

Fig: 2

FLOWCHART OF ESTIMATION OF SOIL EROSION

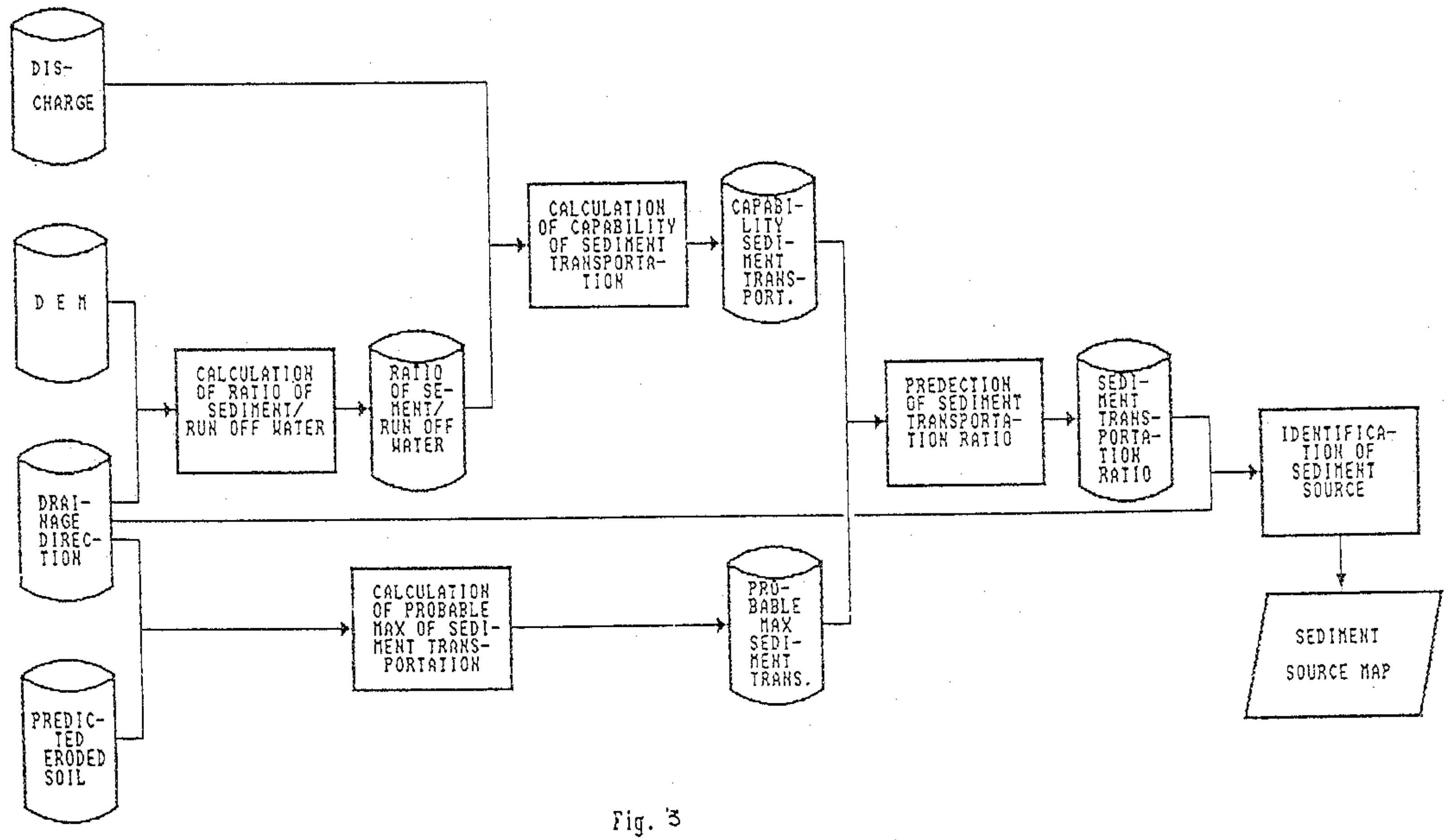

Fig. 3

FLOW CHART OF ESTIMATION OF SEDIMENT SOURCE

II. ESTIMATION OF SOIL EROSION

This study concentrate on only estimation of soil erosion as sediment source, and landslides are also significant as sediment source, however, they are out of consideration, here because there is no way to identify the sediment source from landslides quantitatively with the present remote sensing techniques.

The soil loss yields are predicted using the USIE (Universal Soil Loss Equation) was established on 1978 by FAO. The equation is :

E = R.K.L.S.C.P

where,

E = Annual Soil Loss (Ton/Ha/Year)
R = Rainfall erosivity Index
K = Soil Erodibility Index
S = Slope Factor
L = Slope Length Factor
C = Crop Practice Factor
P = Conservation Practice Factor

Actually, this equation was developed to predict potential and actual soil loss in vast and rather flat agricultural area. So, this equation is not so suitable to apply in this study area. Within the limits of the author's knowledge, however, there is no reliable soil erosion estimation method for agriculture and now agriculture region with steep gradient. And further more, the USLE method have been.

Adopted as recommended method for estimation of soil erosion for watershed management in some national organization such as the Ministry of Forestry and the Ministry of Public Works. It means that the USLE method has recognized as one of the most reliable soil erosion estimation methods as for as it is applied in order to identify the spatial distribution of critical area. Because of the above reason, the USLE method is adapted as a soil erosion estimation method in this study.

2.1. Soil Erodibility Index (K factor).

Soil erodibility index (K factor) is calculated according to the way suggested in the "Handbook for the Preparation of Land Date Base Forms for Regional Planning". That is the method which assesses the K factor on an individual bases using the organic matter content, % of silt, soil structure and permeability of the upper most surface horizon.

Table 1 :
Shows Index Point for assessing the K Factor,
The K Value is Determined by summation of this Index Point

FACTOR	CLASS	INDEX POINT
% Organic Matter	< 2 2 - 5 5 - 10 > 10	4 3 2 1
% Silt	> 50 30 - 50 15 - 30 < 15	4 3 2 1
Structure	blocky, planty or massive medium to coarse granular crumb or fine granular	3 2 1
Permeability	slow to very slow moderate rapid to very rapid	3 2 1

Soil information is acquired from Land Unit and Soil Map published by Center of Soil and Agroclimate Research (CSAR). The data source of soil is digitized and mapped at 1 : 125.000 scale and tabulated against sub-watersheds,

Table 2:
Determination of K Value

Total Score	Class	K Value Range	Repr. Value
5, or less	Very Low	< 0.10	0.05
6 - 8	Low	0.10 - 0.20	0.15
9 - 11	Moderate	0.20 - 0.40	0.30
12, or More	High	> 0.40	0.45

2.2. Rainfall Erositivity Index (R Factor).

Rainfall Erosivity Index (R) is calculated as below :

$Rb = 6.119 \times (R_B)\ 1.21 \times (H_H)^{-4.47} \times R_{(M)}^{0.53}$

Where,

Rb = Average Monthly Rainfall Erosivity Index (Cm/Ha/Hr)

R_B = Average Monthly Rainfall (Cm)

H_H = Average Rainy Day

R_M = Average Maximum Rainy Day

In regard to rainfall data, although the data observed by 12 climate observation stations around the study area (watershed) can be utilized, and average annual rainfall distribution map is made by means of the Thiessen method. The data is useless due to each of Rb, H_H, and R_M data. In this study, 6 rainfall observation station's data compiled by the RePPProT is used for calculation of the R Value.

2.3. Slope and Slope Length Index (SL).

In general, Slope Length are calculate together as a topographical factor as follows :

$SL = SQRT\ (L) \times (0.0138 + 0,0965S + 0,0138S^2)$

Where,

S = Slope gradient (%)

L = Slope Length (m)

The S value is obtained from the slope gradient calculated by means of differential of the precise DEM (Digital Elevation Model) and classified according to the slope classification defined by National Master Plan for Forest Plantations (as mentioned by seminar before).

Therefore slope length is difficult to be determined in accordance with the essence of the USLE method, the L value is fixed as 22.13 m, which is defined as a standard slope length of experimental field for identification of the USLE's parameters, on every pixel.

2.4. Crop and Conservation Practice Index (CP factor).

In general, value of Crop Index (C) are determined for different crops or different cropping systems respectively. However, as far as using satellite data, it is almost impossible to identify crop type and its cropping system in tropical regions in where various types and different stages of plans are vegetating together. Against identification of Conservation Practice Index (P factor), the satellite data is also incompetent.

In this study, therefore, the authors regard the CP index as an integrated factor which indicates an intensity of shielding top soil from rainfall and surface runoff water and calculate it's value by means of combination of Vegetation Cover Ratio (VCR) and the C value of typical land cover type, in stead of a futile attempt to get C and P value respectively

The method of determination of the CP values is as follows :

1. Set up the CP (A) value as the typical CP value of land cover category-A which is which is used in Land Cover Analysis.
2. Obtain the VCR (here, a pixel that is classified as category A of land cover and whose VCR is α % is assumed to consist of α of category - A as the following equation :

$$CP = CP(A) \times \alpha/100 + CP(B) \times (100 - \alpha)/100$$

Where,

α = Vegetation Cover Ratio
CP = Value of CP on the given pixel
CP(A) = Value of CP on a pixel covered by 100% category - A
CP(B) = Value of CP on a pixel covered by 100% of base land

Here, the VCR is obtained by means of the VCR model by M FUKUHARA and S. HAYASHI (1979). The concept of Fukuhara's model is shown in figure below :

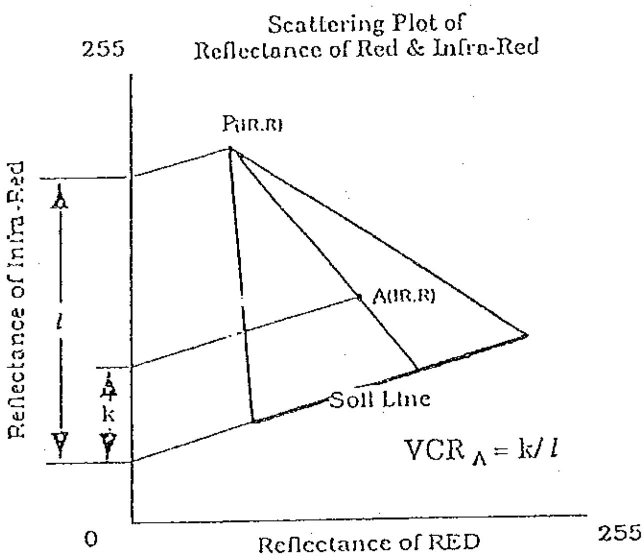

Fig. 4 : Concept of Vegetation Cover Ratio (VCR)
Generally, on diagram of scatter of reflectance of Red and Infrared on an area where is covered by only one kind of vegetation, the scatter forms a triangle as the above figure. It is well known that data of bare land area which has no vegetation are scattered on the Vaseline so-called "Soil Line" and data of area which is completely covered by vegetation are scattered on the point P. By using this spectral characteristic, Fukuhara and Hayashi suggested the graphical estimation of the VCR as the above diagram.

2.4. *Estimation of Soil Erosion Potential (SEP)*

2.4.1. *SEP Under Present Land Cover Condition*

Based on the present land cover condition, which is obtained by classification of satellite data of TM 1992, soil erosion potential is calculated.

Result of calculation is mapped at 1 : 125.000 scale and tabulated summation of soil loss against sub-watershed.

2.4.2. *SEP Under Depleted Land Cover Condition*

Under an assumption of land cover condition in which forest resources of whole area of the study area would be depleted. Soil loss is calculated in this case, the CP value is fixed as 1.0 all over the study area. Results of calculation is mapped at 1 : 125.000 scale and tabulated against sub-watersheds.

This map presents probable maximum potential of soil erosion and also indicates the distribution of the critical areas where vegetation should be conserved against depletion of vegetation.

2.4.3. *SEP Under Reforested Land Cover Condition*

Under an assumption of land cover condition in which whole watershed would be covered by forest due to reforestation, soil loss is calculated. In this case, the CP value is reduced to 0.01 on every pixel where the CP value shows more than 0.01 under the present land cover condition.

Result of calculation is mapped at 1 : 125.000 scale and tabulated against sub-watersheds.

2.4.4. *Improvement Effect of Reforestation*

Difference between soil erosion potential under the present land cover condition estimated in 2.4.1. and soil erosion potential under the reforested condition estimated in 2.4.3. is considered to be improvement effect due to reforestation.

The difference is mapped at scale 1 : 125.000 as an effect map of reforestation and tabulated against sub-watersheds.

III. IDENTIFICATION OF SEDIMENT SOURCE AREA.

Soil erosion potential estimated as the above means an amount of soil detached from surface and it's different than sediment yields which reach to the Kotopanjang Dam Lake.

To identify the sediment source area, it's necessary to predict a portion of sediment transported from upper stream to down stream. Up to now, however, such a prediction method has not been established as far as the authors know.

In this study, a sediment transportation model to identify the sediment source area is propose. This model made based on the following assumptions :

1) Sediment which are able to pass through on an arbitrary pixel per one year (annual maximum probable sediment discharge/Sp) is equal to the product of the annual average runoff discharge multiplied by turbidity ration of sediment)

2) In case that a summation of "annual yields of sediments which reach to an arbitrary pixel from upstream (Sin) " and "sediment yields which are newly eroded on the pixel (S)" is beyond the "annual maximum probable sediment discharge (Sp)", sediment transported to the pixel on the downstream side per year (Sout) is equal to Sin + S".

3) In case that a summation of "annual yields of sediments which reach to an arbitrary pixel from upstream (Sin) " and "sediment yields which are newly eroded on the pixel (S)" is less then the "annual maximum probable sediment discharge (Sp)", sediment transported to the next pixel on the downstream side per year (Sout) is equal to Sp.

4) Turbidity ration of sediment (S) on an arbitrary pixel is in proportion to difference of elevation between the given pixel and it's neighbor pixel on the upstream side.

Based on the above assumption, sediment yields are accumulated from the most upstream pixels of the watershed to the most downstream pixels on the edge of the dam lake along the routes of the DPM. The figure below presents a concept of the sediment transportation model.

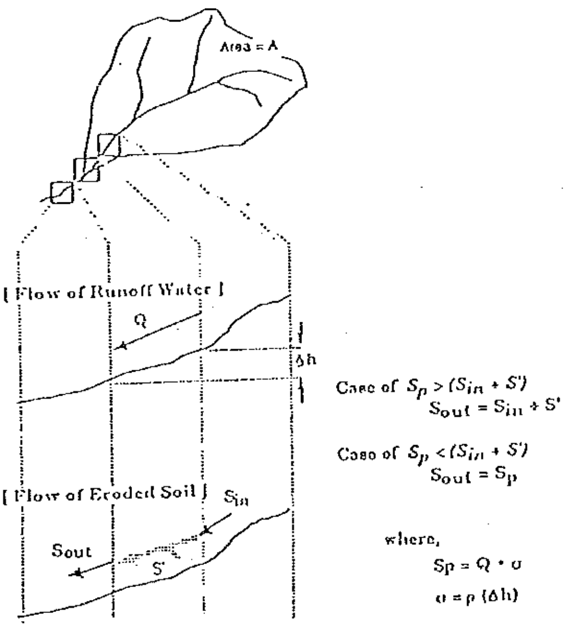

Fig. 5. Concept of Sediment Transportation Model

Amount of sediments which are divided from an arbitrary pixel is calculated as the following equations :

$$SS_{p=a} = S'_{p=a} \times STR_{p=a} \times STR_{p=a+1} \times STR_{p=a+2} \times \ldots\ldots\ldots\ldots \times STR_{p=b}$$
$$SS_{p=a} = Sout_{p=a} / (Sin_{p=a} + S'_{p=a})$$

Where,

$SS_{p=a}$	= Sediment source of pixel - a
$S'_{p=a}$	= Eroded soil on pixel - a
$STR_{p=a}$	= Sediment Transportation Ration on pixel - a
$Sout_{p=a}$	= Sediment transported to the neighbor downstream pixel form pixel - a
$Sin_{p=a}$	= Sediment transported from the neighbor upstream pixel into pixel - a
a + 1	= Neighbor pixel of pixel - a on the downstream side
b	= Terminal pixel (on the edge of the dam lake) of the drainage route of the DPM.

Results of calculation are mapped at 1 : 125.000 scale as Dam Sediment Source Map and tabulated against sub-watersheds.

Results of Analysis.

Based on the results of analysis soil erosion, in this study can be distinguish into three items, the amount of estimation of soil erosion as :

1. Predicted Soil Erosion are :
   a) Predicted soil erosion under depleted land cover are 70.470.000 ton or 220 ton/ha
   b) Predicted soil erosion under depleted land cover are 2.132.285.000 ton or 6.649 ton/ha
   c) Predicted soil erosion under depleted land cover are 20.778.000 ton or 65 ton/ha

2. Reduced soil erosion by reforestation are 49.692.000 ton or 155 ton/ha

3. Sediment source estimation are 2.400.000 ton or 7 ton/ha

The distribution of those data ware expressed in the maps with 1 : 125.000 scale
Fig.6. shows the characteristis of devided sub-watersheds on soil erosion potential and sediment source.

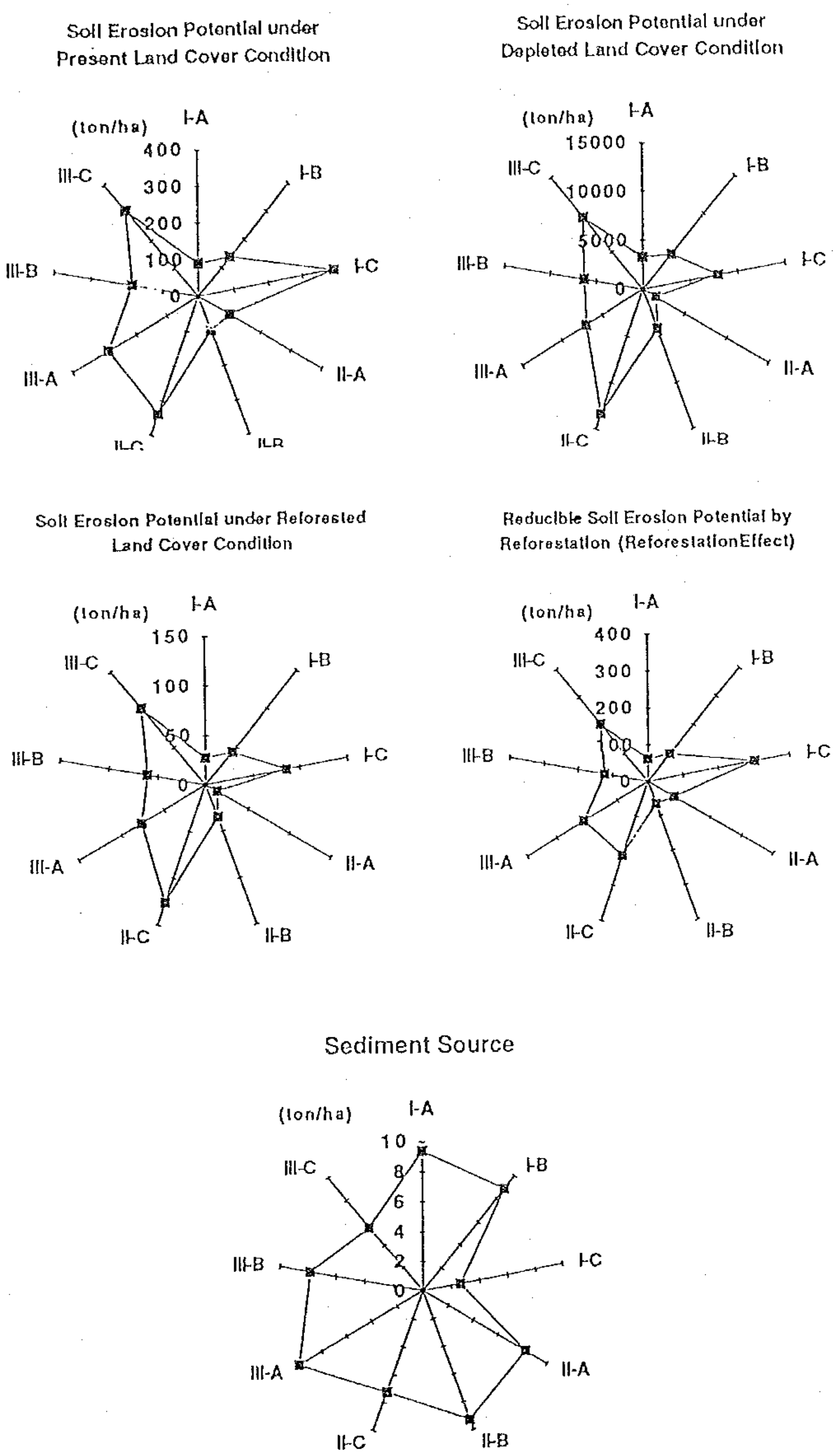

Fig- 6 Diagram of Characteristics of Sub-watersheds

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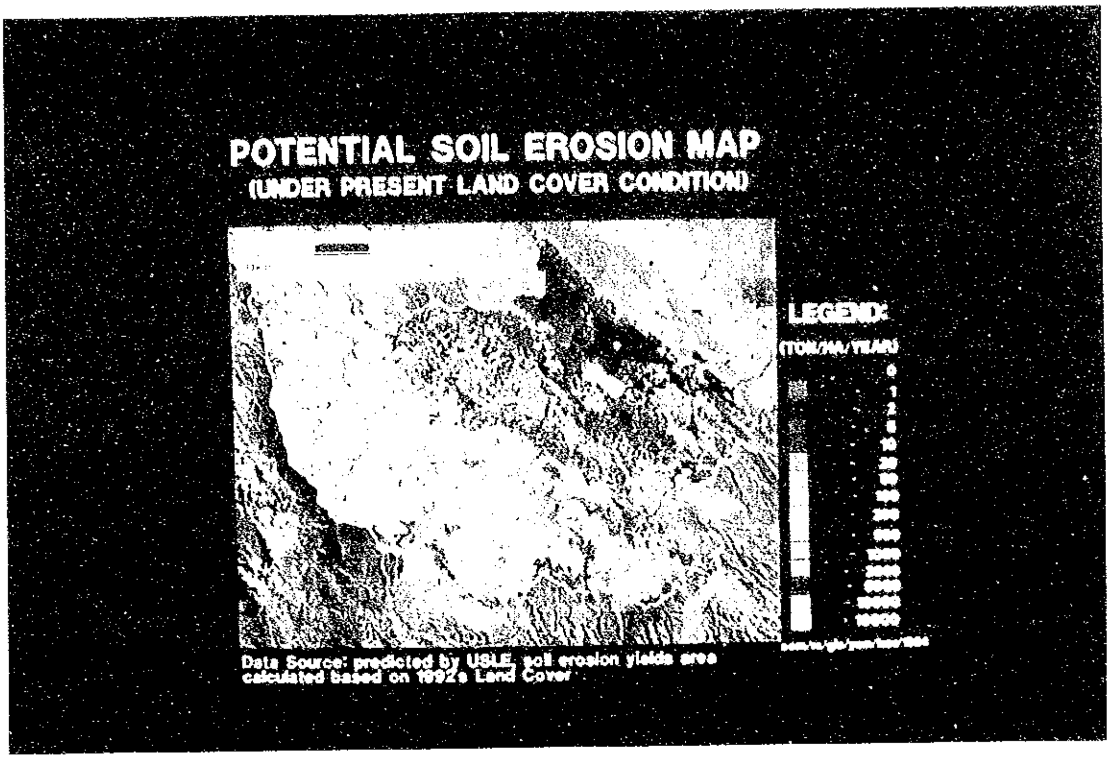
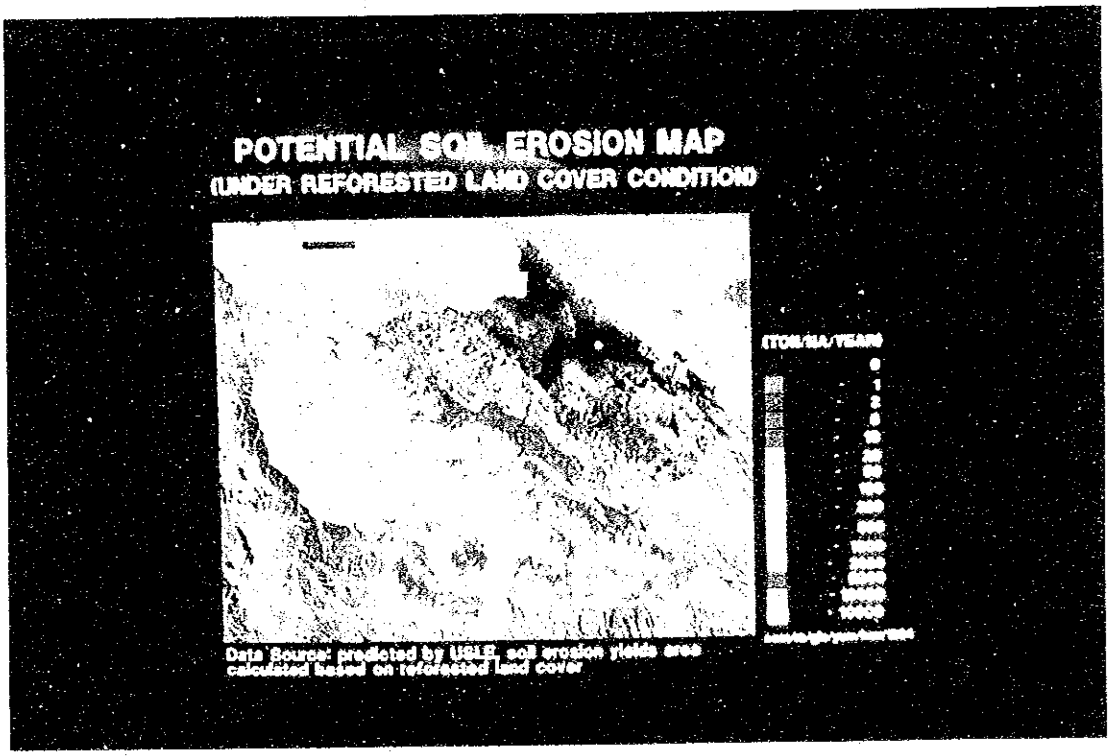
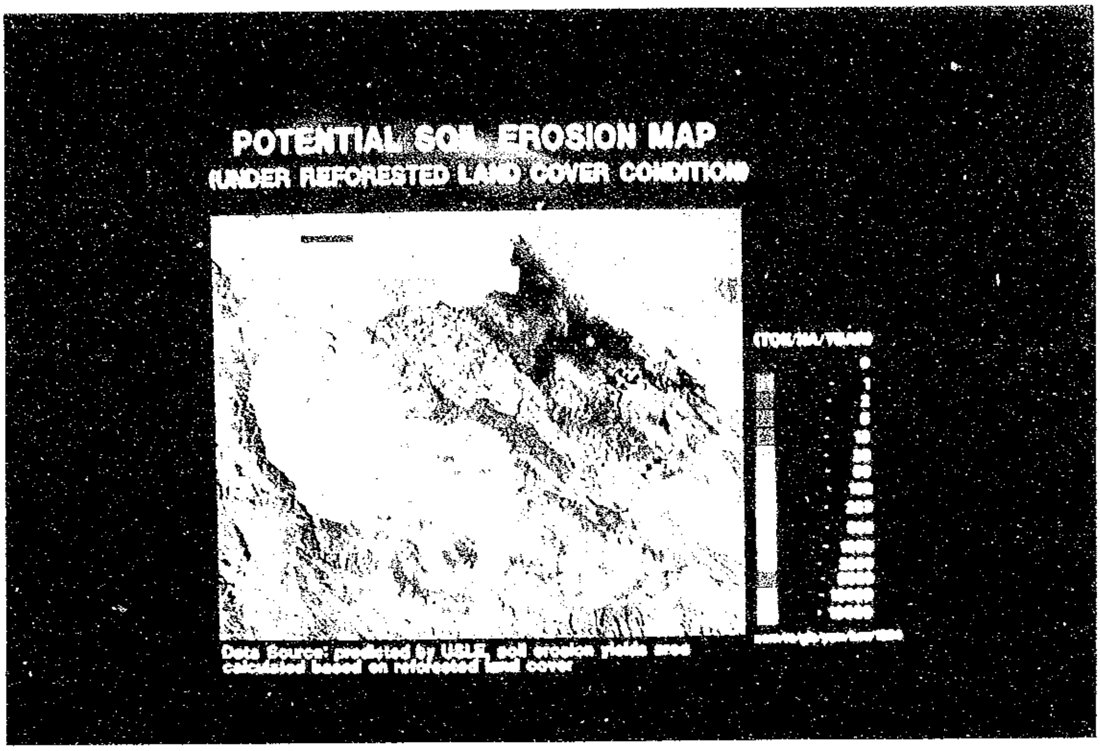


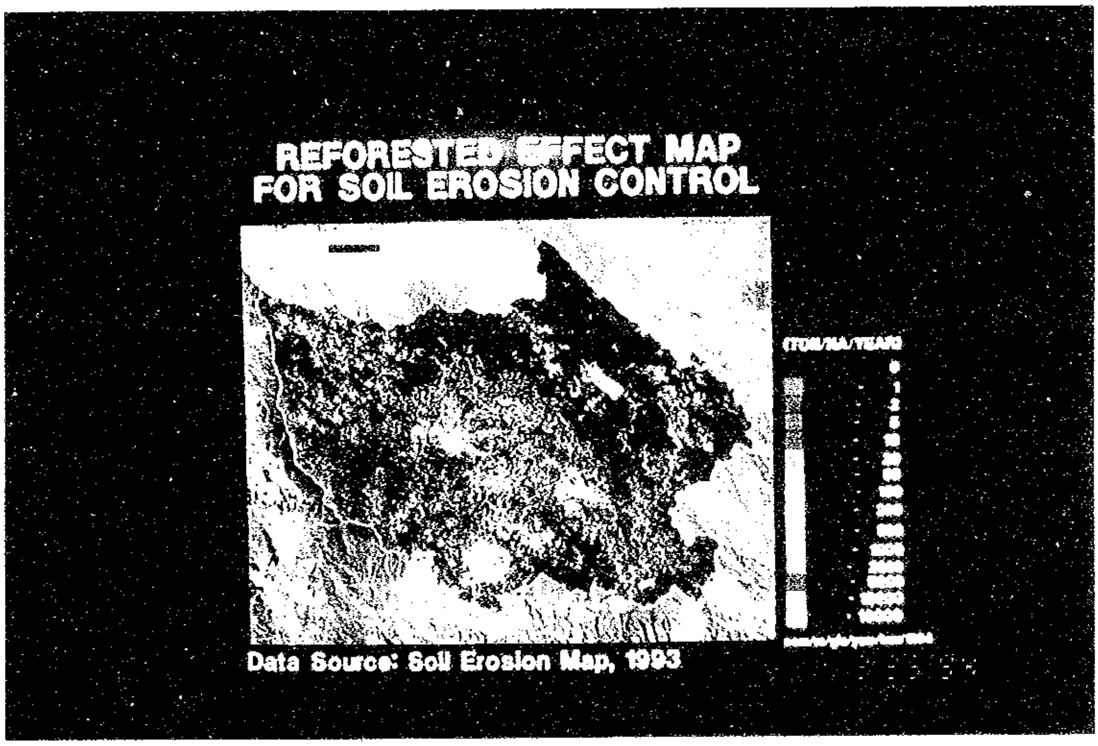
Photo－1. Potential Erosion Map Under Present Land Cover



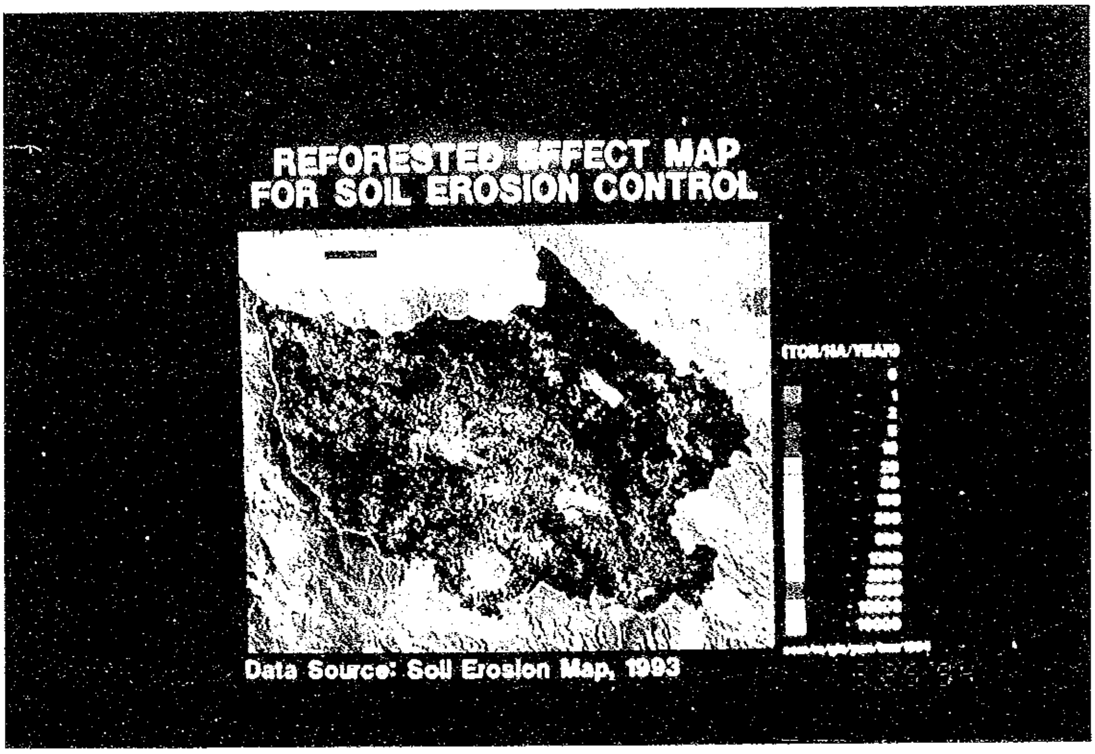
Photo－2. Potential Erosion Map Under Reforested Land Cover



Photo— 3 . Potential Erosion Map Under Depleted Land Cover



Photo— 4 . Effect Map of Reforestation



Photo— 5 . Sediment Source Map

FOURTH SEMINAR ON
THE ROLE OF REMOTE SENSING TECHNOLOGY AND
GEOGRAPHIC INFORMATION SYSTEM (GIS)
FOR INFRASTRUCTURAL DEVELOPMENT PLANNING

OPTIMASI PEMANFAATAN TEKNOLOGI PENGINDERAAN JAUH
DAN SISTEM INFORMASI GEOGRAFI
UNTUK PENGINTEGRASIAN PEMBANGUNAN KE-PU-AN
MENDUKUNG PENGEMBANGAN KAWASAN ANDALAN

APPLICATION OF REMOTE SENSING TECHNOLOGY FOR DETECTION OF SHIFTING CULTIVATION FIELD IN THE KAMPAR RIVER BASIN, RIAU PROVINCE

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JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

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ABSTRACT

This paper describes briefly about the analysis of shifting cultivation field in The Kampar River Basin, Riau Province using the multitemporal satellite imageries namely MSS and TM.

Shifting cultivation field can be detected through the sequence of processes, such as :

1. Overlay between two land cover maps to get the land cover change map
2. Identification of plot characteristics of land cover changing area such as plot size, shape, and temperature
3. Making decision tree for a detection of shifting cultivation fields.

By means of these processes, this paper presents that spatial and quantitative information on distribution of shifting fields can be obtained form multi temporal satellite data.

I. Introduction

When we make a feasibility study or a master plan for regional agricultural or forest development planning of inland area, an adequate understanding for shifting cultivation of the study area is indispensable in order to establish sustainable system of agriculture and forestry in accordance with environment.

There are several kinds of statistic information on the actual condition of shifting cultivation such as total area, number of fields, number of farmers and cropping system compiled by some public organizations. For instance, the Regional Physical Planning Programme for Transmigration (RePPProT) discloses '490,000ha' as area of shifting cultivation fields and '11.1%' as population ratio of shifting cultivation farmers in Riau Province. However, as far as the authors know, it is quite difficult to gather reliable data, because, only by field survey, it is actually impossible to grasp shifting cultivation fields which are scattered on vast and untouched area.

The aim of this study is to estimate how far the shifting cultivation fields can be detected spatially and quantitatively through analysis of land cover changing and understanding of characteristics of land cover changing plots such as size, shape and temperature by using multi-temporal satellite imageries.

II. Study Area and Material

2.1 Study Area

The study area is located on the Upper Kampar River Basin in Riau Province and West Sumatera, and it covers a catchment area of Kotopanjang Dam about 333,000ha, along longitude from 100° 8' 23"E to 100° 54' 23"E and latitude from 0° 30' 56"N to 0° 4' 29" as shown in Fig.-1.

Upperstream of the study area is occupied by steep forest whose slope gradient is more than 25% and in the middle and down stream parts of the study area along the Kampar River, well-cultivated agricultural area are distributed.

Fig.-2 shows statistic data on area of crop production of the Riau Province and the Kampar Region.

2.2 Input Data

a. Landsat-5 TM (Thematic Mapper) with Path/Row:127/60, acquired on the date of June 15, 1992.

Color Composite image of TM is shown in Photo-1.

b. Landsat-5 MSS (Multi Spectral Sensor) with Path/Row:127/60, acquired on the date of June 28, 1985.

Color Composite image of MSS is shown in Photo-2.

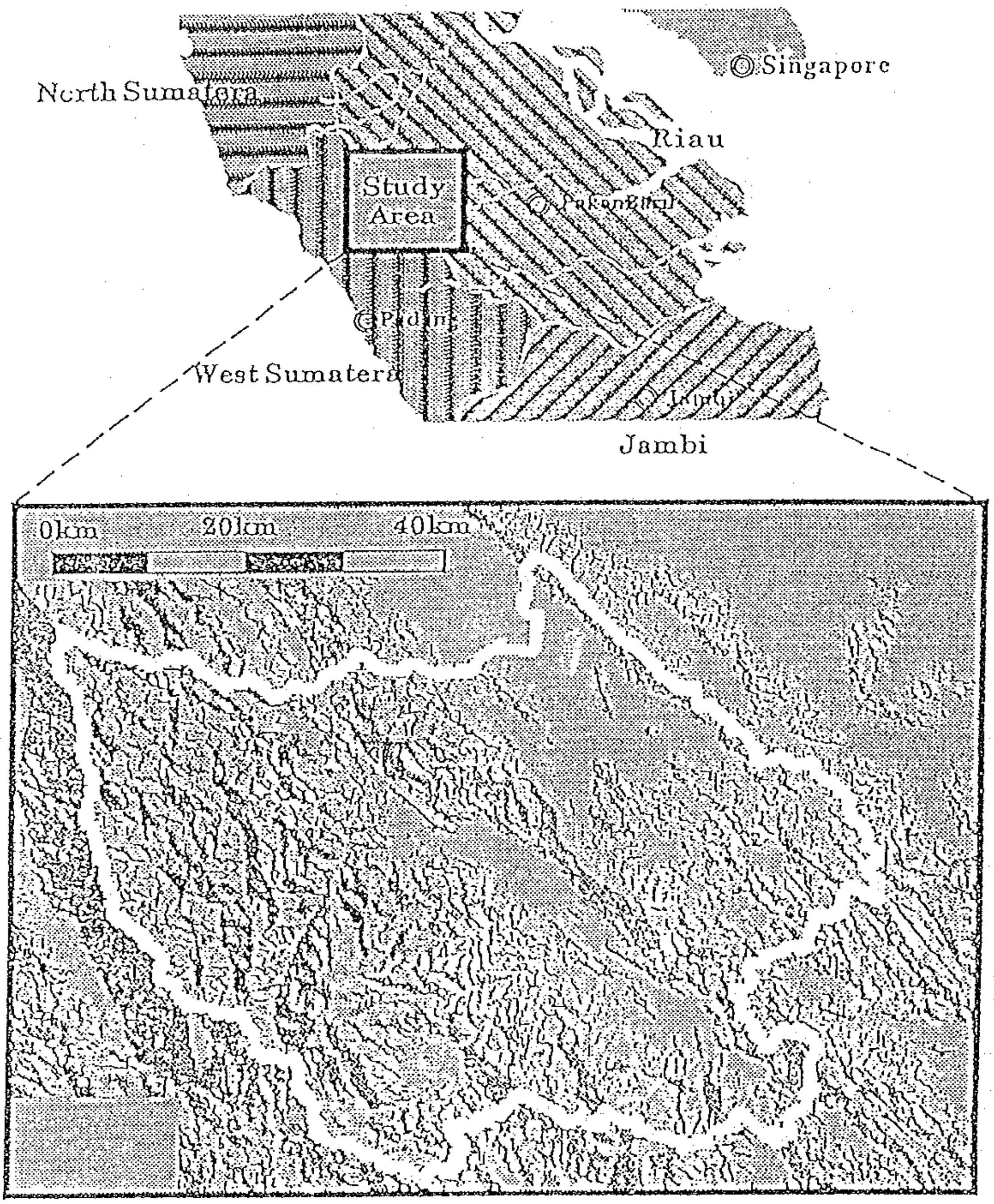
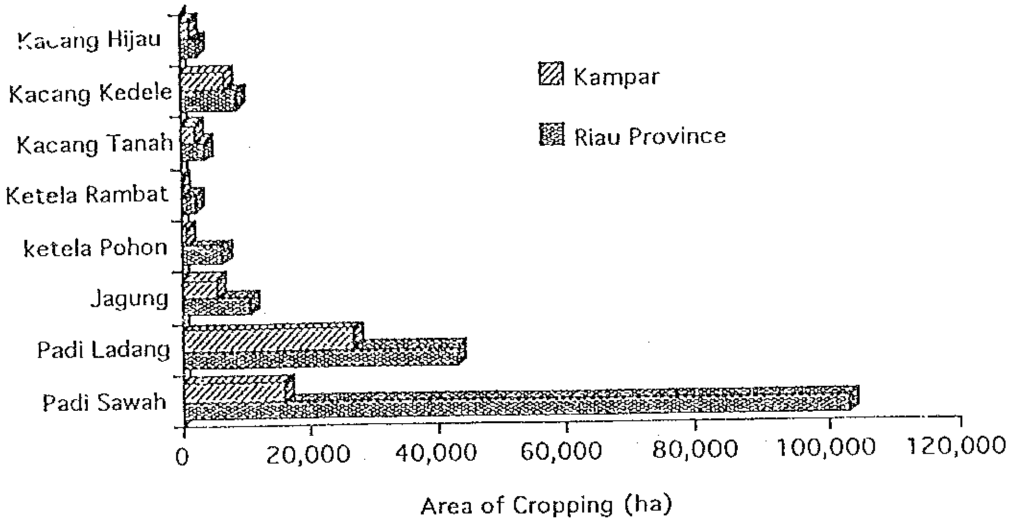


Figure - 1. Location of Study Area



Data Source : Dinas Pertanian Tanaman Pangan Provinci Riau

Fig.-2 Area of Crop Production

III. Methodology

Fig-3 shows the flow chart of analysis on distribution of shifting cultivation fields. The procedure of this analysis can be described as the following steps:

(1) Pre-processing,

- 'Geometric Correction' : Both imageries are rectified respectively in order to let them have an unified coordinate system by cubic convolution method. In this study, the authors use the 'Longitude-Latitude Grid System' as the unified coordinate system.
- 'Resampling' : Although the spatial resolving power of MSS is said to be approximately 60m×60m, MSS data are resampled into 30m×30m pixel size of data. This procedure is carried out to avoid loss of information of TM data overlaid with MSS data.

(2) Land Cover Classification,

- All pixels of two imageries are classified into the selected categories of land cover by means of 'Maximum Likelihood Method'.
- Categories which involve misclassification to some extent in the result of the above process are detected by interpretation of color composite images.

(3) Identification of Characteristics of Land Cover Changing Area,

- Every plot of land cover changing area is isolated from each other in order to grasp its size and shape characteristics.
- After this isolation process, plot size of land cover changing area is calculated as the product of the summation of component pixels of the plot

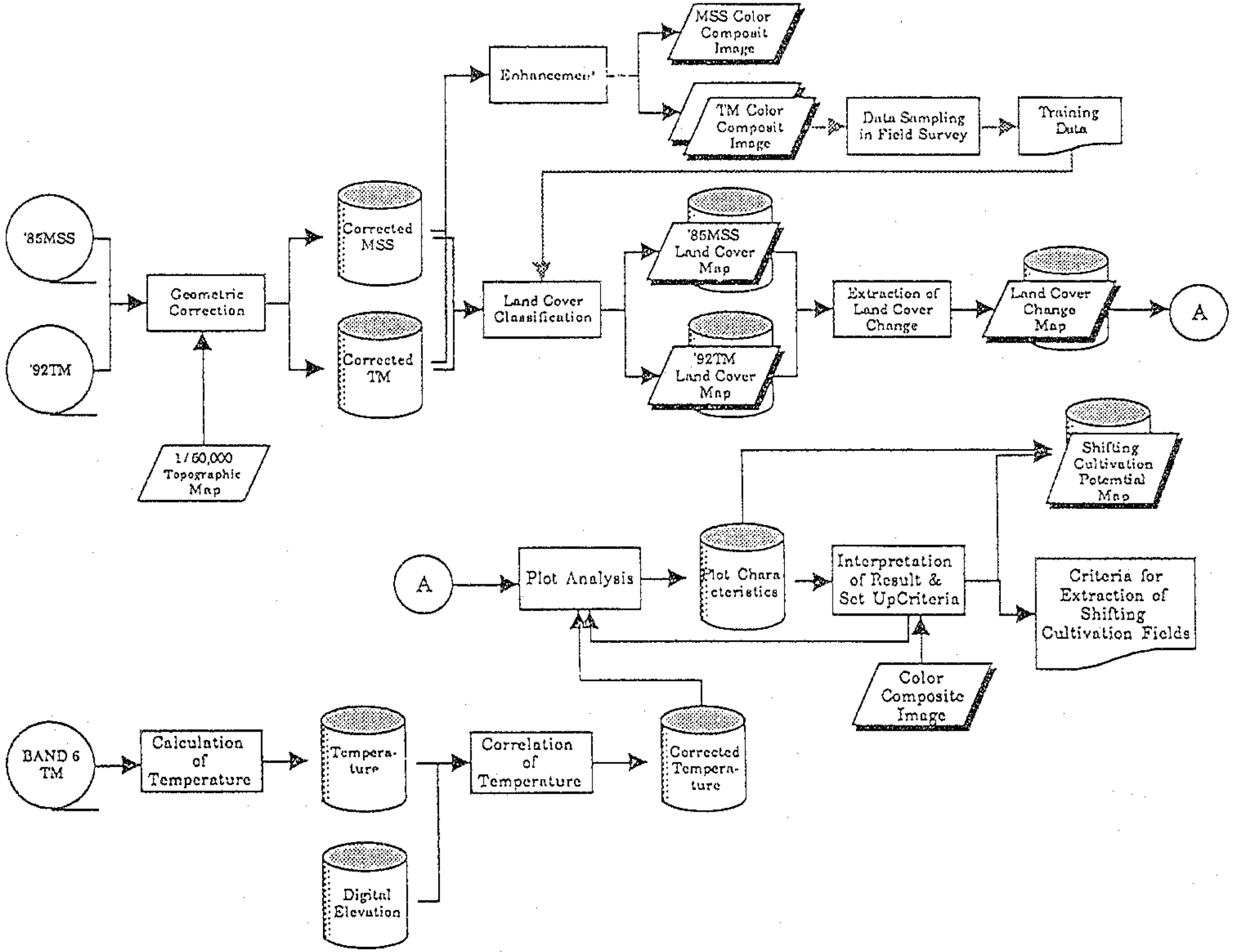


Fig. - 3 Flowchart of Processing

aggregate multiplied by unit area of a pixel.

Shape index of a plot aggregate of land cover changing area is calculated as the following equation:

$$ARI = (Dl^2 + Dc^2) / 2A$$

where,

ARI : Aspect Ratio Index
Dl : Horizontal Width of Aggregate (m)
Dc : Vertical Width of Aggregate (m)
A : Size of Aggregate(m^2)

Thermal characteristic of a plot aggregate of land cover changing area is calculated by using BAND 6 of TM data. Fundamentally, in order to estimate the surface temperature of the objects the following Horiguchi's equation is adopted:

$$T = 906.127+1.0545\times\alpha-0.0037\times\alpha^2+6.606\times10^{-6}\times\alpha^3-273.1$$

where,

T : Surface Temperature
a : CCT count of BAND6 of TM data

Calculated T is corrected with correlation of actual temperature data observed in Pakan Baru. And furthermore, in order to cancel the influence of elevation, offset value corresponding to the elevation of each pixel is added to the above result.

(4) Making a Detection Decision Tree for Shifting Cultivation Field.

- A detection decision tree is formed with the above information through deliberate interpretation of color composite image and the result image.
- Making a potential map for shifting cultivation by means of this detection decision tree as a final result.

IV. Result of Analysis

4.1 Land Cover in 1985

Table-1 shows the result of MSS land cover classification in 1985.

In the result of this classification, there is no Estate Fields. This derives from lack of capability of MSS which does not have intermediate infrared band like BAND 5 of TM sensor. Estate Fields could not be distinguished with Bush/Shrub or Middle Dense Vegetation Forest. Unclassified Area corresponds with cloud and its shadow.

4.2 Land Cover in 1992

Table-1 shows the result of TM land cover classification in 1992.

Table - 1 Result of Land Cover Classification

Category \ Year	Land Cover in '85 (MSS)		Land Cover in '92 (TM)	
High DenseVegetation Forest	133,806 ha	40.2%	143,305 ha	43.0%
Middle Dense Vegetqation Forest	94,554 ha	28.4%	80,503 ha	24.2%
Bush & Shrub	54,015 ha	16.2%	64,610 ha	19.4%
Mix Garden & Settlement	5,352 ha	1.6%	7,606 ha	2.3%
Grassland & Upland Field	16,830 ha	5.1%	22,655 ha	6.8%
Paddy Field	1,638 ha	0.5%	2,306 ha	0.7%
Bare Land	10,182 ha	3.1%	9,185 ha	2.8%
Estate Field	——	0.0%	817 ha	0.2%
Water Bodies	1,140 ha	0.3%	1,356 ha	0.4%
Unclassified Area	15,571 ha	4.7%	745 ha	0.2%
Total	333,087 ha	100.0%	333,087 ha	100.0%

Table - 2 Result of Land Cover Changing

Category of Land Cover Changing			Area
Vegetation Decrease Area			38,893 ha
High Vegetation Area	→	Middle Vegetation Area	14,667 ha
High Vegetation Area	→	Low Vegetation Area	1,739 ha
High Vegetation Area	→	Bare Land	1,613 ha
Middle Vegetation Area	→	Low Vegetation Area	14,614 ha
Middle Vegetation Area	→	Bare Land	5,162 ha
Low Vegetation Area	→	Bare Land	1,098 ha
Vegetation Increase Area			36,990 ha
Bare Land	→	High Vegetation Area	1,116 ha
Bare Land	→	Middle Vegetation Area	5,653 ha
Bare Land	→	Low Vegetation Area	2,242 ha
Low Vegetation Area	→	High Vegetation Area	8,660 ha
Low Vegetation Area	→	Middle Vegetation Area	607 ha
Middle Vegetation Area	→	High Vegetation Area	18,711 ha
Non Changing Area (Incl. Unclassified area)			257,204 ha

High Vegetation Area : High Dense Vegetation Forest
Middle Vegetation Area : Middle Dense Vegetation Forest, Bush /Shrub, Estate Field
Low Vegetation Area : Mix Garden/settlement, Grassland/Upland Field, Paddy Field

4.3 Land Cover Changing

The result of land cover changing in 7 years from 1985 to 1992 is presented in Table-2. The result image is shown in Photo-3.

4.4 Plot Size and Shape

Table-3 shows the size distribution of plot whose shape index is less than 5.0 against each land cover changing categories.

The sample of extracted plots of vegetation decreasing area is shown in Photo -4.

Table-3 Size Distribution of Land Cover Changing Area

Land Cover Change \ Size	-0.1ha	-0.2ha	-0.5ha	-1ha	-2ha	-5ha	>5ha	0.2 - 5ha
High → Bare	2799	802	753	307	163	73	22	2098
Middle → Bare	3377	1286	1236	719	343	209	99	3793
Low → Bare	1706	668	687	301	93	38	11	1787
High → Low	4059	1349	1277	466	124	32	7	3248
Middle → Low	7543	4615	5495	3209	1578	845	290	15742
High → Middle	10003	6816	8339	4595	1822	530	54	22102
Bare → High	1610	664	721	302	109	29	4	1825
Bare → Middle	3395	1335	1423	809	355	176	70	4098
Bare → Low	1708	690	812	480	221	114	42	2317
Low → High	5678	3457	4353	2648	1055	391	107	11904
Low → Middle	2072	680	483	132	23	1	1	1319
Bare → Bare	1892	660	738	323	109	46	10	1876
Low → Low	5085	2074	2322	1301	611	396	155	6704

High : High Dense Vegetation Forest
Middle : Middle Dense Vegetation Forest, Bush /Shrub, Estate Field
Low : Mix Garden/settlement, Grassland/Upland Field, Paddy Field
Bare : Bare Land

Comparing with color composite image, the authors reached the following requirement for shifting cultivation field concerned as plot size and plot shape:

(1) 0.2ha ≦ (Size of a Plot of Land Cover Change) ≦ 5ha

excluding plots less than 0.2ha as error of the analysis, and excluding plots beyond 5ha as not shifting cultivation fields but something other use area such as residents, transmigrations and estate fields

(2) ARI (Shape Index) ≦ 5.0

excluding linear plots whose ARI beyond 5 as something other land use area such as road

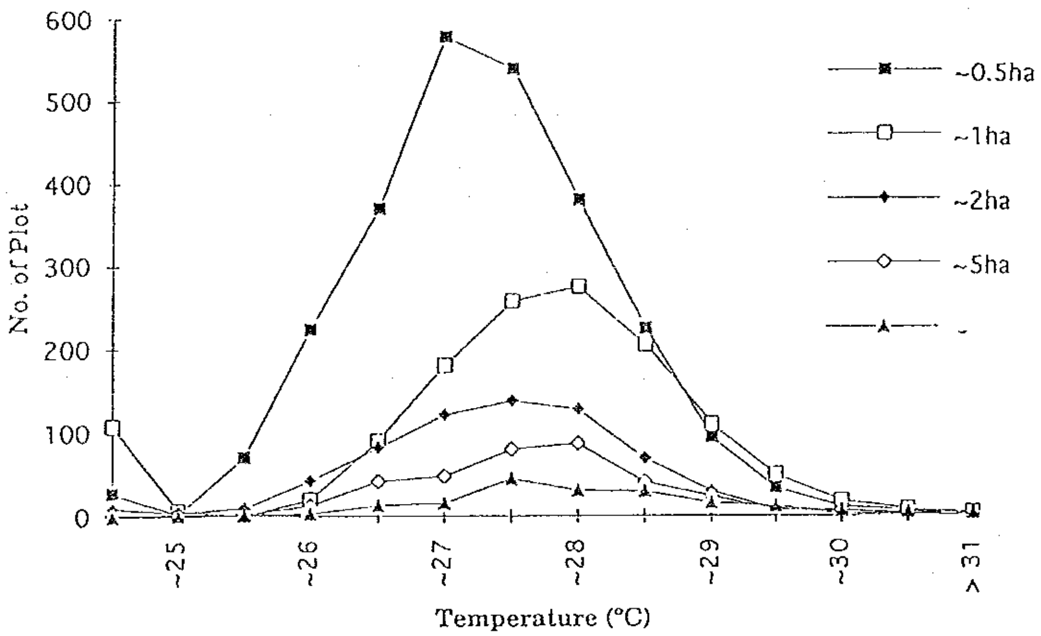
4.5 Temperature

Fig.- 4 shows distribution of temperature of Bare Land plots. A part of plot temperature image is shown in Photo -5.

Since resolution power of Band6-TM is just 120m×120m (= 1.44ha), small size plots are influenced by their surroundings and their temperature are obtained as lower value than real temperature. To evaluate plot characteristics by temperature, at least plots smaller than 0.5ha should be out of consideration.

The authors recognized that most of plots whose temperature are lower than 26°C do not correspond to shifting cultivation field but other land cover changing such as land slide.

Fig.- 4 Temperature Distribution of Bare Land Plot



4.6 Decision Tree for Detection of Shifting Fields

Decision tree for extracting shifting fields is formed by 4 kinds of characteristics of plots, namely, land cover changing type, plot size, plot shape index and plot temperature.

In order to set up the criteria by land cover changing type, the authors make a typical 'Changing Pattern of Vegetation Intensity' on typical land use types as shown in Fig.- 5

Assuming that a cycle of shifting cultivation was from 10 years to 15 years, the authors considered probability of land cover changing in 7years, which corresponded to observation period in this study (1985~1992) as Table-4.

Based on this table, criteria by land cover changing was fixed as follows:

(1) *High Vegetation Area → Bare Land,*

(2) *Middle vegetation Area → Bare Land,*

(3) *High Vegetation Area → Low Vegetation Area,*

(4) *Middle Vegetation Area → Low Vegetation Area,*

(5) *Bare Land → Middle Vegetation Area,*

(6) *Low Vegetation Area → Middle Vegetation Area.*

Criteria by plot size and shape is as follows as described in 4-4:

(1) *0.2ha ≦ (Size of a Plot of Land Cover Change) ≦ 5ha,*

(2) *ARI (Shape Index) ≦ 5.0.*

Criteria by temperature is as the following:

(1) *In case of 1992's plot land cover is Bare Land, Plot Temperature ≧ 26℃.*

Fig.-6 shows the decision tree for extraction of shifting fields.

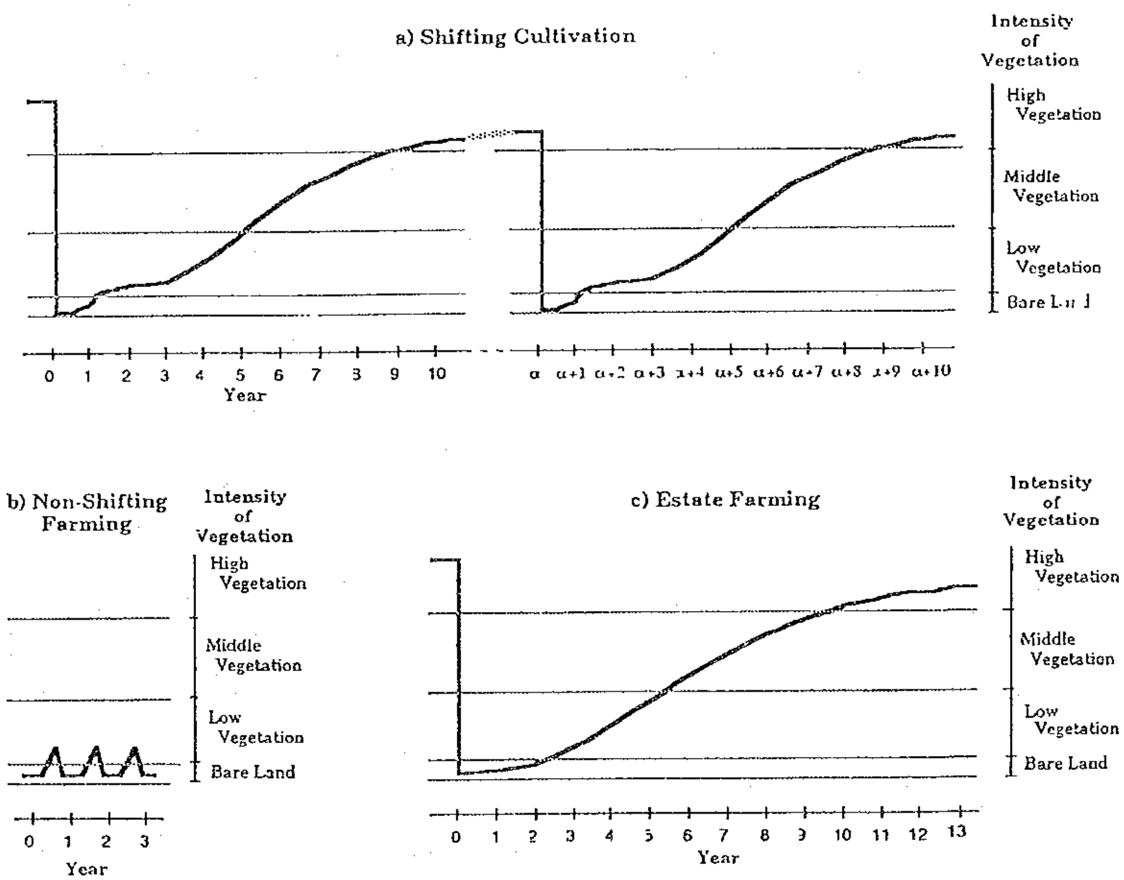


Fig.-5 Changing Pattern of Vegetation Intensity

Table 4 Matrix Table of Land Cover Changing and its Cause

Cause of Land Cover '85 Land Cover ->'92 Land Cover	Shifting Cultivation	Non-Shifting Faming	Estate Prodcution	Other Use Developing (Settlement)	Land Slide
Vegetation Decreasing Area					
High Vegetation → Bare Land	○	×	○	○	○
Middle Vegetation → Bare Land	○	×	○	○	○
Low Vegetation → Bare Land	○	○	○	○	○
High Vegetation → Low Vegetation	○	×	○	○	○
Middle Vegetation → Low Vegetation	○	×	○	○	○
High Vegetation → Middle Vegetation	△	×	△	×	△
Vegetation Increasing Area					
Bare Land → High Vegetation	×	×	×	×	×
Bare Land → Middle Vegetation	○	×	○	×	△
Bare Land → Low Vegetation	△	○	×	○	○
Low Vegetation → High Vegetation	△	×	△	×	×
Low Vegetation → Middle Vegetation	○	×	○	×	△
Middle Vegetation → High Vegetation	△	×	△	×	×
Non Changing Area					
Bare Land → Bare Land	×	○	×	○	○
Low Vegetation → Low Vegetation	○	○	○	○	○
Middle Vegetation → Middle Vegetation	△	×	○	×	△
High Vegetation → High Vegetation	×	×	×	×	×

○ : Probable
△ : Less Probable
× : Improbable

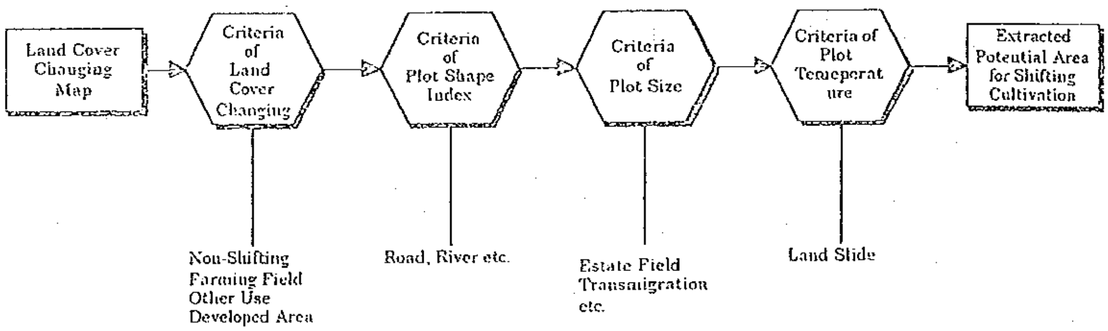


Fig.-6 Decision Tree for Extraction of Shifting Cultivation Fields

Extracted potential plots for shifting cultivation summarized in Table-5 and.

Table-5 Extracted Potential Plots for Shifting Cultivation Fields

Land Cover Type of '92 / Plot Size	Bare Land		Low Vegetation Area		Middle Vegetation Area		TOTAL	
	No. (pcs)	Area(ha)	No. (pcs)	Area(ha)	No. (pcs)	Area(ha)	No. (pcs)	Area(ha)
0.2-0.5ha	1,897	637	6,772	2,278	5,776	1,953	14,445	4,868
-1ha	988	699	3,675	2,576	3,457	2,451	8,120	5,726
-2ha	482	689	1,702	2,405	1,410	1,971	3,594	5,064
-5ha	279	840	877	2,587	567	1,684	1,723	5,112
0.2 - 5ha	3,646	2,866	13,026	9,845	11,210	8,060	27,882	20,770

The decision tree made in this study could not distinguish 'Shifting Cultivation Fields' and 'Estate Fields' that is smaller than 5.0ha, therefore the values in Table-5 are considered to indicate larger value to some extent than actual condition of 'Shifting Cultivation Fields'. However, the values are deemed to show tendency of distribution pattern of shifting cultivation fields in this region.

Based on the results, the potential map of shifting cultivation fields was made as shown in Photo-6.

V. Conclusion

1) The authors estimated how far the shifting cultivation fields could be detected spatially and quatitatively by using multi-temporal satellite imageries.
2) High potential plots for shifting cultivation field were extracted by means of the decision tree which consisted of 4 criteria, namely, land cover changing type, size, shape index and temperature.
3) Total area of potential plots for shifting cultivation field extracted by the decision tree reached 20,770ha (6.2% of the study area).
4) Plots extracted by the decision tree have possibility to include other land use such as estate field, however, the results are deemed to reflect the tendency of distribution pattern of shifting cultivation fields in this region.
5) Only 2 sets of satellite data were used in this study, but if more sets of data could be used, the accuracy of results would be improved.

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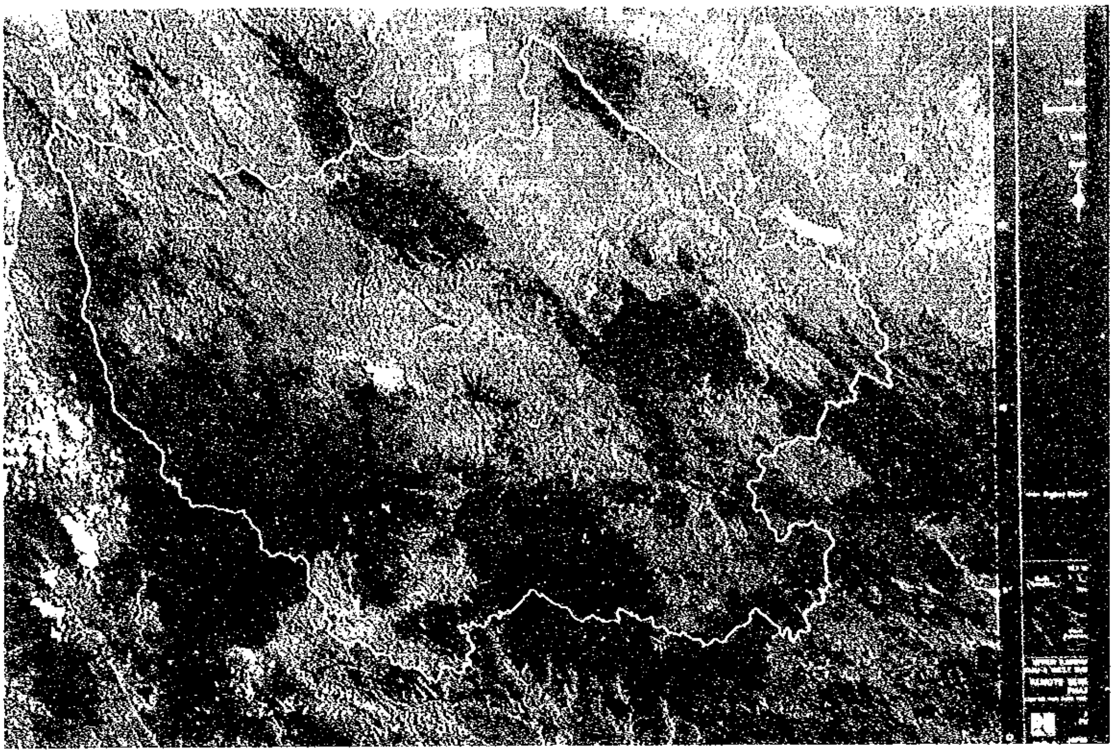
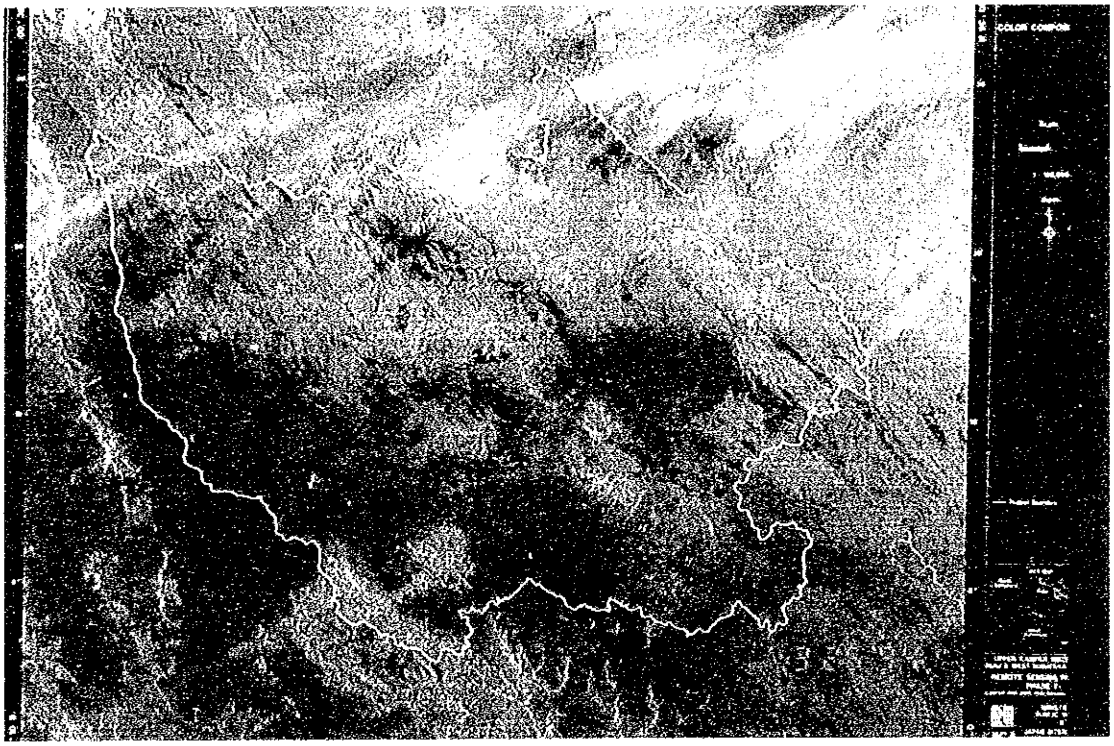
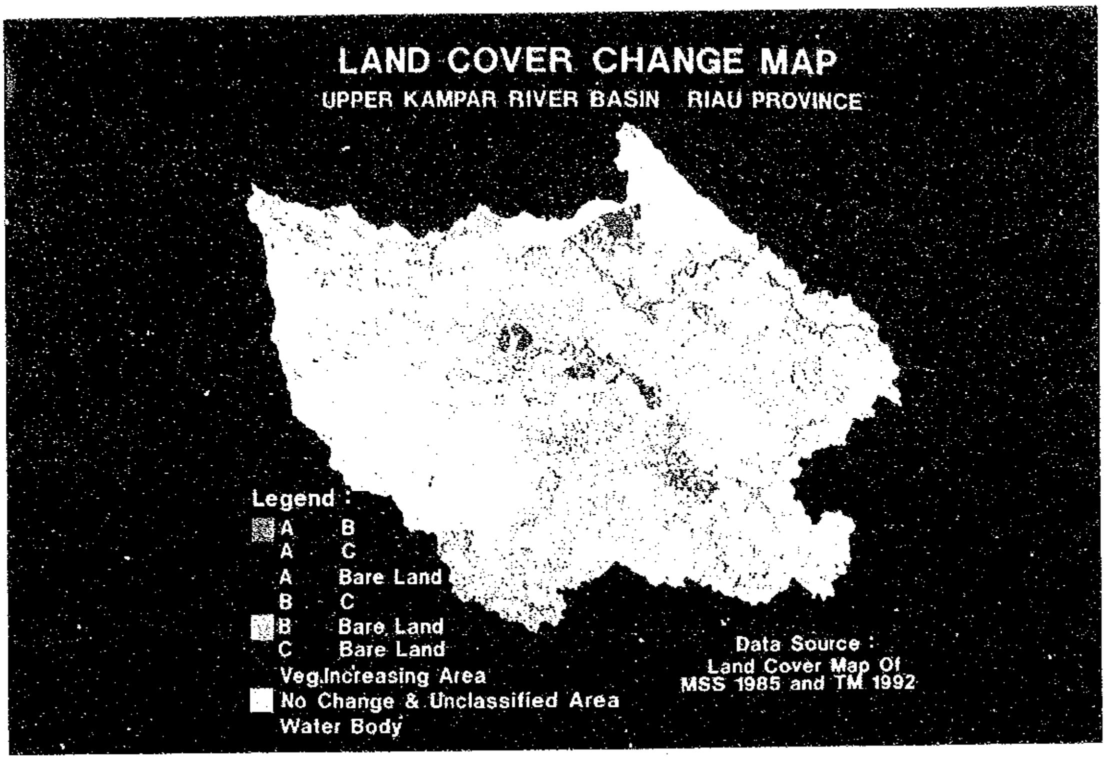


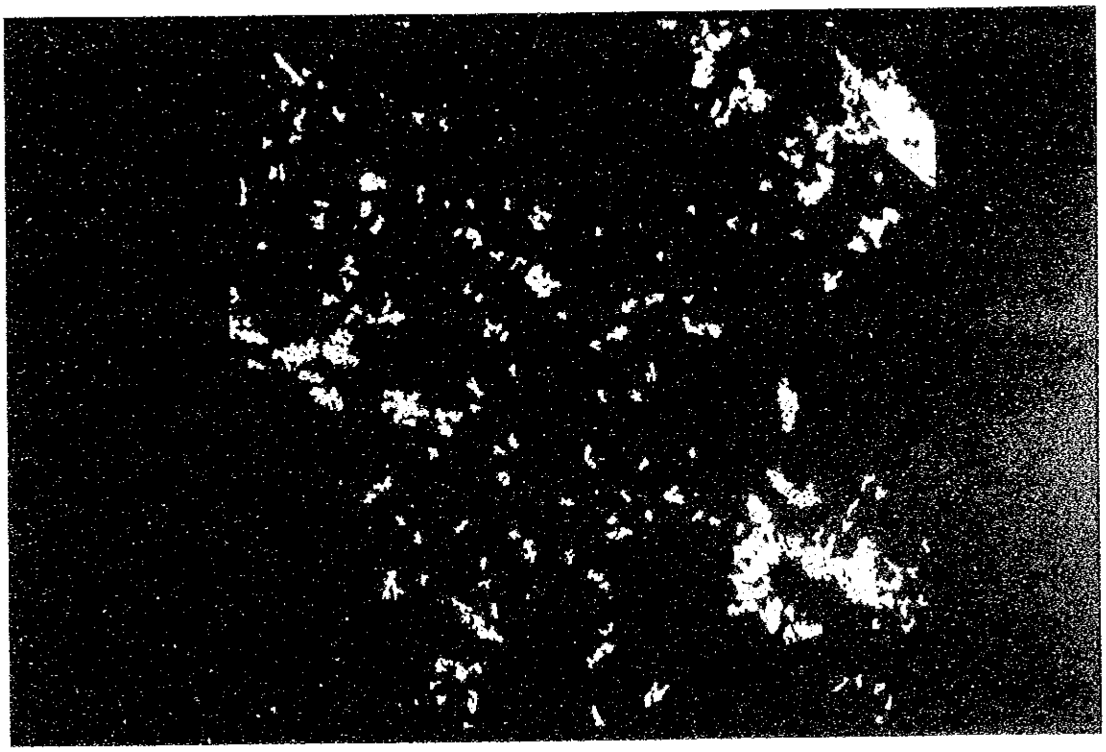
Photo— 1 . Color Composite Image of TM



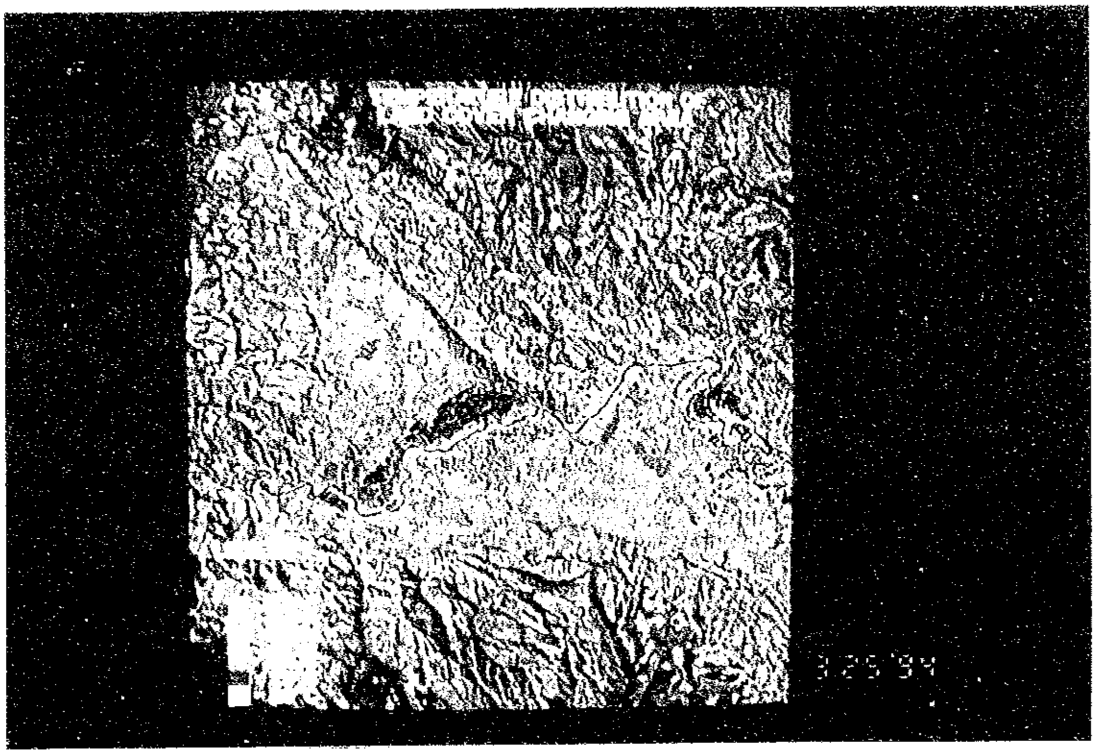
Photo— 2 . Color Composite Image of MSS



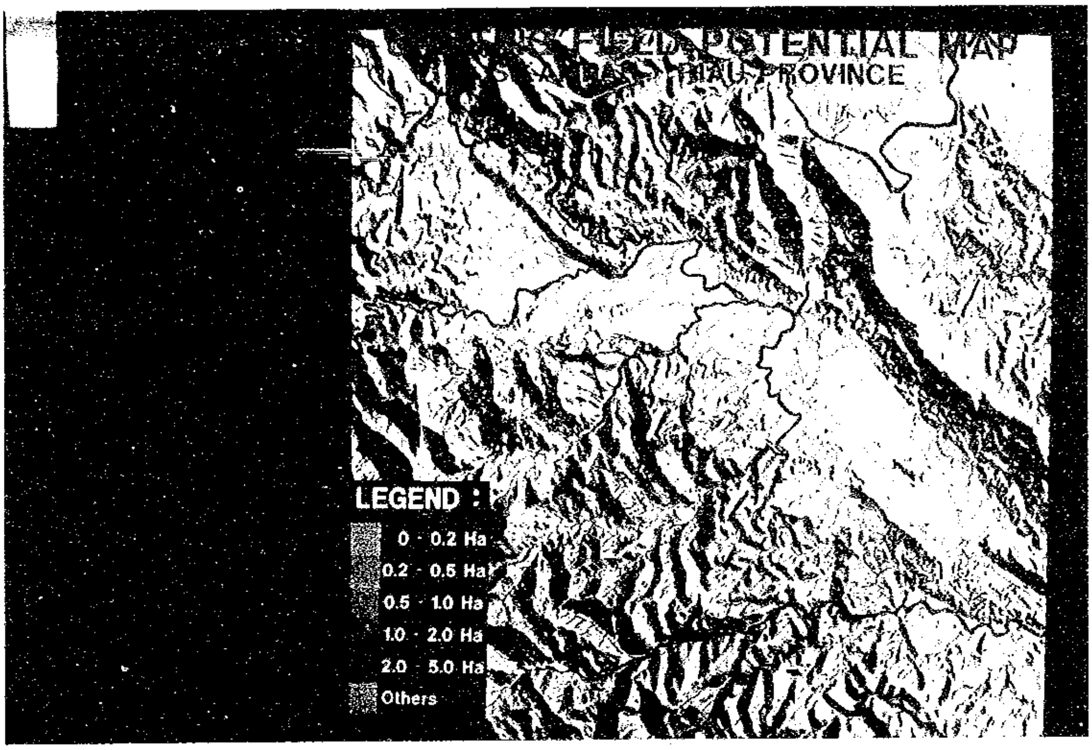
Photo— 3 . Land Cover Change Map



Photo— 4 . Extracted Plot of Vegetation Decreasing Area



Photo— 5 . Temperature Distribution of Land Cover Change Area



Photo— 6 . Shifting Field Potential Map

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