3.4. Making of vegetation map

The classification of vegetation on the North Banten area was made by combining the results of photo interpretation and the field survey. And the result of it is shown in Table 3.4. The vegetatopm map was corrected by re-interpretation on the basis of the result shown in Table 3.4. The vegetation map is shown in Fig. 3.6. The land in the target area has been cultivated for relatively long period and primary forest is only found in the mountain crest and slope. In the relatively high elevation areas the secondary forest exsists mixed with coconut palm. It is also found in some areas which is thought as shifting cultivated field in the past. The hilly area is covered with mixture of the secondary forest, coconut palm, paddy field and in accordance with the irrigation situation the pattern is detailed and complicated. The alluvial areas is used mostly for paddy fields and depending on the irrigation double cropping are conducted (two season harvest on two type harvest).

Table 3.4. Classification of vegetation cover in North Banten.

NO.	CLASSIFICATION OF VEGETATION COVER
1.	Primary forest
2.	Secondary forest
3.	Secondary forest, coconut palm (Mix each other)
4.	Coconut palm (Dominant trees)
5.	Swampy forest
6.	Mangrove forest
7.	Bush, Grassland
8.	Bush, Coconut palm
9.	Swampy, Grassland
10.	Paddy field, Coconut palm
11.	Paddy field, Coconut palm (Wet season only)
12.	Paddy field (Wet season only)
13.	Paddy field (either wet or dry season)
14.	Fish pond
15.	Rubber plantation
16.	Others.

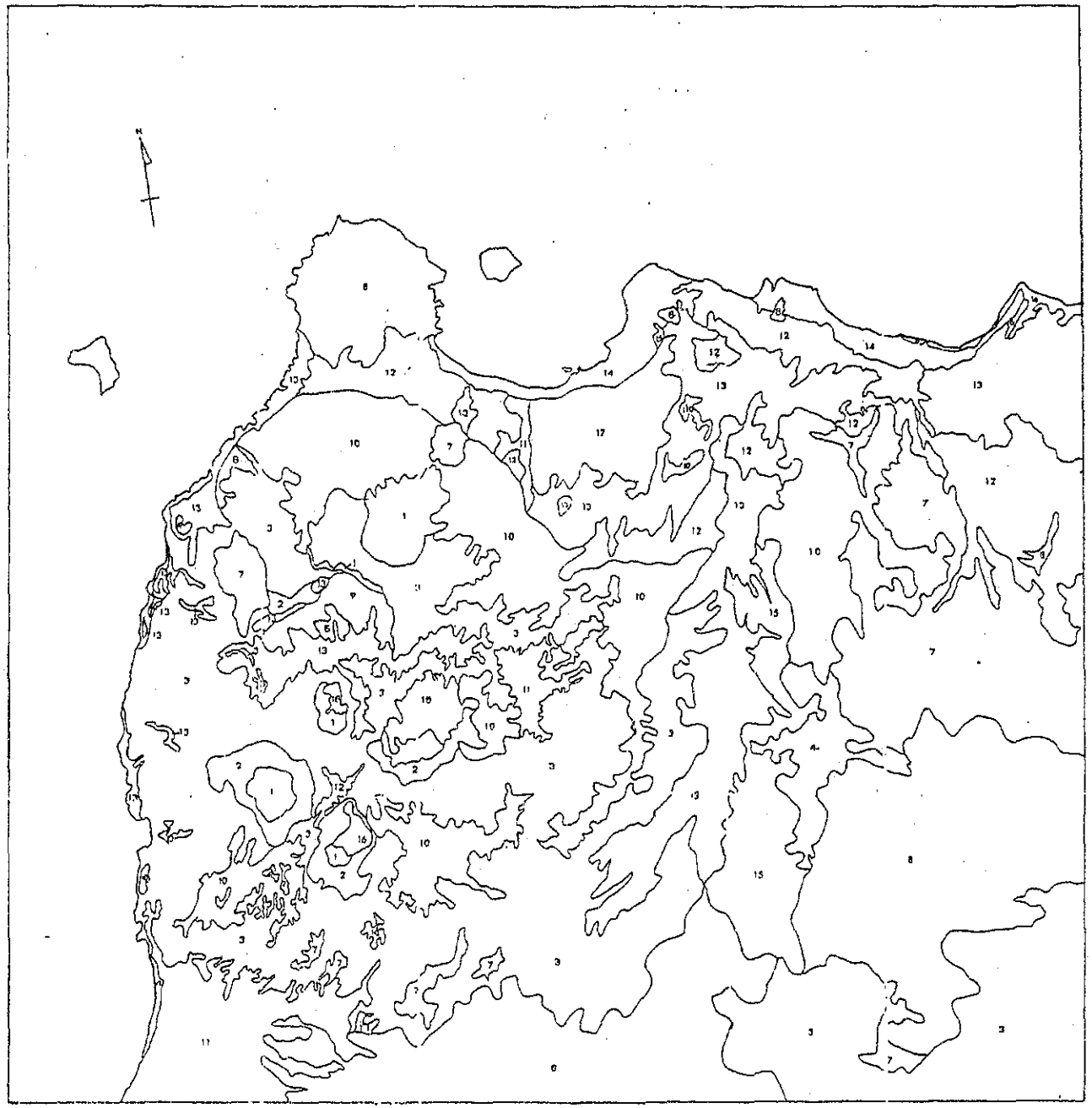

FIG. 3.6. VEGETATION MAP

LEGEND

1 Primary Forest
2 Secondary Forest
3 Secondary Forest, Coconut Palm
4 Coconut Palm
5 Swamp Forest
6 Mangrove Forest
7 Bush, Grassland, Alang-Alang
8 Bush and Coconut Palm
9 Swamp Grassland
10 Paddy Field, Coconut Palm
11 Paddy Field, Coconut Palm; Wet Season Only
12 Paddy Field, Wet Season Only
13 Paddy Field, Either Wet or Dry Season
14 Fishpond
15 Rubber Plantation
16 Others

1 : 500,000

4. Analysis of vegetation and natural condition

4.1. C o n c e p t

The relation between suitable land for agricultural development and natural condition has been reported several times by experts. According to the report made by Mr. Matsuo (short term agrarian forming expert) as the result of relevant analysis of suitable land for agricultural development and natural condition, elevation and slope is closely related. In this report a study is made for the suitable land for agricultural development by trying to make an analysis by overlaying method the relation between the present vegetation with elevation and slope using the above mentioned result. There are two kinds of overlaying methods, mesh metnod and analog method. However, since the relation between vegetation with elevation and slope is comparatively clear, the analog method is used here.
Now, data of elevation and slope are derived from elevation classification map and slope classification map that have been compiled in this project.

4.2. Vegetation and elevation

As shown in Fig. 4.1. the relation between vegetaion and elevation is found by overlaying the thematic map and check the ratio of each elevation for each classification of vegetation. The result can be seen in Table 4.1.
In the result it can be seen that in the North Banten area there is a certain relation between the vegetaion and elevation. It can be seen taht the tendency of vegetation in this area from the low elevation area to the high elevation area the order of vegetation is paddy fields, paddy fields-coconut palm, coconut palm, the secondary forest, and the primary forest.

Table 4.1. Relation between vegetation and elevation

Classification of Vegetation cover	ELEVATION							
	0-25m	25-100m	100-200m	200-500m	500-700m	700-1000m	1000-1000m	1500m -
1. Primary forest				o	o	◯	◎	◯
2. Secondary forest			o	◎	◯	◯	o	
3. Secondary forest Coconut palm	◯	◎	◎	◯	o			
4. Coconut palm	◯	◯						
5. Swamp forest		o						
6. Mangrove forest	o							
7. Bush Grassland	o	◎	◯	o				
8. Bush, Coconut pakm	◯	◎						
9. Swamp Grassland		o						
10. Paddy field coconut palm	o	◎	◯	◯	o			
11. Paddy filed (wet) Coconut palm	◎	◯	o					
12. Paddy field (wet)	◎							
13. Paddy field (wet, dry)	◎	◯						
14. Fish pond	◯							
15. Rubber plantation	o	◯						
16. Others.					o	o	o	o

◎ Much

◯ Middle

o Least

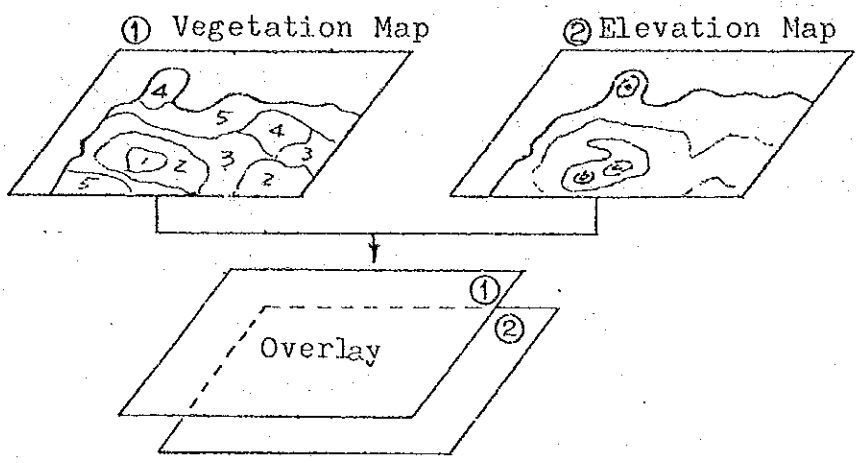

Fig.4.1 Vegetation-Elevation

In other words, paddy fields are found in the elevation of 0 - 25 maters, paddy fields-coconut palm in 25 - 100 meters, coconut palm 100 - 700 meters. And the secondary and primary forests are found in elevation of higher than 700 meters. Thus in the North Banten area lands of upto 700 meters elevation are used for agriculture purpose and therefore, it can be regarded that lands under 700 meters elevation are suitable for agriculture.

4.3. Vegetation and slope

The analysis of relation between the vegetation and elevation is conducted by the same way in case of vegetaion and elevation as shown in Fig. 4.2. The result can be seen in Table 4.2. Similar to relation between the vegetation and elevation in the relation between vegetaion and slope, here is a tendency from the low elevation area to the high elevation area the order of vegetaion is paddy fields, paddy fields-coconut palm, coconut palm, the secondary forest and the primary forest. The slope for paddy fields is 0 2 %, paddy fields-coconut palm 2 - 15 %, coconut 15 - 40 %. Therefore, it can be regarded that lands with slope of less than 40 % are suitable for agricultural development.

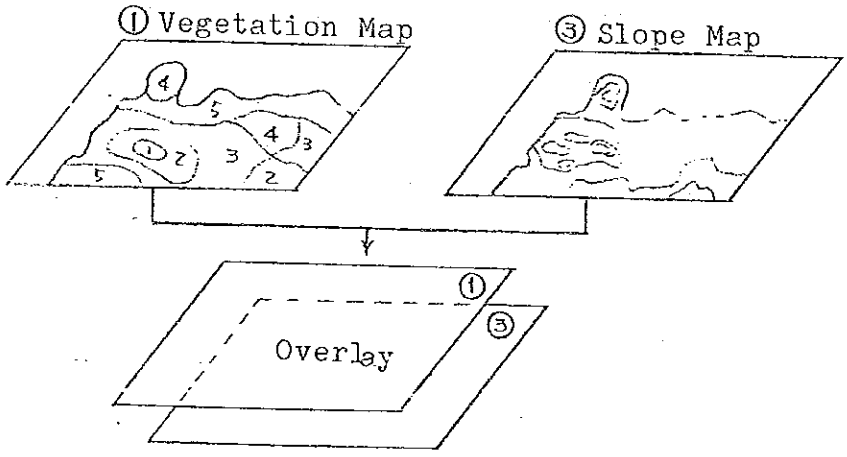

Fig.4.2 Vegetation-Slope

Table 4.2. Relation between vegetation and slope.

Classification of Vegetation	S L O P E			
	0-2%	2-15%	15=40%	40%-
1. Primary forest		○	◯	◎
2. Secondary forest		○	◯	◎
3. Secondary forest Coconut palm	○	◯	◎	○
4. Coconut palm	○	◯		
5. Swampy forest	○			
6. Mangrove forest	○			
7. Bush Grassland	○	◎	◯	○
8. Bush, Coconut palm	◯	◎	○	
9. Swampy Grassland	○			
10. Paddy field Coconut palm	◎	◯	○	
11. Pady field (wet) Coconut palm	◎	◯		
12. Paddy field (wet)	◎			
13. Paddy field (wet, dry)	◎	◯		
14. Fish pond	◯			
15. Rubber plantation	◎	◯	○	
16. Others			◯	◎

◎ Much

◯ Middle

○ Least

4.4. Study of suitable land for agricultural development

For the suitable land for agricultural development, from the relation between condition of the North Banten area with elevation and slope, evaluation is made for the suitable land as shown in Table 4.3.

Fig. 4.3. shows the result.

Table 4.3. Evaluation of suitable land for agricultural development.

Slope / Elevation	0-2 %	2-15 %	15-40 %	40 %-
0-25m	I	II	III	IV
25-100m	II	II	III	IV
100-200m	III	III	III	IV
200-500m	III	III	III	IV
500-700m	III	III	III	IV
700-1000m	IV	IV	IV	IV
1000-1500m	IV	IV	IV	IV
1500m-	IV	IV	IV	IV

I : Suitable for paddy fields, farmland, orchards.

II : Suitable for farmland, orchards.

III : Suitable for orchards

IV : Unsuitable for agricultural development

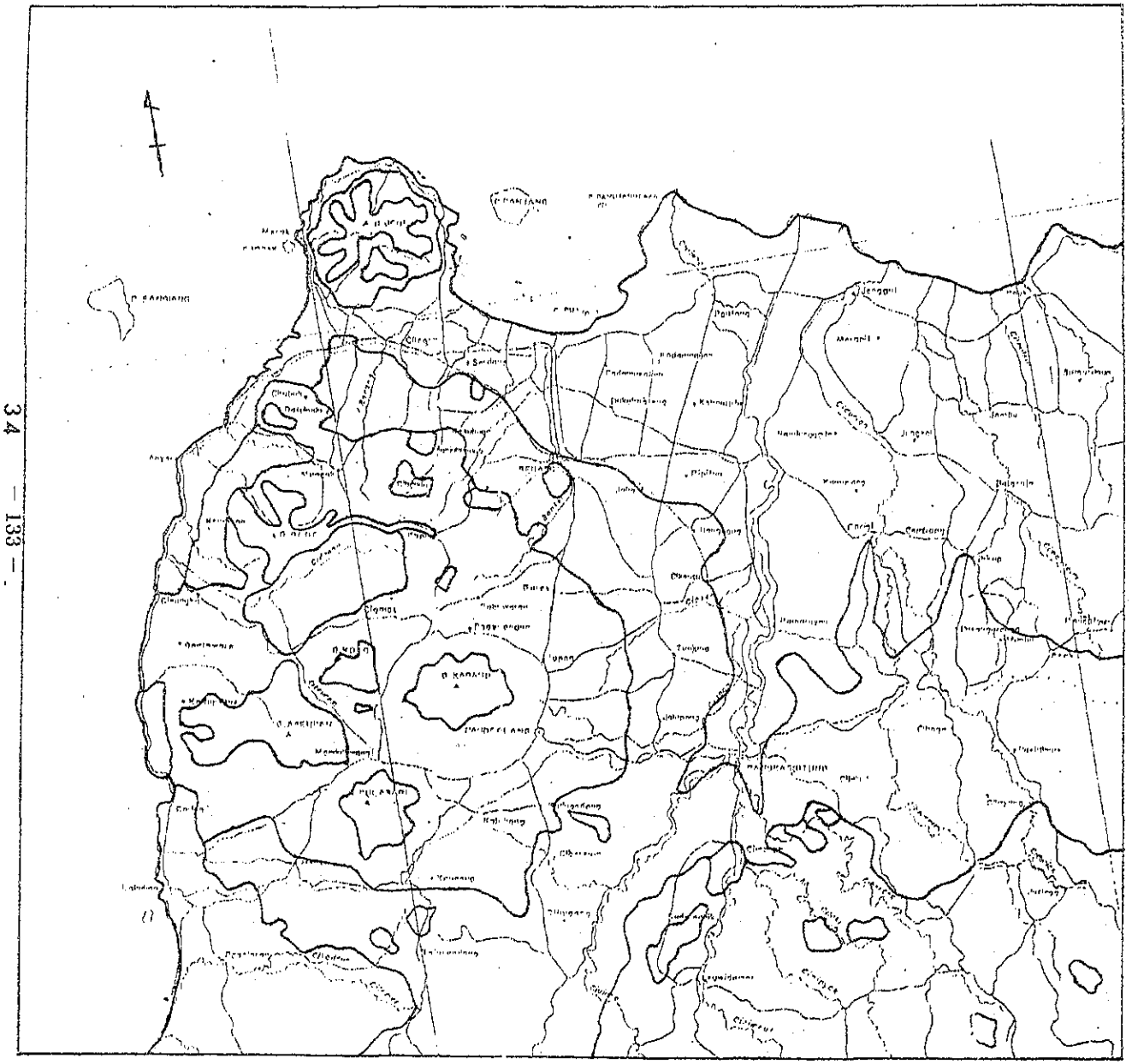

Fig. 4.3.

Evaluation map of suitable land for agricultural development.

LEGEND :

- Suitabel land for paddy fields, farmland and orchards.
- Suitable land for farmland orchard
- Suitable land for orchard
- Unsuitable for agricultural development.

1 : 500,000

I. Suitable land for paddy field, farmland, orchard.

Areas with 0-25 m elevation and 0-2% slope. At present most of these lands are used for paddy fields, and depending on the irrigation condition, the harvest is once or twice a year. If irrigation is sufficient, this is suitable for ideal paddy fields.

II. Suitable land for farmland, orchard.

Areas with 0-100 m elevation and 0-15% slope. At present area II is used for paddy fields and coconut palms. However, judging from the topographic condition, it is better to use this land for farmland. Therefore, it is suitable for farmland. It is thought that this area is mainly hilly land and the soil is a bit dry. However, depending on the irrigation this area can be used as paddy fields.

III. Suitable land for orchards

Areas with 0-700 m elevation and 0-40% slope. Judging from the elevation and slope, area III is difficult to turn into agricultural land. Even if it is done, there is danger of soil erosion. Therefore, this area is suitable for orchards. At present this area is used mostly to plant coconut palms.

IV. Unsuitable land for agricultural development

Areas with elevation over 700 m and slope over 40%. The elevation is high and the slope is steep and since this is not suitable for agriculture. It must be maintained as forest to prevent soil erosion and water keeping purposes.

5. Vegetation in North Sumatera

This North sumatera is a target area for the site selection of suitable area for agricultural development in this project.

In this chapter, the present vegetation in North Sumatera is explained, based on field survey, comparing with it in North Banten above mentioned.

The elements of the vegetaion in North Sumatera (arround Medan) are mainly the primary forest and the secondary forest in mountainous area, the farmland in hilly area, and the plantation area in the lowland.

In the mountainous area, the land higher then 1000 m is almost covered with forests. Depending on the topographic condition the forests divide into the primary forest (photo 7) and the secondary forest. And the pine plantations are found in some places. The hilly land is used for a large scale farmland, and maize, cacao, and some kinds of vegetable are planted there. In the lowland, large scale plantations, planted oil-palm (photo 9) or rubber tree are found. Paddy fields (photo 10) are found on a small scale in the plain of the buttom of the valley.

The characteristics of vegetation in North Sumatera area, comparing with it in North Banten area, are shown in below.

(1) The primary forest comparatively remains in high elevation area.

(2) The hilly land is used for a large scale farmland.

(3) The lowland is used for the plantation of oil-palm or rubber tree on a large scale.

(4) Paddy fields struggle in the plain of the buttom of the valley or a small scale.

Thus, the agricultural land in Indonesia has various kinds of type depending on the location. Therefore, in case of the site selection of suitable area for agricultural development, it is thought that we need grasp the situation of utilization in not only North Banten area, but also North Sumatera and so on.

PHOTO -7 PRIMARY FOREST

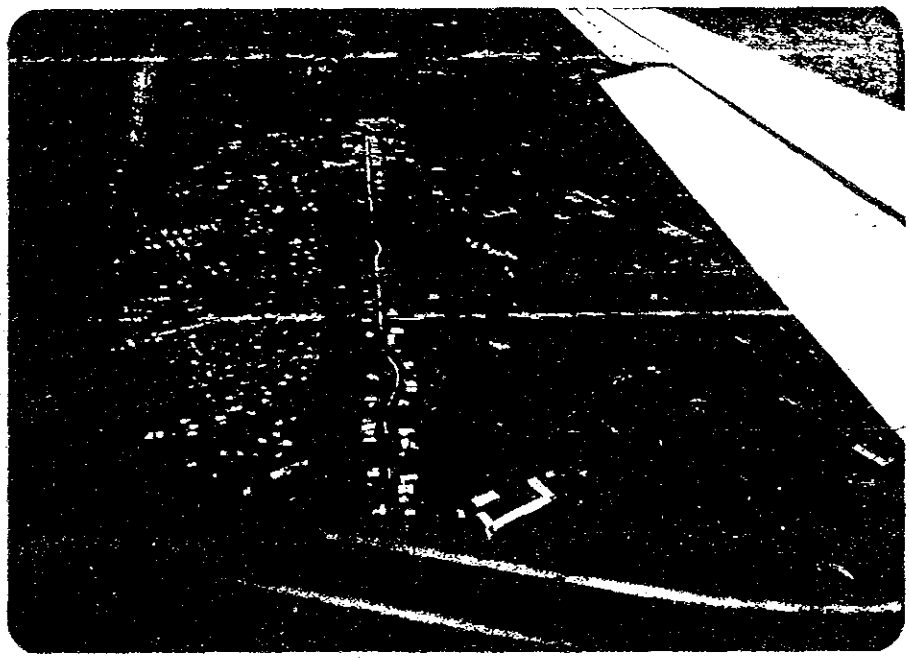

PHOTO -8 FARMLAND

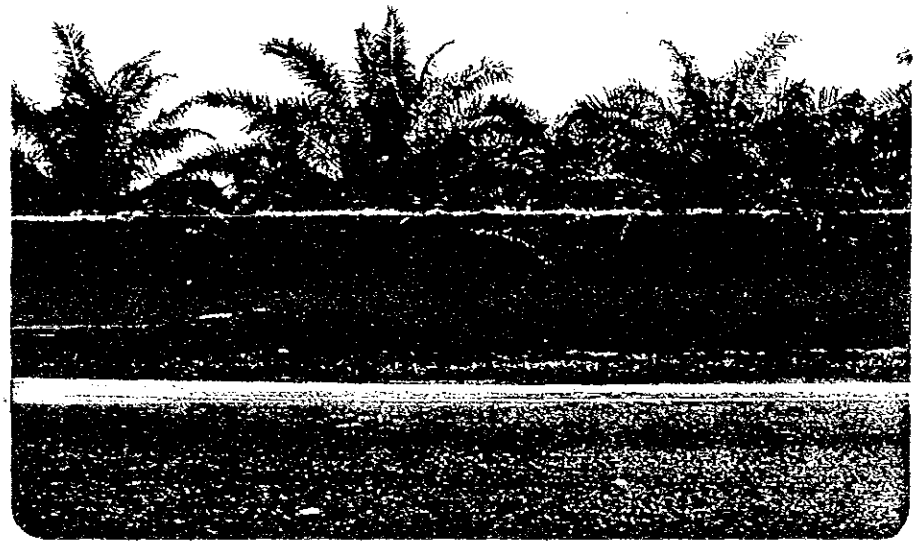

PHOTO -9 OIL PALM PLANTATION

PHOTO -10 PADDY FIELD

6. Conclusion

6.1. Interpretation of aerial color infrared photographs.

By the interpretation of aerial color infrared photographs taken for the swampy area, the variety, height and density of trees, the height, area of grassland can be correctly interpreted. And from the difference of the type of environment, the condition of location can be grasped upto a certain extent. Therefore, it is considered that for unopened areas where field survey is not possible, the aerial color infrared photographs have high potential to substitute the field survey.

6.2. Making of vegetation map by the interpretation of Landsat Image

From the result of the making of vegetation map by the interpretation of Landsat Image (1 : 250,000) it is possible to sufficiently grasp the vegetation condition of North Banten area. However, in this case, the vegetation pattern of the Landsat Image is not clearly expressed and the field survey has more weight in the result. Therefore, it is considered necessary to produce an effective Landsat Image for vegetation interpretation in the future.

6.3. Analysis of vegetation and natural condition

From the result of analysis of vegetation and natural condition (elevation, slope) in North Banten area it was known that the agriclutural lands were found in areas with elevation under 700 meter and slope under 40% and the land use was suited to each elevation and slope.

From the result it is possible to estimate that in the North Banten area, suitable area for agriculture, for paddy fields are land with elevation of 0-25 m and slope of 0-2%, for farmland elevation of 0-100 m and slope of 0-15%, for orchards elevation of 0-700 m and slope of 0-40%.

In the future it is hoped that analysis using natural condition other than elevation and slope and analysis for other areas can be conducted.

ランドサットデータを用いた農業開発のための土地評価システムの確立
北スマトラ・アサハン地域への適用

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はじめに

本プロジェクトの大きな課題は，リモートセンシング技術とコンピュータによる情報システムとをいかに有機的に組合せ，実際の農業開発適地選定に利用するかという点にある。このために，コンピュータによる情報システムを利用して，リモートセンシングによって得られる土地利用，水系，植生などの情報と，地形，土壌，気象などの農業開発に必要な既存の情報とを有機的にインテグレイトすることにより，農業開発のための広域的で詳細な土地資源の解析と評価手法を模索している。

しかし広大な国土の上に，多くの未開発地をもつインドネシアにおいては，農業開発適地の選定に際して，最も重要な自然立地条件（地形，土壌，水系等）を十分に調査することは不可能である。その上，高温と豊富な雨量に恵まれた大地は，一年中植生に被れているため，空から地表を直接的に探査することも困難である。しかし，地表を被う植生型を判読し，これによって環境要因を推定することができれば，より有機的・統一的に農業適地を選定することができるはずである。なぜなら，自然環境要因の総和が植物体を通じて植生型となって再現されるからである。

第Ⅰ章　目　　的

農業開発は自然立地条件の評価，および農業経済的立地条件の評価にもとずいて計画，実施される。このうち本プロジェクトは，北スマトラ地域の自然立地条件の評価を主な目的としている。

インドネシアリモートセンシングプロジェクトにおいては，すでに農業開発適地選定のための各種主題図が作成され，一部の地域については，これらを組合せてのランキング法による評価図も作成され，評価システムの確立と評価精度の検定が要求されている。

今回の派遣期間中，筆者らは以下の点について解析ならびに検討を行った。

1. 農地開発に関する土地評価システムの確立
2. このシステムのアサハン地区への適用
3. 評価精度の検定

今回，ここに呈示した手法の特徴は，①各種主題図を 500 m × 500 m のグリッドセルデータファァイルとしてインテグレートした点，②土地評価の一つの情報源として植生型を用いたこと，③利用しうるデータ（主題図）の量と質に応じて3段階の評価ステップを提案し，それぞれの条件下での評価を行ったことなどである。

第Ⅱ章　ASAHAN 地域の概要

Ⅱ－1　立　　地

位置および行政単位

トレーニングエリアは北緯 2°00′ から 3° 30′，東経 99° 00′から 100° 15′に位置し，

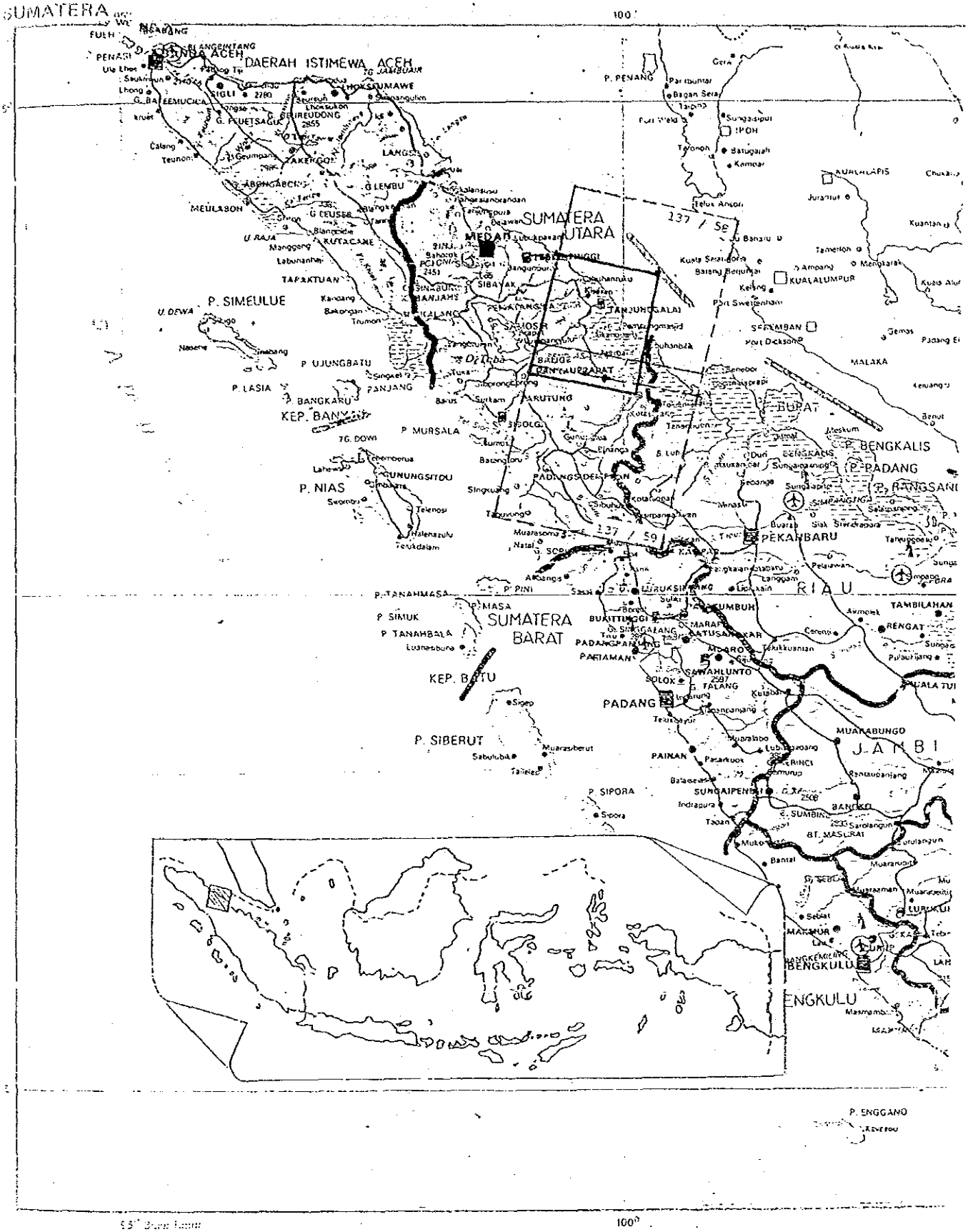

Fig. 1 Location of Target Area (Asahan area)

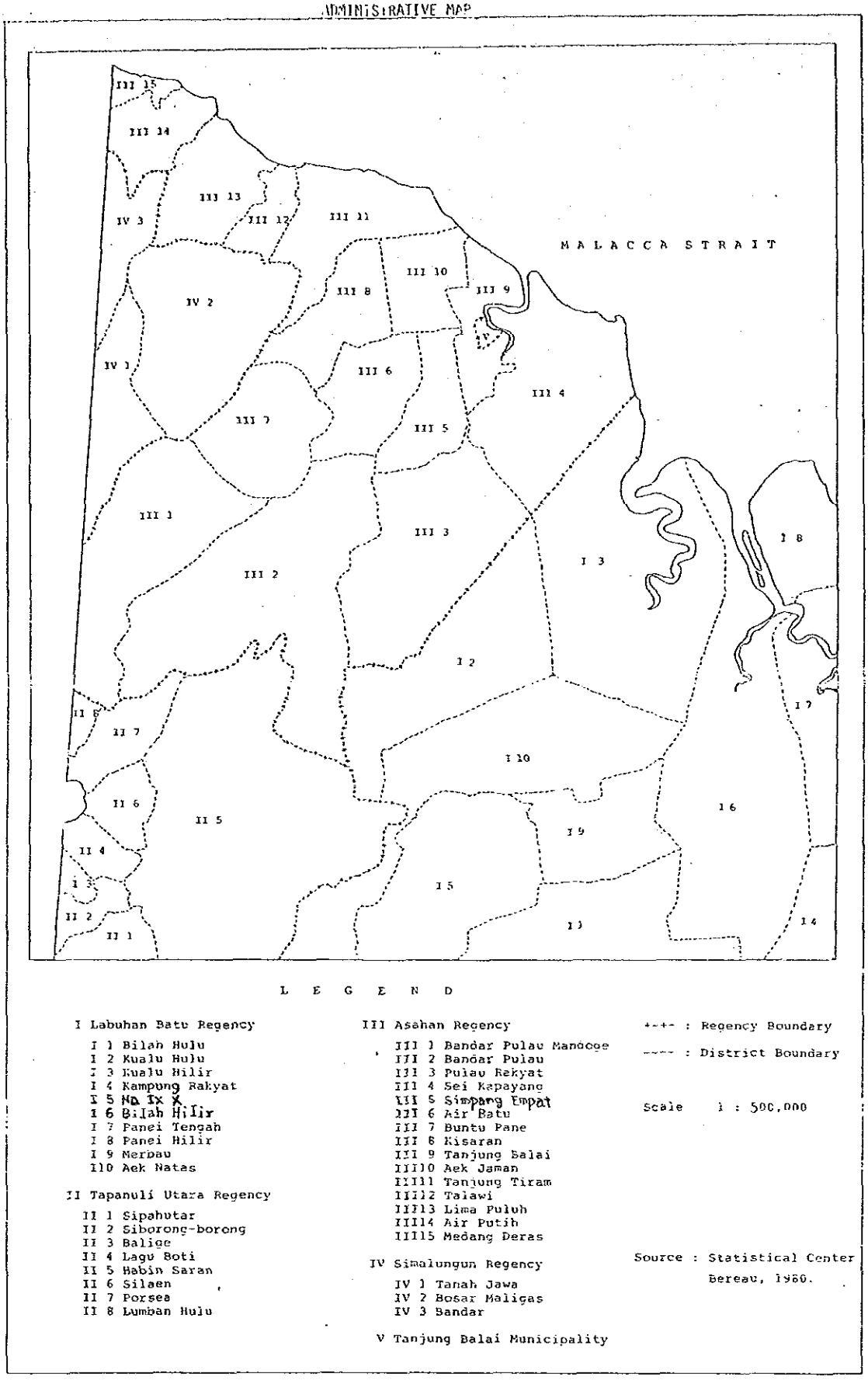

Fig. 2 Administrative Map of Target area

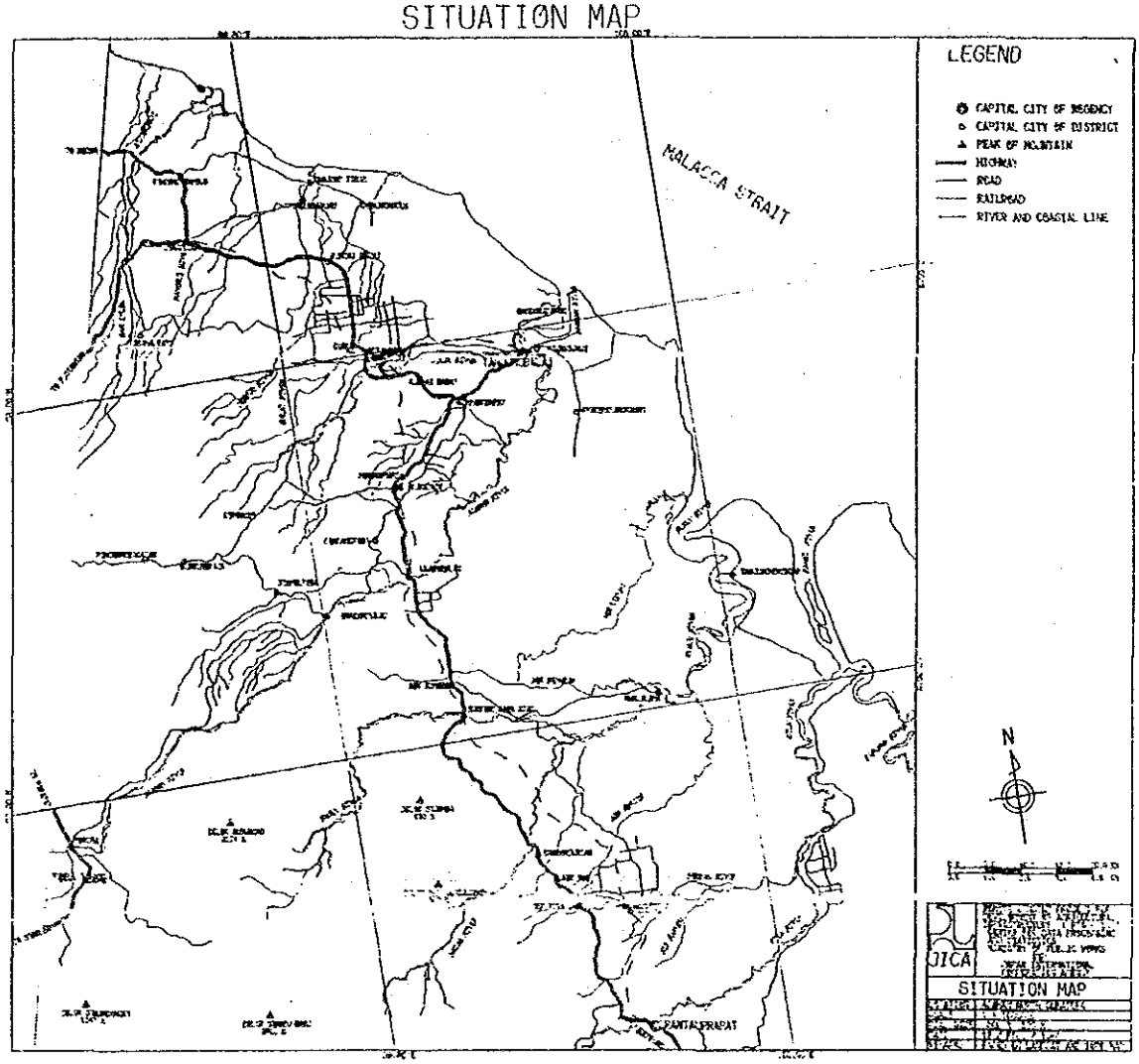

Fig. 3 Topograph and road map of the target area

南北 140 *km*，東西 125 *km*にまたがっている（Fig. 1）。行政単位としては，北スマトラ県（Sumatera Utara Propinci）のUabuhan Batu, Tapanli Utara, Asahan, Simalungun の 4 つの郡（Kapupaten）と 1 つの町 Tanjung Balai（Kota Madya）を含み，この中で人口約 280 万人が生活している（Fig 2）。〔Kantor Statistik Sumatera Utara, 1981〕

地　形

対象とする地域（Fig. 3）は地形的に大きく 3 つに分けられる。Surungan 山（2174 *m*）と Panindi 山（1627 *m*）の 2 つの山塊が対象地域の南西部を占めている。またアサハン川以北のマラッカ海峡側の大地は，オイルパーム，ゴムなどのプランテーションとしてすでに開発されている。ここより南半分の北東斜面を，Asahan 川，Kualu 川，Bali 川の 3 つの大きな河川がマラッカ海峡に向けてゆるやかに流れ込み，それぞれの川の間に広大な湿原を形成している。これらの湿原は河口から 50 *km* 以上の内陸にまで及んでいるが，まだほとんど開発されていない。この他，3 つの大河川に沿って沖積平野が認められる。

気　候

雨季はふつう 9 月から 4 月まで，乾季が 5 月から 8 月までとされている。雨季の月間雨量は 300 *mm* 程度だが，乾季でも 150 *mm* 程度の雨が期待できる。年間雨量は海岸沿いが 1500 ～ 2000 *mm*，平野部 2000 ～ 2500 *mm*，低山地部が 2500 ～ 3000 *mm* で最も多い。

Ⅱ－2　熱帯常緑降雨林の特徴

植生的に見るならば，スマトラ島は熱帯常緑降雨林帯に含まれる。この地域は熱帯雨林気候と呼ばれる気候帯に属し，月平均気温は 26 ～ 30 °C，年降雨量は 2000 *mm* 程度で，著しい乾季がない点に特徴がある。

熱帯常緑降雨林は，地球上で最も多様で，繁茂した植物群落を形成し，高さ 30 *m* 以上の好湿性の常緑樹から成り，太い茎をもったつる植物と，草本，木本の着生植物に富む。植生は上，中，下の 3 つの高木層と低木層および地表層から成り，出現種数は 1 *ha* で 100 種を越すといわれている。

土壌は熱帯性沖積土壌，低地熱帯性ポドソル，熱帯性泥炭土壌，ラトゾル，赤黄色ポドソルなどがあり，気候，地形，および土壌との相互作用により，スマトラにおいては Table 1 のような森林群系を形成している（Whitmore, 1975）。逆にいうならば，森林群系からその他点の土壌や気候条件を推察することができる。

Ⅱ－3　北スマトラにおける農業生産

Table 2 は北スマトラ県の主要農産物の作付面積，生産量，収益性についての統計値である。

作付面積としては水田が最も多く，乾湿田合計で約 60 万 *ha*，ゴム 34 万 *ha*，オイルパーム 19 万 *ha* がこれについでいる。これらの面積のうち，ゴムの 47.5%，オイルパームの 99.1% がプランテーションによるものである。

水田のヘクタール当り生産量は，かんがい地区で3.7トン，その他で1.9トンであった。面積当りの収益性は，クローブ（丁字）が最も高く，茶，オイルパーム，ゴム，コーヒー，米，ココナツの順であった。

この他山岳地域では木材生産が主な産業であり，1年に100万m^3の木材を生産している。

第Ⅲ章　解析のフローおよび使用データ

Ⅲ－1　解析の流れ

Fig. 4に土地評価のための解析の主な流れを示した。対象地は北スマトラのアサハン川流域とした。

第1ステップの解析では，ランドサットフォールスカラー写真（Photo. 1）のアナログ判読によって得られた地形分類図と植生型分類図を使用し，ランキング法で土地評価を行った。このステップでは，対象地域の概要を把握できる。

第2ステップの特徴は，ランドラットＭＳＳデータのディジタル解析結果を用いた点にある。ＭＳＳデータの教師なし分類によって得られた土地被覆図を軸として，1ないし3枚の主題図（ランドサットデータより得られたもの）を重ねてプレ評価を行った。この評価過提にはランキング法とパターン法を使っている。

第3ステップはRegional　assesmentを目的とした総合評価過程である。ここでは，これまでに得られている１１の主題図（ランドサットデータ及び既存データ）のすべてを，500 m × 500 mのグリッドセルファイルデータに直し，これらを重ね合わせて土地評価を実施した。評価手法としてはランキング法とパターン法を用いた。また，評価のためのランキングテーブルやパターン法の評点付けの資料として，第2ステップで得られたプレ評価図と各主題図とのクロス表分析結果を使用した。

Ⅲ－2　使用したランドサットデータおよび補助データ

解析には1977年4月29日に撮られた2枚のランドサットシーン（シーン番号 8282802342500，8282802344500）を用いた。補助データとしては地形図（1：250,000），地質図（1：250,000），降雨表，土壌図（1：1,000,000）等であった。

この他，1983年3月13日に撮影された赤外カラー空中写真（Kodak　2443）を併用した。撮影高度は10,000 ft，縮尺1：20,000であった。

Ⅲ－3　使用した主題図

次の１１の主題図（グリッドセルデータファイル）は予めインドネシア側カウンターパートが作成したものであり，土地評価に使用した。

a. 標　高　図　（Photo. 2）

d. 傾　斜　図　（Photo. 3）

c. 土　壌　図　（Photo. 4）

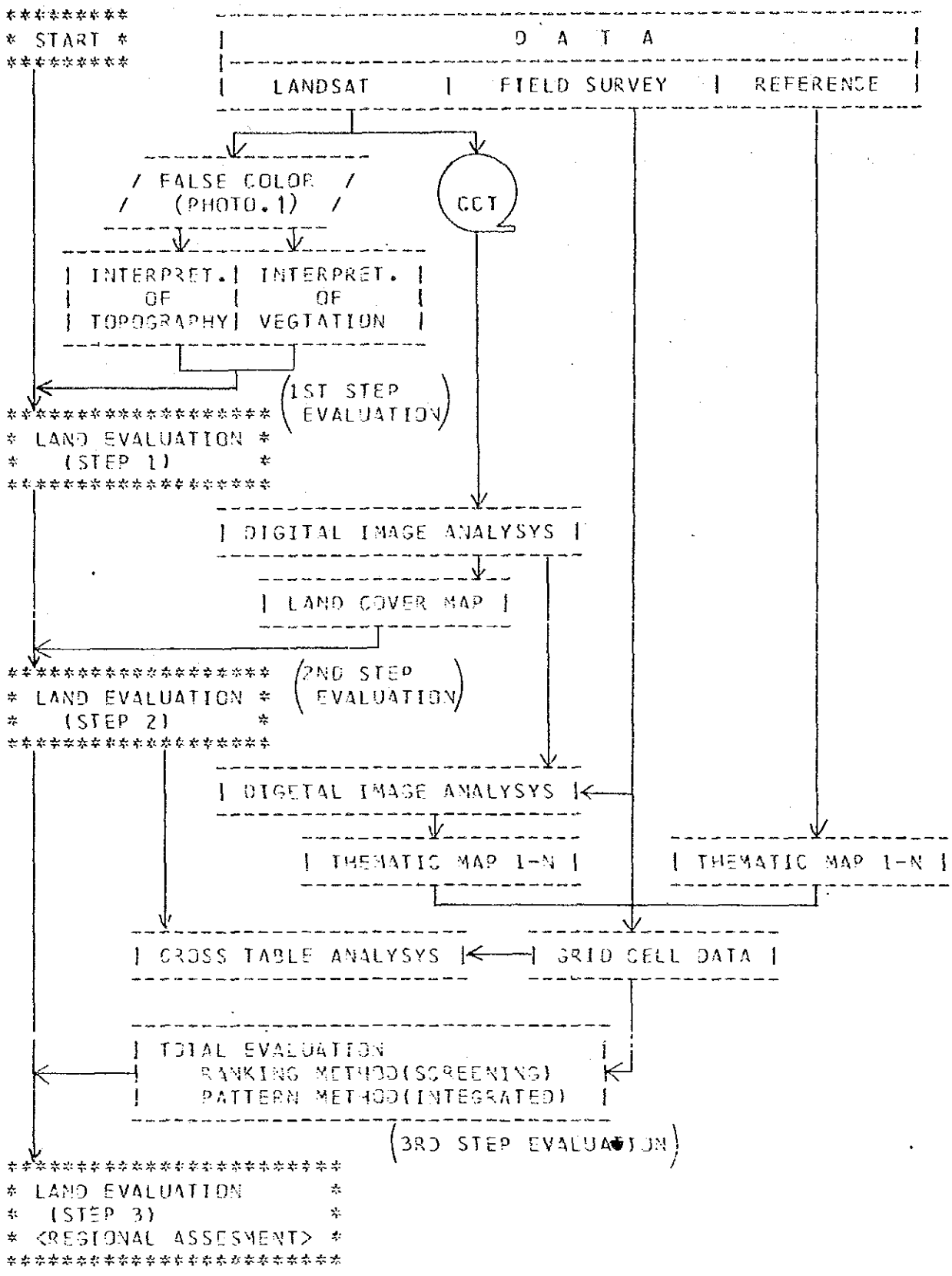

FIG. 4 MAIN FLOW-CHART OF LAND EVALUATION SYSTEM

d. 地　質　図　（Photo. 5）

e. 有効土層厚図（Photo. 6）

f. 土　性　図　（Photo. 7）

g. 土地被覆図－教師付分類－（Photo. 8）……ランドサットデータより

h. 植物生体量図（Photo. 9）……　ランドサットデータより

i. 土壌反射図　（Photo. 10）……　ランドサットデータより

j. 8月降雨図　（Photo. 11）

k. 洪水危険図　（Photo. 12）

この他，今回新たに作成・追加したものとして次の3主題図があり，これらも土地評価に使用した。

l. 地形分類図　（Photo. 13）……　ランドサットデータより

m. 植生型分類図　（photo. 14）……　ランドサットデータより

n. 土地被覆図－教師なし分類－（Photo. 15）……　ランドサットデータより

Ⅲ－4　グランドトゥルース

土地評価の解析精度の向上，ならびに解析結果の検定データ収集のために，1月26日から10日間，北スマトラトレーニングエリアのグランドトゥルースを行った。ついては，巻末付録を参照されたい。

第Ⅳ章　解析結果

Ⅳ－1　ランドサットイメージのアナログ判読による土地評価（Step 1）

土地評価Step1は，ランドサットフォールスカラーイメージのアナログ判読による土地評価ステップである。フォールスカラーイメージからは地形及び植生状況を判読し土地評価に使用した。これらの情報は近赤外バンドを含むフォールスカラーイメージから直接的に判読できる情報であり，なおかつ，農業利用適正のための土地評価にとって非常に有効な情報である。このStep 1により，対象地域の農業利用適性をマクロ的に把握することができる。

判読された地形，植生のクラスはPhoto. 13，14に示した通りであり，これらのクラスのランキングをTable 3，4に示すようにして実施した。たとえば水田最適地（クラス1）としては，最も富栄養な土壌と考えられる沖積平野に位置し，なおかつ植生が水田開発に適当と考えられる　水湿地林植生の地域をScreeningした。

Ⅳ－2　ランドサットデータのみを用いた土地評価（Step　2）

未開発地の土地評価を実施する場合，評価に必要な主題図（地形図や土壌図など）がまったくないか，あったとしても信頼性に欠ける場合が多い。このような場合はランドサットデータのみが最新かつ多様な情報源として利用できる。土地評価Step2は，ランドサッ

トデータからの情報のみを用いて行う土地評価のステップであり，マクロ的な Regional Assesmentに有効である。さらにこのステップで得られる土地評価図は，次の土地評価Step 3のトレーニングデータとしても使用可能である。

(1) 教師なし分類による土地被覆図の作成

土地被覆や土地利用の現況は，その地域の土地評価にとって欠かすことのできない重要な情報である。ランドサットデータを用いた土地被覆状況の判別は，教師なし分類や教師付分類などで可能である。しかしStep 2では現地調査も不可能のような未開発地での土地評価が前提であるため，トレーニングフィールド（土地被覆状況の既知のフィールド）を必要とする教師付分類による土地被覆の判別は適当でない。そこでFig. 6 に示すように，教師なし分類で得られた分類クラスをもとに土地被覆分類を行い，土地被覆図を作成した。結果はPhoto. 15に示す通りであり，この主題図を軸としてStep 2の土地評価を実施した。

(2) ランキング法による土地評価

ランギング法による土地評価Step 2の特徴は，第一に，ランドサットデータから得られた土地被覆図と地形分類図のみを使用したこと，第二に，現況土地被覆，すなわち植生の情報を主体に土地評価のランキングを行ったことによる。そのプロセスはFig. 5に示した通りである。評価結果はPhoto. 17 に示した。Fig. 5の中にRanking 1 , Ranking 2 , はTable 5 ～ 8 にRanking table として示してある。これらのRanking tableは,次のような植生による土地評価を基本に作成した。

① オイルパーム，ゴムの卓越した地域 …… プランテーションエリア
② 水田利用の卓越した地域 …… 水田エリア
③ 水田の存在する地域及び
ココナツを主体とした２次林 …… 水田適地
④ ココナツ２次林 …… 水田又は畑適地（主に水田）
⑤ ココナツ以外の２次林及び
畑の卓越する地域 …… 畑又は水田適地（主に畑）
⑥ 標高の高い畑，２次林地域 …… 畑適地
⑦ スワンプ植生１（比較的乾） …… スワンプ一次開発地域
⑧ スワンプ植生２ …… スワンプ二次開発地域
⑨ スワンプ植生３（湿） …… スワンプ開発不適地
⑩ 高山植生地域 …… 農業開発不適地

(3) パターン法による土地評価

Step 2ではPATTERN法 る土地評価も実施した。PATTERN法とは Planning Assistance Through Technical Evaluation of Relevant Number の頭文字をとったものである。この方法は土地評価のために，各主題図のクラスの評点づけ及び各主題図

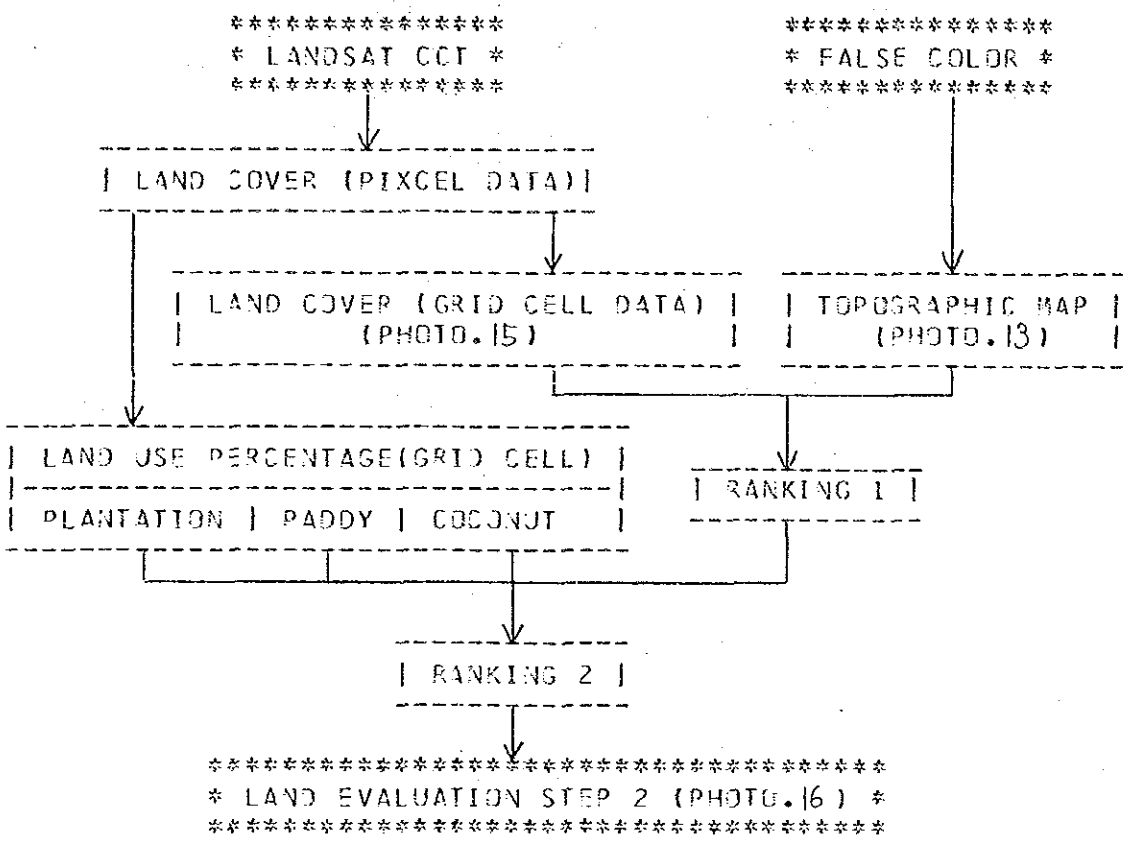

FIG. 5 FLOW OF LAND EVALUATION BY RANKING METHOD (STEP 2)

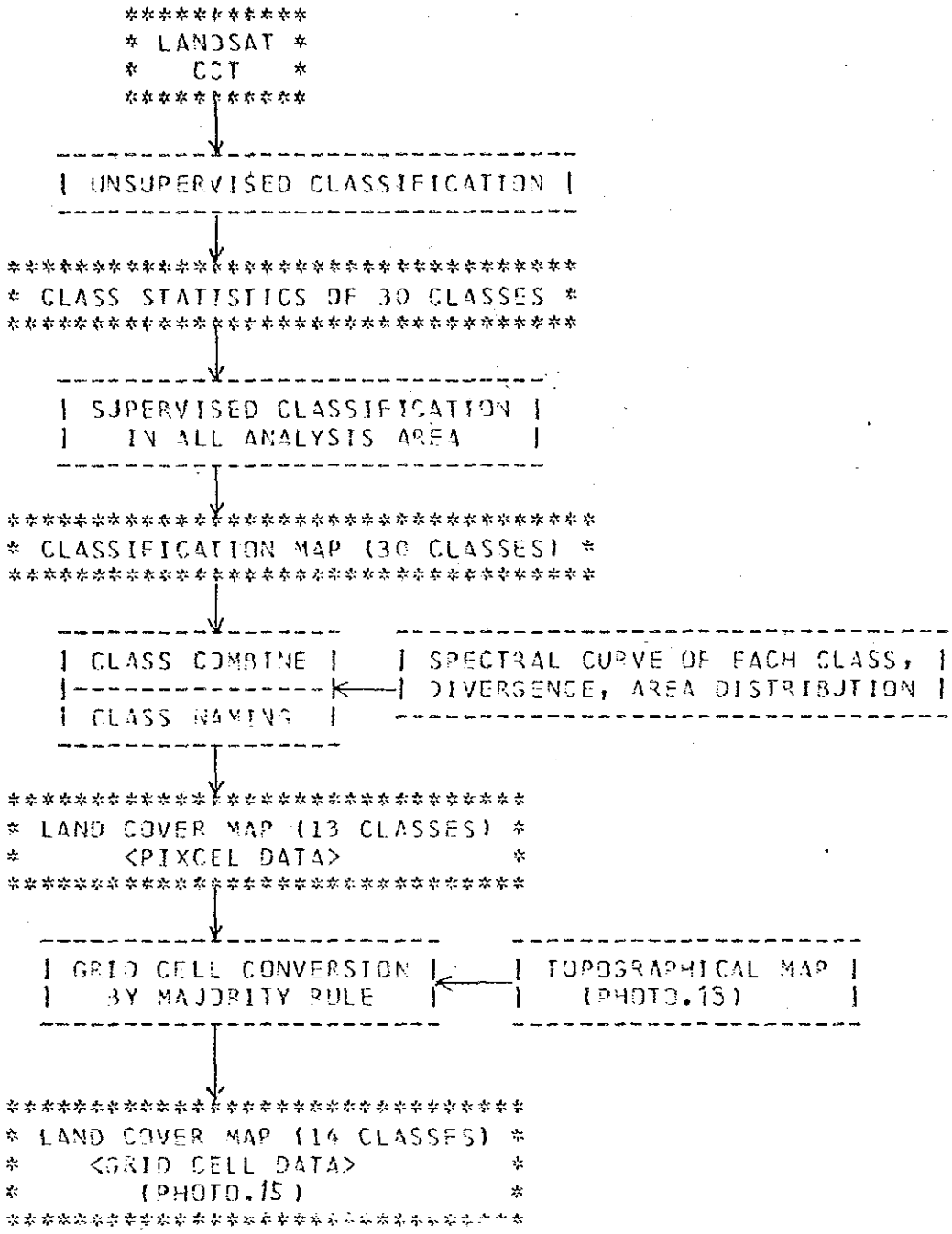

FIG. 6 FLOW OF MAKING PROCESS OF LAND COVER MAP

のウエイトを設定し，これらの総合得点をもって土地評価を行うものである。

Fig.7 はStep 2 におけるパターン法のツリー構造を示している。このステップでは，LANDSATデータより得られた4主題図のみを使用した。各主題図とも複数個のカテゴリー（クラス）を持つ。これらのカテゴリーにつけられた評点及び各主題図のウエイトは，評価の目的や，対象とする地域によって変化させる必要がある。ここでは植生及び土地被覆に大きなウエイトをかけた。評価結果はPhoto. 18 に示した通りである。

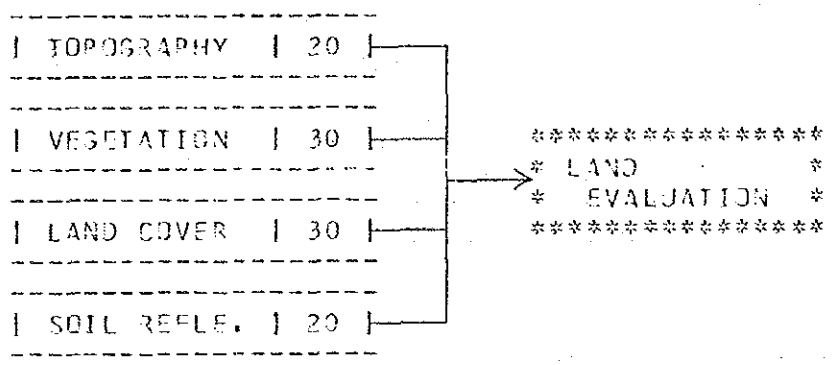

FIG. 7 LAND EVALUATION BY PATTERN METHOD (STEP 2)
(USING 4 THEMATIC MAPS FROM LANDSAT DATA)

Ⅳ－3　各種主題図を用いた総合的な土地評価（Step 3）

土地評価Step3は，LANDSAT情報及び既存の主題図情報を使用し，総合的な土地評価を行うステップである。そのためFig.4に示したような，LANDSATデータ解析による主題図の作成と，既存主題図のグリッドセル化のプロセスが不可欠である。さらにStep2で作成された土地評価図をトレーニングデータとして，各主題図とのクロス表解析（相関解析）などを実施し，ランキング表やPATTERN法におけるウエイト，スコアーの設計に資するようなプロセスも必要となる。

(1)　クロス表解析による土地評価要因の検討

土地評価図（Step2）と既存主題図とのクロス表解析の結果の一例をFig.8に示した。この図から既存農地である水田，プランテーションの標高分布や土壌タイプの特徴が明らかである。このように，クロス表解析は土地評価のための有用な情報を提供してくれるとともに，対象地域内の農地立地特性を考慮したランキングやスコアの決定に有効である。

(2)　ランキング法による土地評価

土地評価図Step3の作成プロセスはEig. 9に示した通りである。最初にStep2で得られた土地評価図と，土地の農業利用上最も重要な評価因子と考えられる地形（Landform）及び土壌（Soilquality）情報を使用して基本土地評価図（Photo.19）を作成した。この場合のランキング評価は，前節で述べたクロス表解析の結果や既応の知識をもとに,Table

```
ELEVATION--PADDY FIELD
                    0         20         40         60         80        100%
 CLASS LEGENT       +----------+----------+----------+----------+----------+
   1   0-50FT       |****************************************
   2   50-250       |******
   3   250-500      |***
   4   500-1000     |
   5   1000-2000    |
   6   2000-3500    |
   7   3500-        |
                    +----------+----------+----------+----------+----------+

ELEVATION--PLANTATION
                    0         20         40         60         80        100
 CLASS LEGENT       +----------+----------+----------+----------+----------+
   1   0-50FT       |**********************************
   2   50-250       |******************
   3   250-500      |**
   4   500-1000     |
   5   1000-2000    |
   6   2000-3500    |
   7   3500-        |
                    +----------+----------+----------+----------+----------+

SOIL TYPE -- PADDY FIELD
                    0         20         40         60         80        100%
 CLASS LEGEND       +----------+----------+----------+----------+----------+
   1   ORGANIC      |**
   2   ALLUVIAL     |*
   3   GLEY HUM     |*****************
   4   GREY HYD     |************************
   5   LA(IGNE)     |*******
   6   LA,RYPO      |*
   7   LA(VOLC)     |
   8   RYPO(SE)     |*
   9   CLASS9-14    |
                    +----------+----------+----------+----------+----------+

SOIL TYPE -- PLANTATION
                    0         20         40         60         80        100
CLASS LEGEND        +----------+----------+----------+----------+----------+
   1   ORGANIC      |*
   2   ALLUVIAL     |
   3   GLEY-HUM     |*
   4   GREY-HYD     |**************************
   5   LA(IGNE)     |****************
   6   LA,RYPO      |***
   7   LA(VOLC)     |
   8   RYPO(SE)     |***
   9   CLASS9-14    |
                    +----------+----------+----------+----------+----------+
```

FIG. 8 RESULTS OF CROSS TABLE ANALYSIS

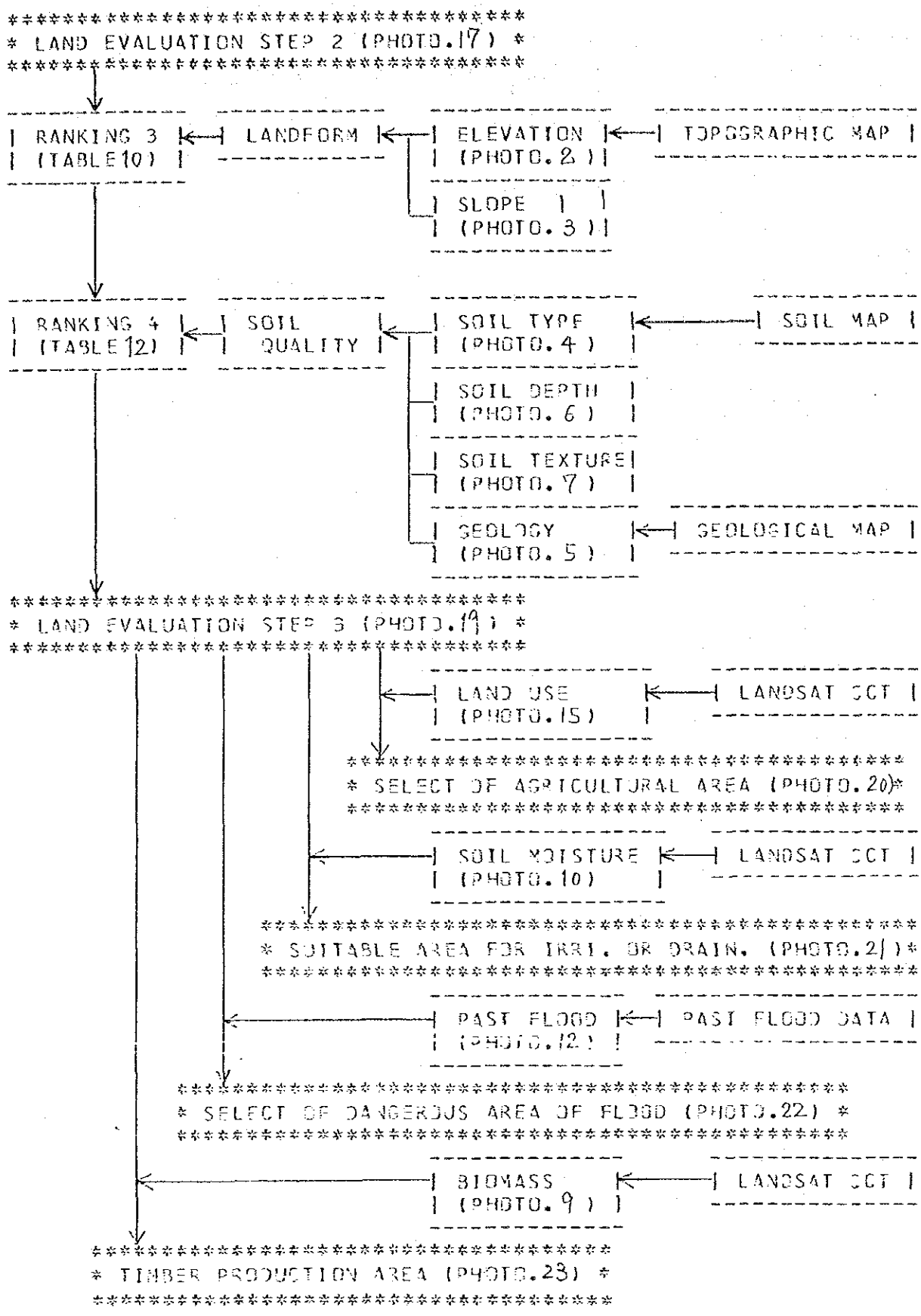

FIG. 9 FLOW OF LAND EVALUATION BY RANKING METHOD (STEP 3)

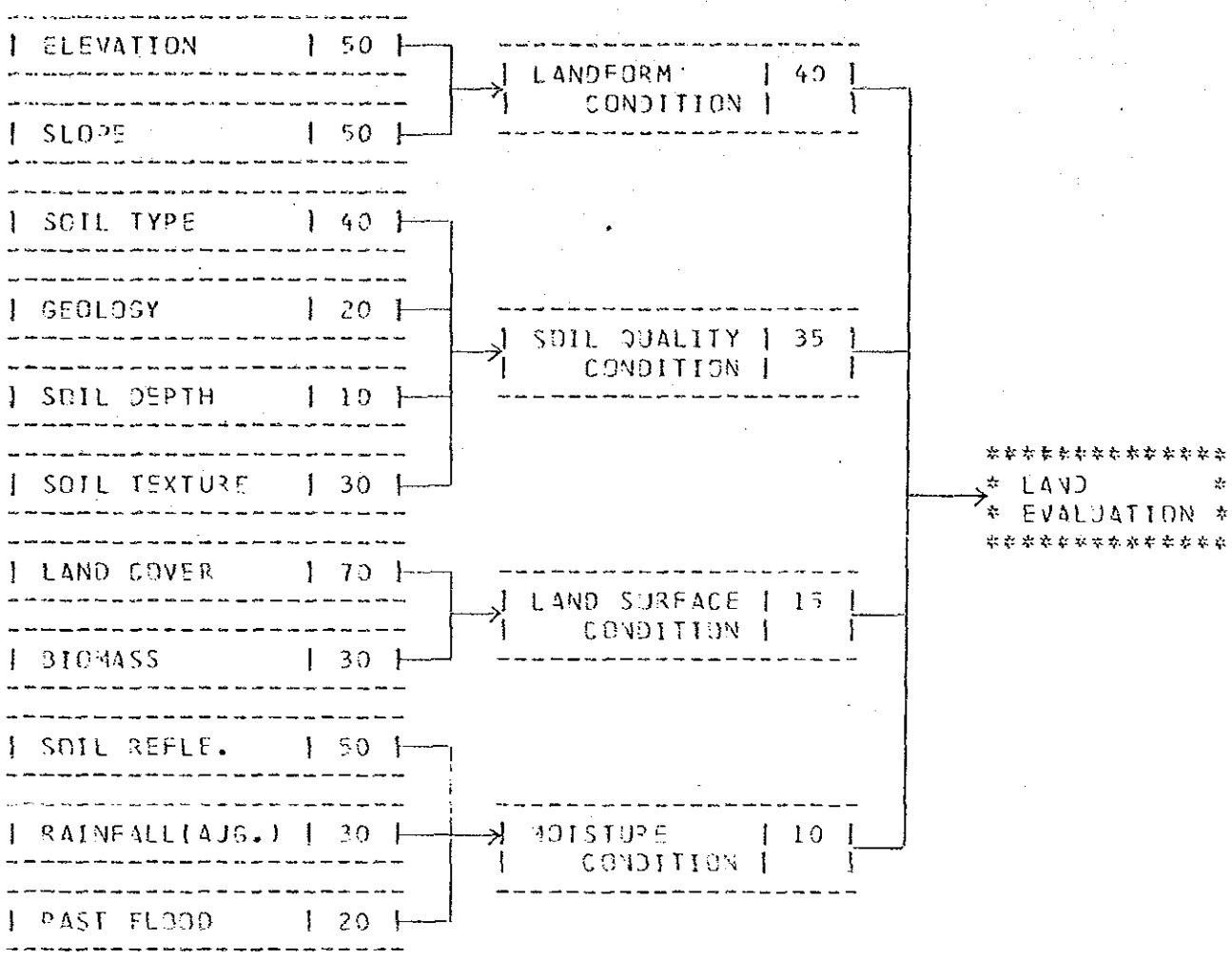

FIG.10 LAND EVALUATION BY PATTERN METHOD (STEP 3)
(USING 11 THEMATIC MAPS)

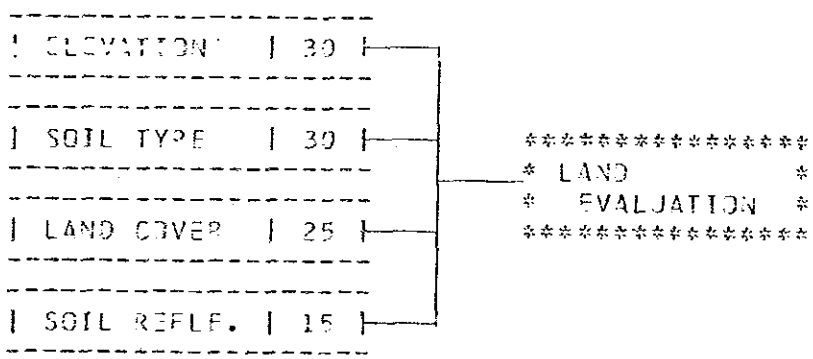

FIG.11 LAND EVALUATION BY PATTERN METHOD (STEP 3)
(USING SELECTED 4 THEMATIC MAPS)

11 ～ 13 に示すRanking table を作成して実施した。次にこの基本評価図に，目的とする土地評価に必要な主題図を重ねる（Ranking or Screening ）ことにより，様々な観点からの土地評価図が作成できる。本報告では，既存農地の分布状況（Photo. 20 ），かんがい排水の必要な地域（Photo. 21 ），水害危険地域（Photo. 22 ），木材供給地域（Photo. 23 ）の各評価図作成を試みた。

(3) パターン法による土地評価

土地評価のプロセスとして１１主題図すべてを使用した場合，及び重要評価要因と考えられる４主題図のみを使用した場合の２ケースを実施した。１１主題図を使用した場合のツリー構造図及び各主題図カテゴリー（クラス）のスコアーはそれぞれFig.10, Table14 に示してある。なおこの場合，４つの中間評価図を作成して使用した。すなわち，１１主題図のグルーピングにより， Landform condition , Soil quality condition , Land surface condition , Soil moisture condition の中間評価を行った(Photo 24 ～ 27)。最終評価結果はPhoto. 28 に示した。

さらに，使用可能な主題図が少ない場合を想定し，４つの重要主題図（標高，土壌型，土地被覆，土壌反射）を選定しPATTERN法を実施した。この場合のツリー構造及びウエイトはそれぞれFig. 11 , Table15に示した。そして最終評価結果はPhoto.29に示してある。両ケースの解析結果（Photo. 28 とPhoto. 29 ）は多くの点でよく一致している。

第Ⅴ章　解析結果の検討

Ⅴ－１　３ステップ方式の土地評価システムの特徴

アサハン（北スマトラ）地域へ３ステップ方式の土地評価システムを適用した結果，この評価システムの特徴が明かとなった。すなわち，本評価システムは，各ステップに応じて使用データ及び解析手法が明確に区分されているため，各ステップでの評価結果の意味が理解しやすい。また前ステップでの評価結果を次のステップへ連結することが可能であり，評価精度の向上に有効である。さらにこのシステムは，土地評価の目的，精度，費用，時間に応じた適当なステップの選択が可能であり，評価対象地域の実状に応じた土地評価を行うことができる。

Ⅴ－２　植生情報利用による土地評価

３ステップ方式の土地評価システムの中のStep1, Step2は主にLANDSATデータから得られる植生（土地被覆）情報を利用している。アサハン地域は山岳部，スワンプエリアを除けばほとんどの場所が何らかの人の手の入った２次植生（２次林，プランテーション植生，農作物など）である。このような２次植生もまた自然植生と同様に，その土地の自然条件を反映していると考えることができる。たとえば，Fig. 8に示したように，Gray Hydromorph やLatozol（Igneous rock)の土壌は水田及びプランテーションに多いが，

Gley Humic は水田に多くプランテーションにはほとんど存在しない。またココナツは平野部の湿潤土壌地域に多く生育している。Step 2では，このような2次植生の立地環境を考慮した土地被覆図（LANDSATデータより作成したもの）のランキングや評点づけを行い，土地評価に使用した。この評価結果は次のStep 3のプレ評価データとして非常に有効であった。

Ⅴ－3　Ranking法とPATTERN法の特徴

各ステップでの評価はRanking法とPATTERN法を採用した。Ranking法の評価結果は，その手法の特徴から，評価結果がそのまま農地利用特性として理解できる。しかし，PATTERN法では0～100点のスコアとして結果が表現されるため，土地の相対的な優劣は理解しやすいが，スコアと土地の農地利用特性の関係づけが必要となる。そのためRanking法とPATTERN法を併行的に実施し，両者の長所を取り入れて評価結果を理解することが望ましいと考えられる。このような視点から，本報告でのPATTERN法での評価結界は，Ranking法の評価結果を参考に，農地利用特性を加味した6段階の評価に再区分（スコアのレベルスライス）して表示した。

Ⅴ－4　評価精度の検討（現地調査データより）

解析エリア内の既存農地（水田，プランテーション）の分布は，現地調査からほぼ明らかとなっている。既存農地は比較的，農地立地条件の良好な場所に分布していると考えられる。このような既存農地の分布状況をStep 3の評価結果と比較検討した結果，土地評価図Step 3は，Regionel Assesmentとして十分な評価精度を持つものと判断された。さらに詳細な精度の検討には，条件の異なる多地点での現地調差データが必要である。なお既存農地の分布と評価結果の比較はPhoto. 20を参照されたい。

おわりに

本報告の解析　取りまとめに際し，インドネシアリモートセンシングプロジェクトの諸氏に多大の御援助・御指導をいただいた。ここに厚く感謝の意を表するものである。特にIr HAEDAR ALI，Drs. SUROSO DJOJOSUKARTOの両氏には特別の御配慮をいただいた。またMr. MINE，Mr. S. SAKAI，Mr. K. UEDA，Mr. K. MIMAの各氏には解析システムの利用等に際し並々ならぬ御指導をいただいた。厚くお礼申し上げるものである。

ESTABLISHMENT OF LAND EVALUATION SYSTEM FOR AGRICULTURAL DEVELOPMENT USING LANDSAT DATA

- APPLICATION ON THE NORTH SUMATERA AREA -

March 1984

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C O N T E N T S

INTRODUCTION

How to combine remote sensing technology with computer information system, and how to apply this combined new technology for agricultural development are to be important subject of this Project. In order to fulfill the subject, the Project seeks for detailed and large areal analysis and evaluation system for land development by integrating remote sensing data, such as landuse, vegetation, drainage, etc., with already acquired data such as geology, topography, climate and soil.

However in Indonesia, possessing immense land area which includes a region where no human beings have ever penetrated, it is impossible to carry out precise soil examination in a short time which is most important for selecting suitable land for agricultural development.
Besides, the land surface, blessed with abundant precipitation and high temperature in all seasons, is covered by vegetation through the year, it is also impossible to examine soil condition from space. If one can identify the vegetation from remote sensing data in which total assessment of site factors will be done, more useful idea for agricultural development can be expected. The reason is, the present vegetation can be considered as a comprehensive state resulted from interrelation suroounding vegetation units. That is to say, environment factors may be reflected in plant.

1. OBJECTIVES OF STUDY

Agricultural development program is designed and performed by assessing natural land conditions and agro-economical conditions.

However, this Project for "the development of the agricultural infrastructure in Indonesia", is limited only to assess natural land conditions.

Several thematic maps for selection of suitable land has already drawn up in the Project. Combining these maps, land evaluation maps for the North Banten Area and CJC district were prepared by Ranking method. Therefore, evaluation system and verification of precision are urged to establish at present.

During the dispatch period, we tried to analyze and investigate the following points.

A. Establishment of evaluation system for selection of agricultural development.
B. Application of the system on the North Sumatera Training Area.
C. Verification of precision of the evaluation system.

The characteristics of the method presented here are;

1) Each thematic map was integrated as grid cell data file of 500 meters by 500 meters size.
2) Vegetation type was used as a land evaluation information.

3) According with the quality and quantity of available thematic maps, three-step evaluation was proposed carrying out the evaluation at each Step.

Through the analysis and evaluation, Mr.Miyama mainly took part with Ranking Method, and Mr. Akiyama with PATTERN Method.

2. OUTLINE OF THE NORTH SUMATERA TRAINING AREA

2-1 Situation and Climate

Administrative district

Geographically, the target area (Fig.1) lies between 02°00' - 03°30' North latitude and 99°15' - 100°15' East longitude. Administratively, involve four regencies, those are Labuhan Batu, Tapanuli Utara, Asahan and Simalungun, and one mucipality (Kota Madya) Tanjung Balai (Fig.2). Nearly 3 millions of people live in the area of the North Sumatera Province. The population density of the area is about 160 per hectare (Kantor Statistik Sumater Utara,1981).

Topography

Topographically, the target area will be devided into three parts (Fig.3) mountainous area, representative of Mt. Surungan (2174 m) and Mt. Panindi (1627 m), is situated at the southwestern part of the training area. Along the Malaka Strait, beyond the Asahan River, Northern plain which has almost developed as oil palm and rubber plantation lies. While in the southern half of the training area, three ri - vers across the plain creating huge swamp area. These swamp areas spreads out from river mouth up to about 30 km inland. Most part of the swamp area left as undeveloped condition.

Climate

Rainy season in this disctrict begins usually in Sep - tember and terminates in April. The rainfall per month du - ring rainy sesaon is arround 300 mm, however, 150 mm is ex- pected even in dry season.

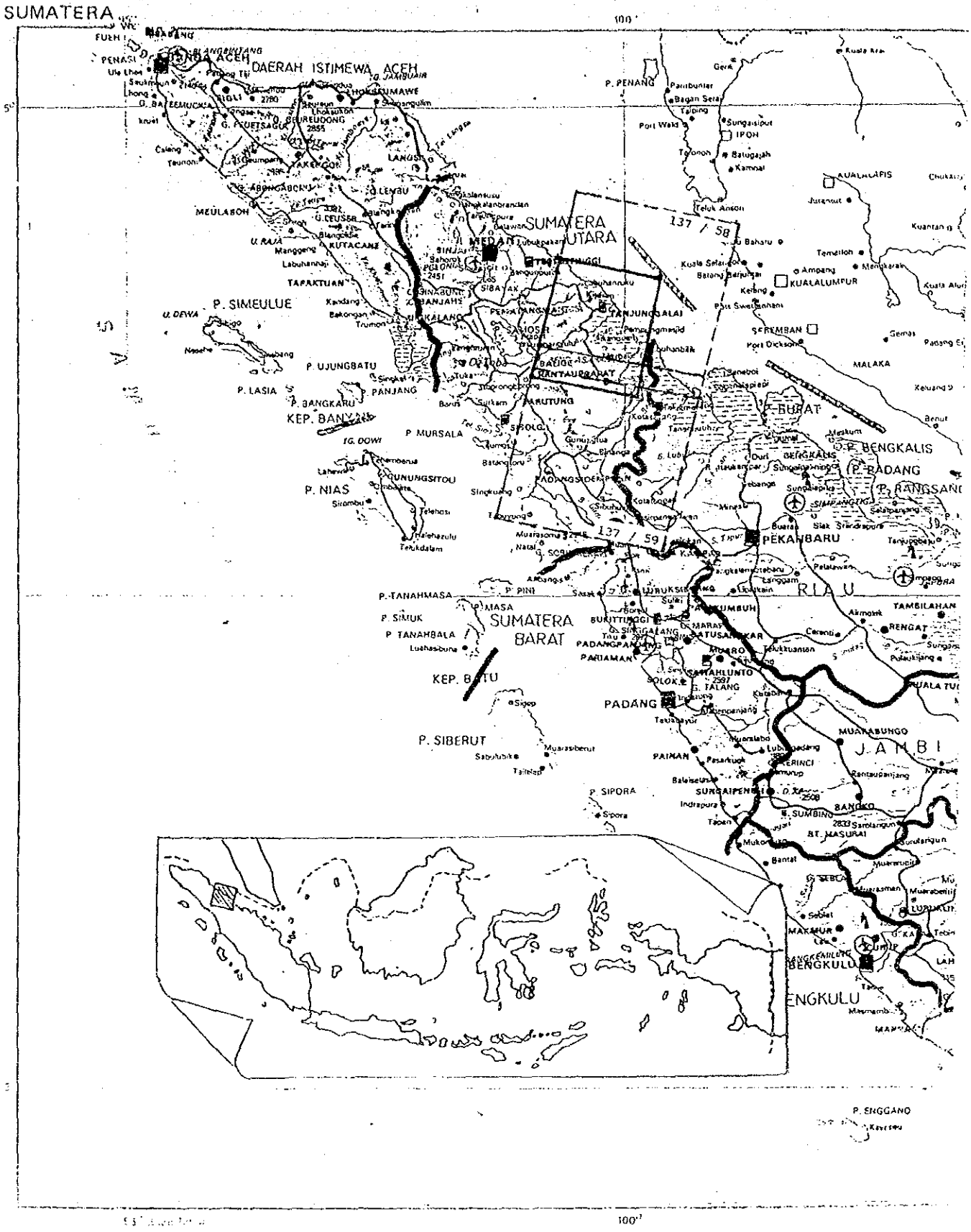


Fig. 1 Location of Target Area (Asahan area)

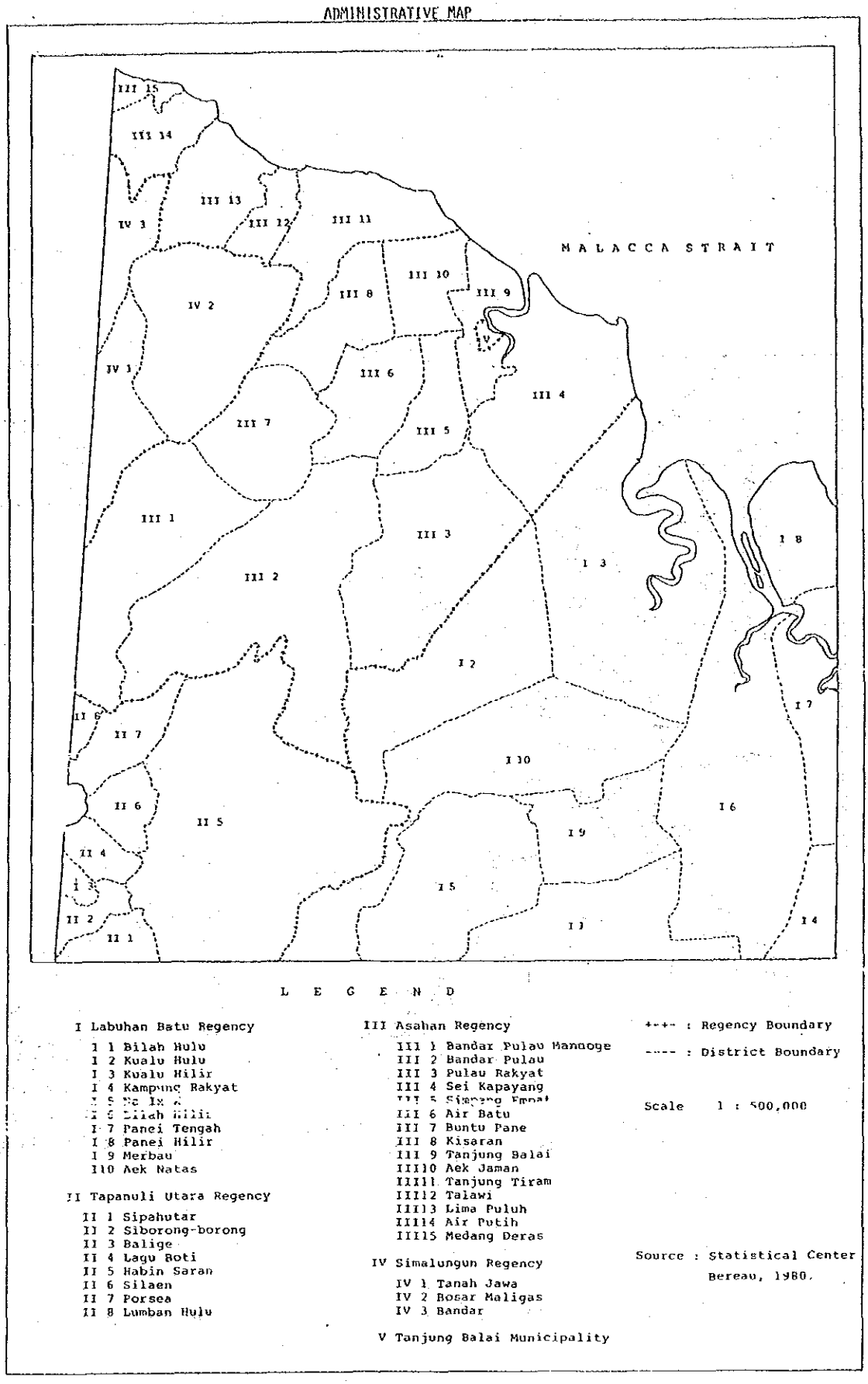


Fig. 2 Administrative Map of Target area

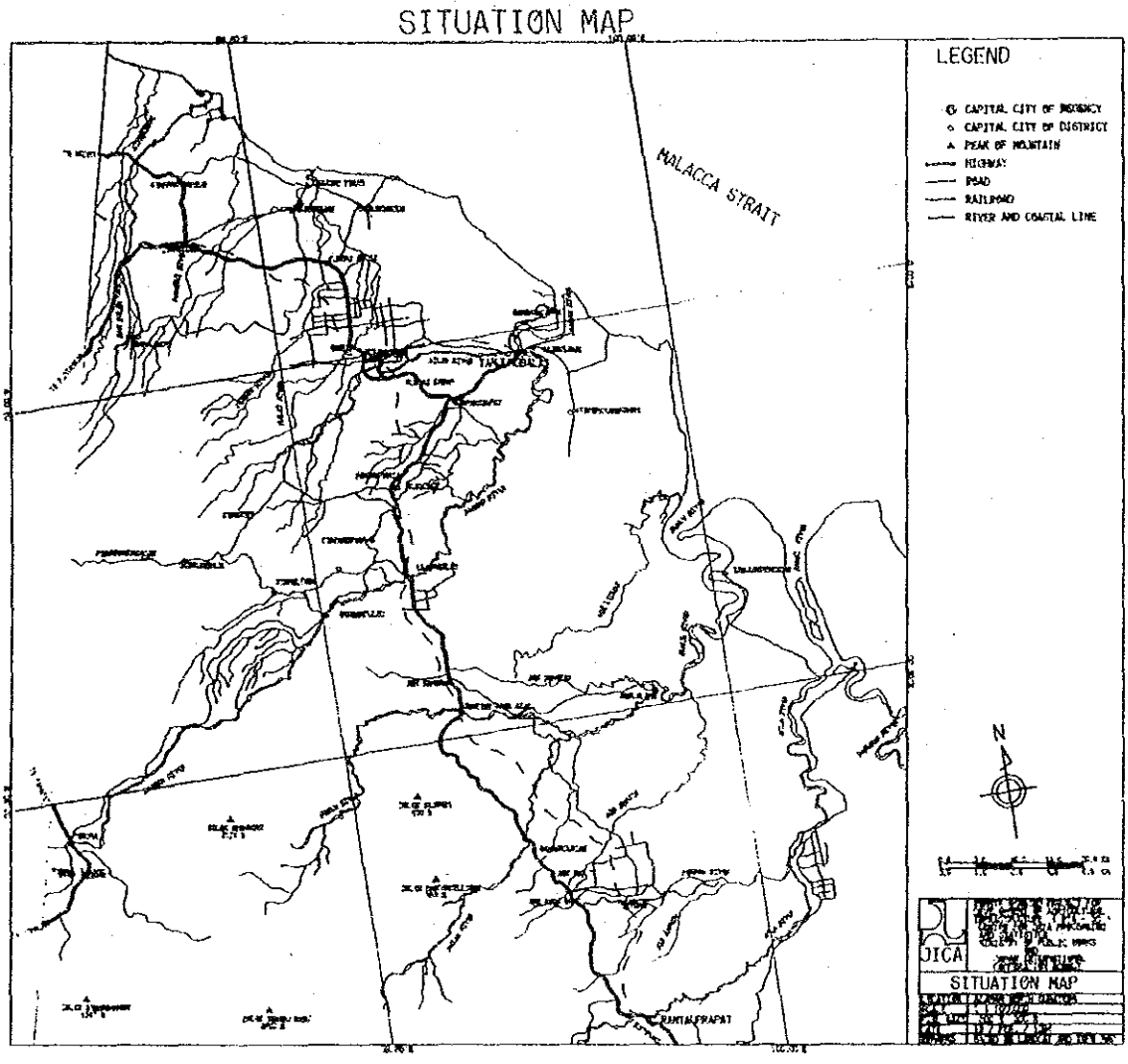


Fig. 3 Topograph and road map of the target area

Annual rainfall stands high in the mountainous district ranging from 2500 to 3000 mm, then the central plain (2000-2500 mm) followed it, but low in the coastal plain (1500-2000 mm).

2-2 Characteristics of Tropical Rain Forest

From view point of vegetation type, the Sumatera Island is included in the tropical evergreen rain forest. In this vegetation, plants grow vigorously as tall as 30 m in height, which have buttress and large edged leaves with many climbing plants and epiphytes on the trunk. This type of forest often contains the richest flora on the earth beyond 100 species per hectare consisting of several vegetation layers inside the canopy.

Many types of soil such as Alluvial, Lowland Podzolic, Peat, Latosol and so on cover the area. Under the interrelationships between climate, topography, soil etc., the following forest formation types were created (Table-1 by Whitmore, 1975). In the other words, we can estimate the environmental condition from the forest formation types.

2-3 Agricultural Outline in the North Sumatera

Tabl 2 shows the statistics about harvested area, production and profitability of main agricultural products in the North Sumatera Province.

As for the harvested area, rice field occupied almost 600,000 ha in total of dry and wet paddy field, then followed rubber (340,000 ha) and oil palm (190,000 ha). Among these fields, 99.1% of oil palm and 47.5 % of rubber field are depend upon the plantation estates.

Productivity of wet paddy field was 3.7 tons per hectare, while 1.9 tons in dry paddy field.

As for profitability per hectare, highest in clove, then follows tea, oil palm, rubber, coffee, rice and coconut in the descending order. Besides, logging is the most important industry in the mountainous area where produces arround 1 million cubic meters of timber in a year. (Kantor Statistik Propinsi Sumatera Utara, 1981).

3. MAIN FLOW CHART AND REFERENCE DATA USED IN THE ANALYSIS

3-1 Main Flow of the Analysis

Flow chart used in the analysis is shown in Fig.4.

Asahan Area in the North Sumatera Province was selected as the training area. In the first Step, land evaluation by analog analysis was carried out using topography and vegetation maps obtained from LANDSAT false color photograph (Photo.1).

Land evaluation in the second Step was executed by digital image analysis. Here, digitally analyzed LANDSAT data by un-supervised method was combined with topography map. The results obtained by Ranking Method and PATTERN Method were utilized for pre-evaluation.

In the third Step of total evaluation, results of Cross Table analysis provided usefull information on regional assessment. Here we used all 11 thematic maps which were prepared on the grid cell data file of 500 m by 500 m size. Ranking Method and PATTERN Method were applied again in this Step.

3-2 LANDSAT and Reference Data Lists

LANDSAT MSS data (Scene No. 8282802442500, path/row 137/58 and Scene No. 8282802344500, path/row 137/59), taken on April 29, 1977 were chosen for this survey. Prior to the present analysis, pre-processing such as geometric correction and enhancement have given by the Project.

Other supplemental data were shown in the following lists.

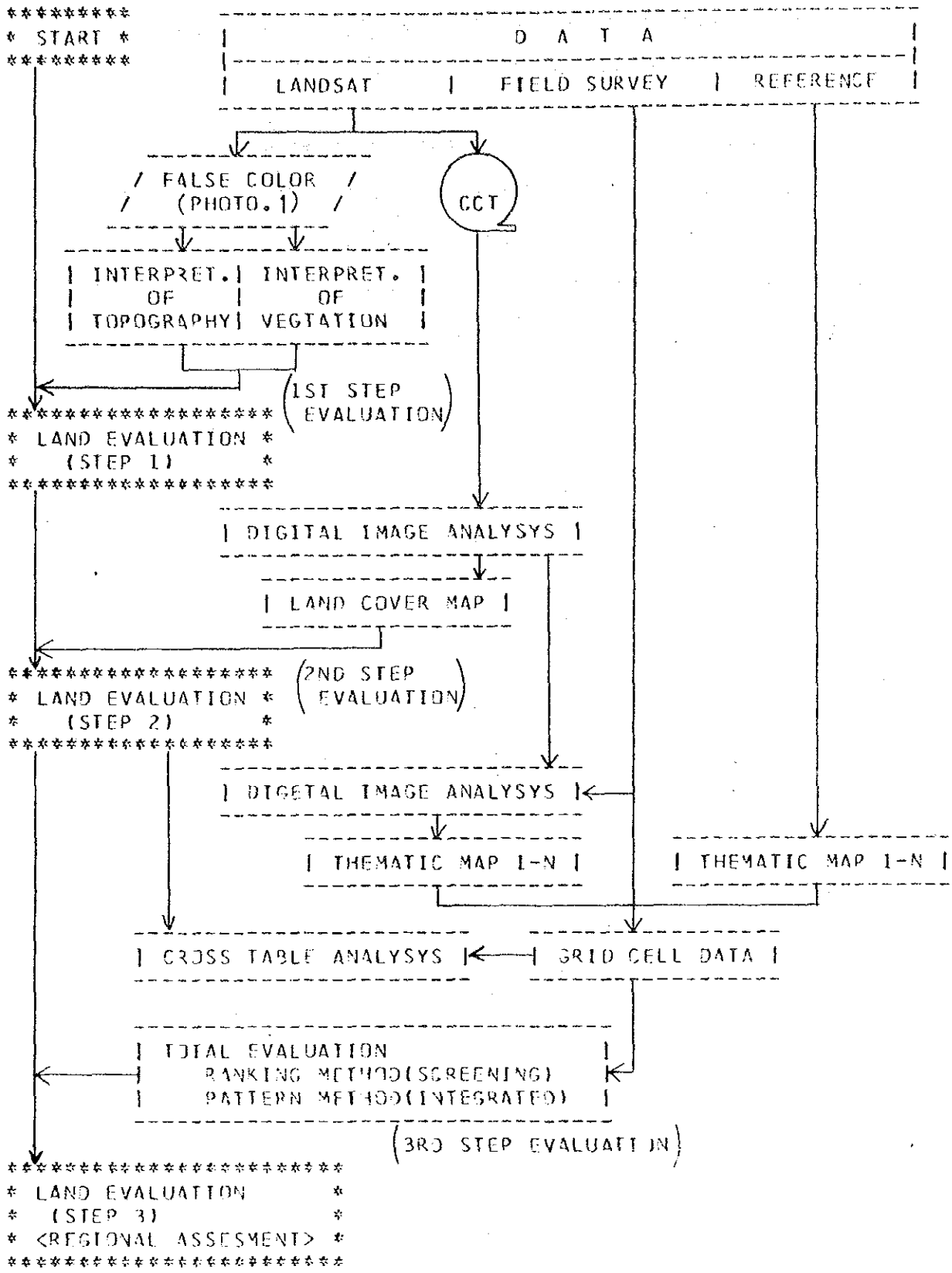


FIG. 4 MAIN FLOW-CHART OF LAND EVALUATION SYSTEM

elevation and slope :

Topographical map, scale, 1:250,000 by U.S.ARMY (1949)

geological map :

Geological map of the Pematangsiantar quadrangle, scale 1:250,000 Sumatera Directorate of Geology, Ministry of Mines and Energy, Bandung (1982)

rainfall :

Meteorological Note No.9 (1911-1940), scale 1:1, 1:1,000,000,Departement of Communications, by Meteorological and Geophysical Institute (1973)

soil type :

Peta Tanah Eksplorasi Sumatera Bagian Utara, scale 1:1,000,000, by Institute of Soil Research and Fertilization (1964)

soil depth, soil texture and past flood :

Besides these reference data, we could use the areal photographs. They were taken on March 13, 1983 by IR film (Kodak 2443) from the altitude of 10,000 ft on 1:20,000 scale. It was really available for the identification of swamp vegetation types.

3-3 Thematic Map Lists

The following 11 thematic maps including several category levels have prepared by Indonesian counterparts as an advance preparation.

Here we omit to give explanation on each of it, because most of the conception was presented previously in the analysis of other districts (for example, see Yamamoto 1983, Saito et.al. 1983, or Draft Report From Remote Sensing Project on "A Case Study on Asahan Regency, North Sumatera, Indonesia").

a. Elevation map (Photo 2)

	Category levels
1.	0 - 50 ft
2	50 - 250
3	250 - 500
4	500 - 1000
5	1000 - 2000
6	2500 - 3800
7	> 3500

b. Slope map (Photo 3)

	Category levels
1	0 - 2 %
2	2 - 15
3	15 - 30
4	> 30

c. Soil type map (Photo 4)

	Category levels
1	Organic soil
2	Alluvial soil
3	Gley humic soil
4	Grey hidromorphic soil

5	Latosol (from Igneous rock)
6	Latosol Podzolic + Red Yellow Podzolic soil
7	Latosol (from volcanic soil)
8	Red Yellow Podzolic Soil (from sedimentary rock)
9	Red Yeloow Podzolic Soil (from Alluvial)
10	Red Yellow Podzolic + Latosol + Lithosol complex
11	Brown Podzolic + Podzolic + Lithosol
12	Regosol + latosol
13	Lithosol + Regosol
14	Grey brown Podzolic soil

d. Geology map (Photo 5)

Category levels	
1	Younger alluvium
2	Older alluvium
3	Petani formation
4	Sihapas formation
5	Tapanuli group
6	Kualu formation
7	Toba tuff
8	Samosir formation

e. Soil effective depth map (Photo 6)

Category levels	
1	> 90 cm
2	60 - 90
3	30 - 60
4	< 30

f. Soil texture map (Photo 7)

	Category levels
1	fine
2	medium
3	coarse

g. Land cover map (from LANDSAT data, photo 8)

	Category levels
1	paddy field
2	paddy + dry field
3	palm oil
4	rubber
5	grass, bush and shrub
6	coconut +
7	mix garden
8	swamp + swamp forest
9	upland forest
10	cloud

h. Biomass map (from LANDSAT data, photo 9)

	Category levels
1	< 2 kg
2	2 - 9
3	9 - 17
4	17 - 24
5	24 - 32
6	> 32

i. Soil reflectance map (from LANDSAT data, photo 10)

	Category levels
1	dry
2	slightly dry
3	medium
4	slightly wet
5	wet

j. August rainfall map (Photo 11)

	Category levels
1	100 - 150 mm
2	150 - 200
3	200 - 300

k. Past flood frequency map (Photo 12)

	Cateogory levels
1	never flooded
2	once per year
3	more than twice

Besides above mentioned thematic maps, we prepared 3 original maps in this analysis obtained from LANDSAT data.

1. Topography map (from LANDSAT data, photo 13)

	Category levels
1	coastal plain
2	island
3	alluvial plain
4	non-drainaged paddy field

5	plain
6	swamp area
7	drainaged swamp
8	foot slope
9	mountain
10	basin
11	lake
12	sea
13	cloud

The topography map was created with analogic way from LANDSAT false color image,

m. Vegetation map (from LANDSAT data, photo 14)

Category levels	
1	tropical lowland evergreen rain forest a
2	tropical lowland evergreen rain forest b
3	tropical low mountain evergreen rain forest
4	coastal forest
5	mangrove forest + brackish water forest
6	peat soil swamp forest a
7	peat soil swamp forest b
8	peat soil swamp forest c
9	fresh water swamp forest
10	water + urban
11	cloud _ shadow

Most of the original vegetation was disappeared in the central plain.

However, among forest formation types shown in Table 1, 7 types were distinguished in the training area. They are tropical lowland evergreen rain forest, tropical low mountain evergreen forest, Coastal forest, Mangorove forest, Brackish water forest, Peat soil swamp forest and fresh water swamp forest. Since growing area for Mangrove and Brackish water forests were closely adjoined in a coastal area of river mouth, so we put them together in one class. On the other hand, lowland evergreen forest and peat soil swamp forest were sub-divided by the difference of color tone on false color image. As the results, 9 classes of vegetation were finally extracted.

n. Land cover map (from LANDSAT data, photo 15)

	Category levels
1	cloud + shadow
2	water
3	urban
4	mountain forest
5	rubber
6	palm oil + rubber
7	palm oil
8	coconut mix
9	dry field
10	paddy field
11	swamp (arround)
12	swamp (middle)
13	swamp (center)
14	grassland + bare soil
15	out of area

This map was created by un-supervised classification. More precise explanation will be done in Chapter 4-2-1.

3-4 Field Survey

In order to ascertain and verificate the results of analysis, and to feedback the ground truth data on further analysis, a trip for field check to the North Sumatera was carried out for 10 days from January 26. The typical ground cover types are shown in Appendix.

4. RESULT OF EVALUATION ANALYSIS

4-1 Land Evaluation by Landsat Analog Analysis

Land evaluation taken is Step 1 is the phase that land evaluation by analog analysis is done utilizing LANDSAT false color image. Here, topographical features and vegetation types were detected from the false color image (Photo 1). These two thematic maps (Photos 13 and 14) are not only directly detectable from LANDSAT especially for IR band data but also bring very useful information for land selection of agriculture utilization.

On this Step, we intended to grasp the land suitability in macroscopic view points. Detected topography and vegetation classes are shown in legend in Photos 13 and 14, which were used as the ranking data, according to the categories presented in Tables 3 and 4. For example, excellent land for paddy, Class 1, was screened as the combination of alluvial plain, which is thought to be the most fertile soil among 13 topographic features, and fresh water swamp forest, which inidcates the most productive environment for rice plant among listed 11 forest formation types.

4-2 Land Evaluation only Using LANDSAT Data (Step 2)

In the case of land evaluation on undeveloped area, we generally can not obtain available thematic maps such as topography and soil type. Because, in this area, these thematic maps are often unreliable or not exist. On that situation, LANDSAT data will be the most important and the latest information which we can obtain.

The land evaluation at Step 2 (Fig.5) is the evaluation process which used LANDSAT data alone. This process will be not only available for regional assessment but also can be usefull as a training data in Step 3 land evaluation.

4-2-1 Making process of land cover map using unsupervised classification

The present situation of land cover or land use is one of the most indispensable information for agricultural suitable land evaluation. We can interprate the land cover type on the target area by using either supervised of unsupervised classification of LANDSAT MSS data. However, the evaluation at Step 2 stands on the assumption that we can not make direct survey or can not use thematic maps of objective area by some kind of regulation. So supervised classification method which need the training field (so that, where we have enough knowledge about the land cover) is not suitable method for the interpretation on this Step. Therefore, we made a land cover map of object area by using the class statistics which were calculated in the unsupervised classification process of LANDSAT MSS Data (Fig.6). The land cover map is shown in Photo 15.

4-2-2 Land evaluation by the Ranking Method

It is a characteristics of land evaluatio of Step 2, not to use other reference data, but only to use the land cover map and the topographic map which are resulted from LANDSAT Data analysis.

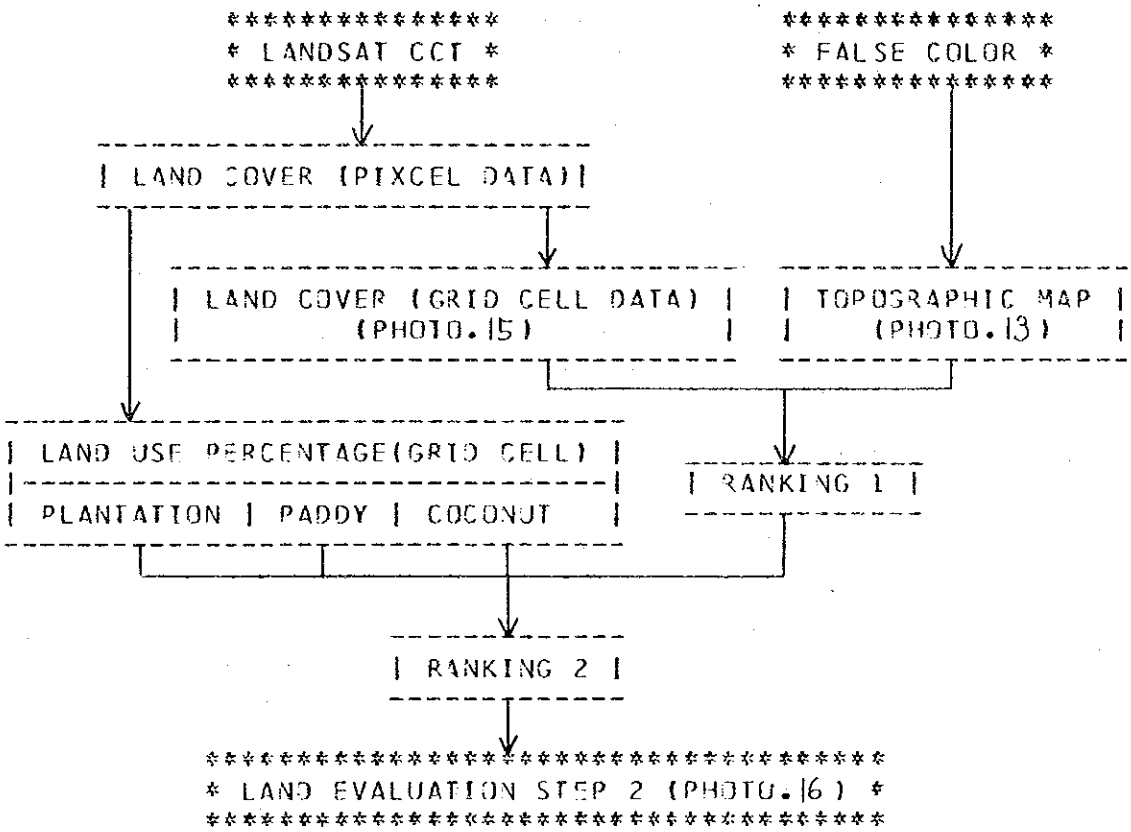


FIG. 5 FLOW OF LAND EVALUATION BY RANKING METHOD (STEP 2)

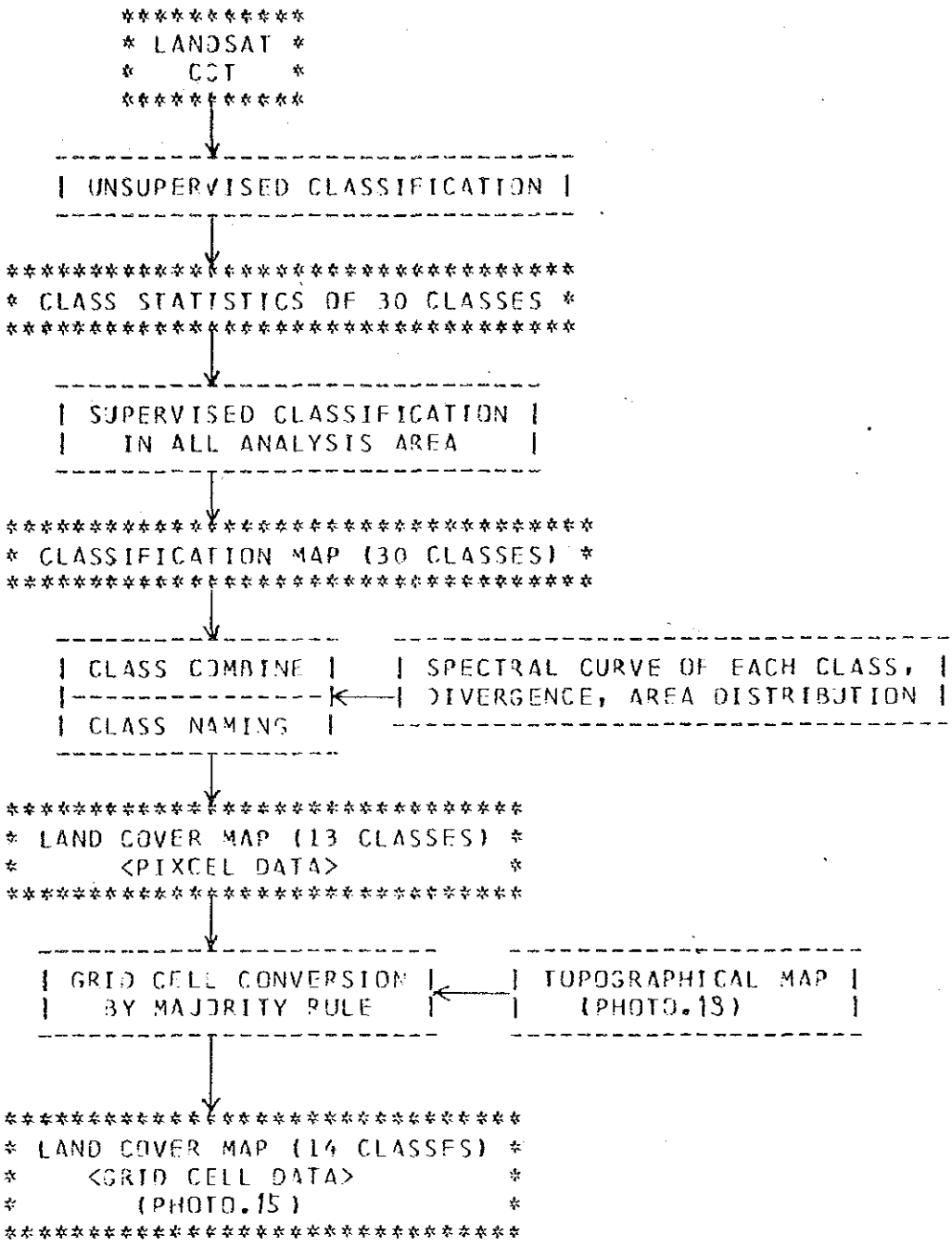


FIG. 6 FLOW OF MAKING PROCESS OF LAND COVER MAP

We have made the ranking table for land evaluation using mainly information of vegetation. This process and the results are shown in Fig. 5 and Photo 17. Ranking 1 and 2 presented in this Figure were explained in ranking table (Tables 5 to 8). These ranking table created basing on the following general idea which came from the relation - ship between present vegetation and land suitability.

Present vegetation	Land suitability
1. Oil palm and rubber dominated	Plantation area
2. Paddy field dominated	Paddy field area
3. Mainly composed of coconut and paddy field	Paddy field area
4. Seccndary forest mainly composed of coconut	Paddy or dry field area (mainly for paddy)
5. Dry field dominated with secondary forest not including coconut	Dry or paddy field area (mainly for dry field)
6. Dry field or secondary forest in upland area	Dry field area
7. Swamp vegetation 1 (relatively dry area)	Primary develop area
8. Swamp vegetation 2 (intermediate area)	Secondary develop area
9. Swamp vegetation 3	Unsuitable for agricultural development
10. Mountaineous vegetation area	Unsuitable for agricultural development

4-2-3 Pre-evaluation by the PATTERN Method

As the other evaluation method for Step 2, we applied the PATTERN Method. Here, PATTERN is the abbreviation for "Planning Assistance Through Technical Evaluation of Relevant Number". This method is a logical overlay technique that employs rules of weighted linear combination across many variables to determine certain classes of land characteristics utilizing the landscape model (See Nasu, 1983, 1984).

Fig.7 shows the tree structure used in this process. Here we utilized 4 thematic maps, all of them obtained from LANDSAT data. Each theme has category containing several levels. The ralative value (or weight) of category (Table 9) and absolute value for each theme might be changed depending upon the object and target district. In this case we put the emphasis on vegetation and land cover. The results of evaluation is given in Photo 18.

4-3 Synthetic Land Evaluation Introducing Each Thematic Map (Step 3)

In the Step 3, we evaluated suitable land for agricultural use by synthetic mathod utilizing both LANDSAT data and all other available reference data. In order to execute this process, it is essential to create thematic maps for LANDSAT analysis according to the main flow in Fig.4, in addition, grid cell data file process is also indispensable. Furthermore, the process including results of the Cross Table Analysis (or Relation Analysis) using land evaluation map which was produced in the previous stage (Step 2).

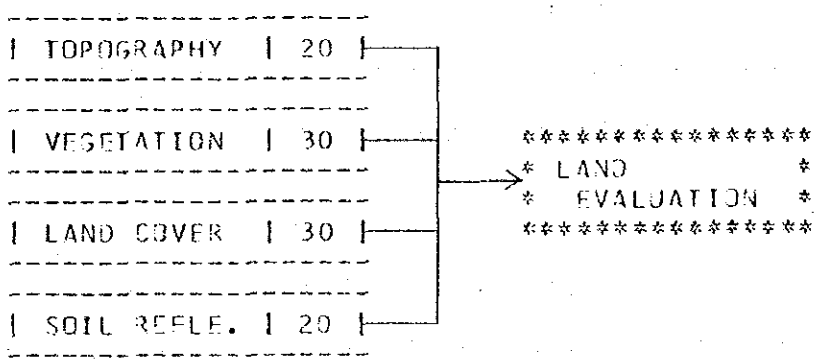


FIG. 7 LAND EVALUATION BY PATTERN METHOD (STEP 2)
(USING 4 THEMATIC MAPS FROM LANDSAT DATA)

These results may be requested in the decision process of weight and score in the Ranking Method and the tree structure in the PATTERN Method.

4-3-1 Investigation of factors of land evaluation used in the Cross Table Analysis

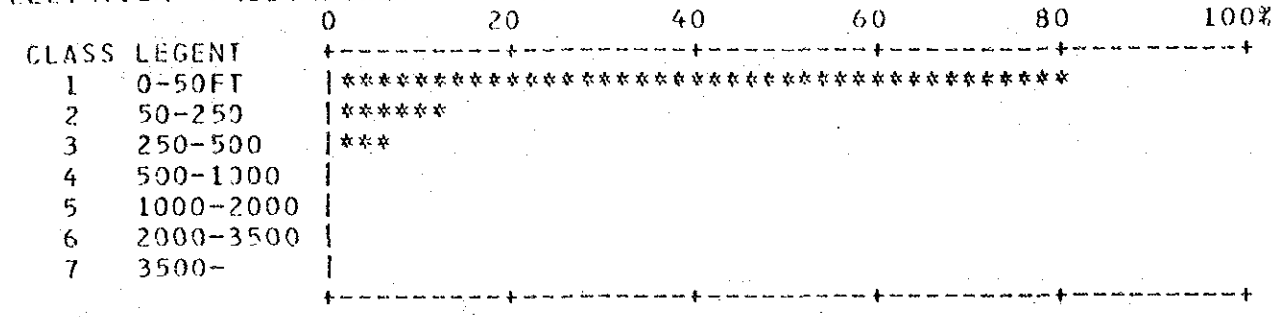
An instance of the Cross Table Analysis between land evaluation data obtained in Step 2 and existing thematic map was presented in Fig.8. It clarified the special distribution pattern of paddy field and plantation of certain elevation on special soil type. The Cross Table Analysis not only provides valuable information for land evaluation but also usefull for decision making of ranking and score with due regard to agricultural feature of target area.

4-3-2 Land evaluation by the Ranking Method

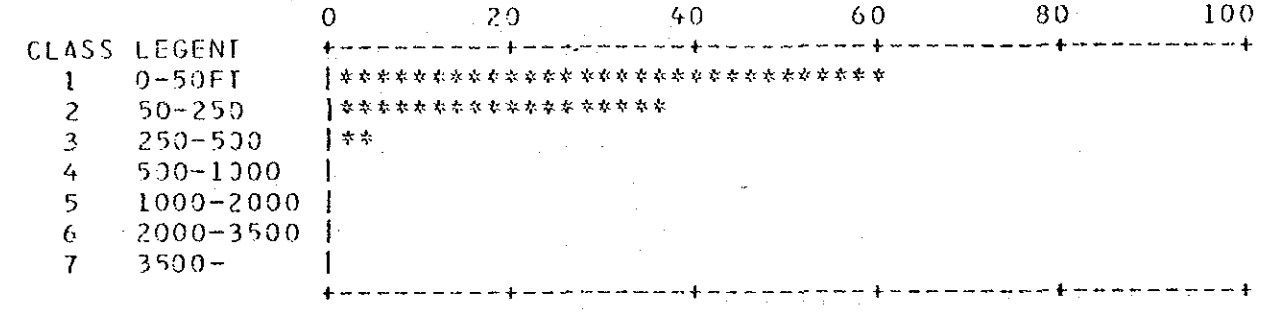
The preparation process at Step 3 is shown in Fig.9. Here, in addition to land evaluation map resulted from process of Step 2, basic land evaluation map (Photo 19) was drwan up using landform and soil information which are thought to be the most important for agricultural utilization of land. This ranking evaluation was framed up from the results of the Cross Table Analysis mentioned in the previous paragraph and existing knowledge, furthermore, the results of the ranking table are shown in Tables 10 to 13.

Starting from this basic map, several land evaluation maps for various view points of application were created overlaying required thematic maps.

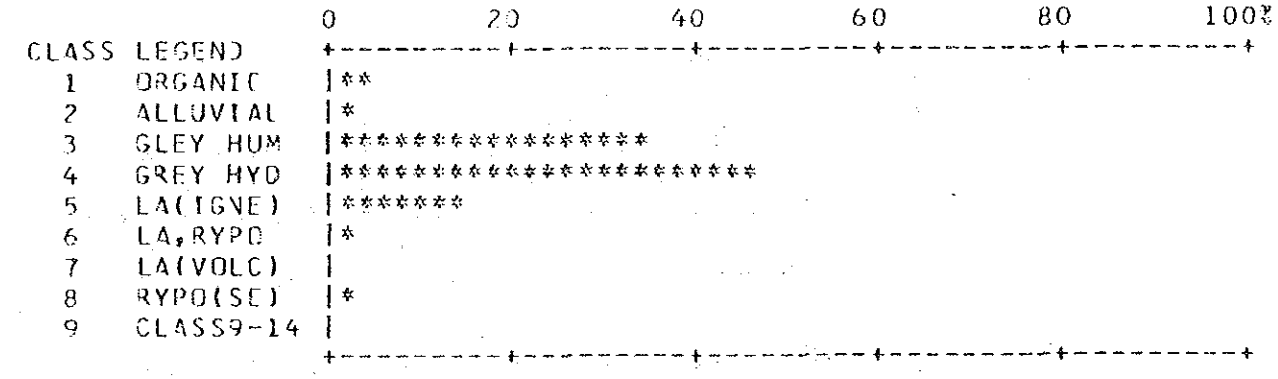
ELEVATION--PADDY FIELD



ELEVATION--PLANTATION



SOIL TYPE--- PADDY FIELD



SOIL TYPE -- PLANTATION

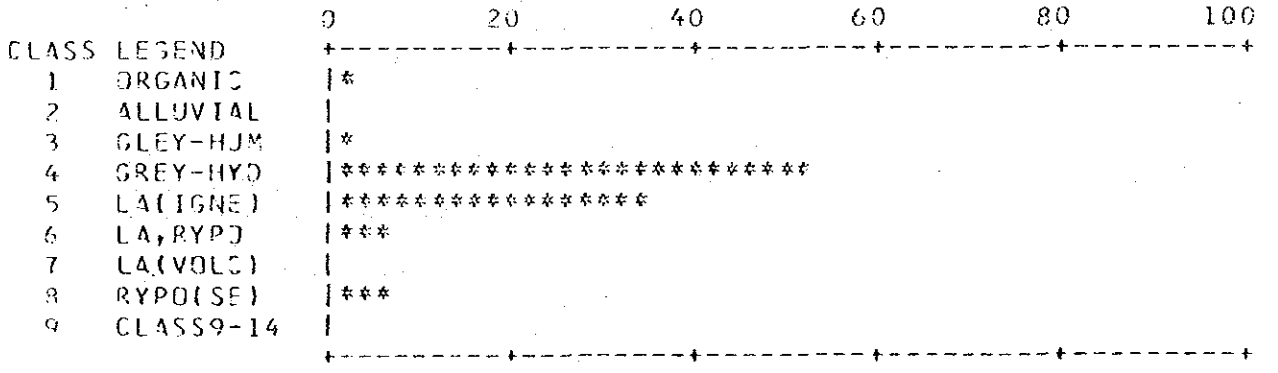


FIG. 8 RESULTS OF CROSS TABLE ANALYSIS

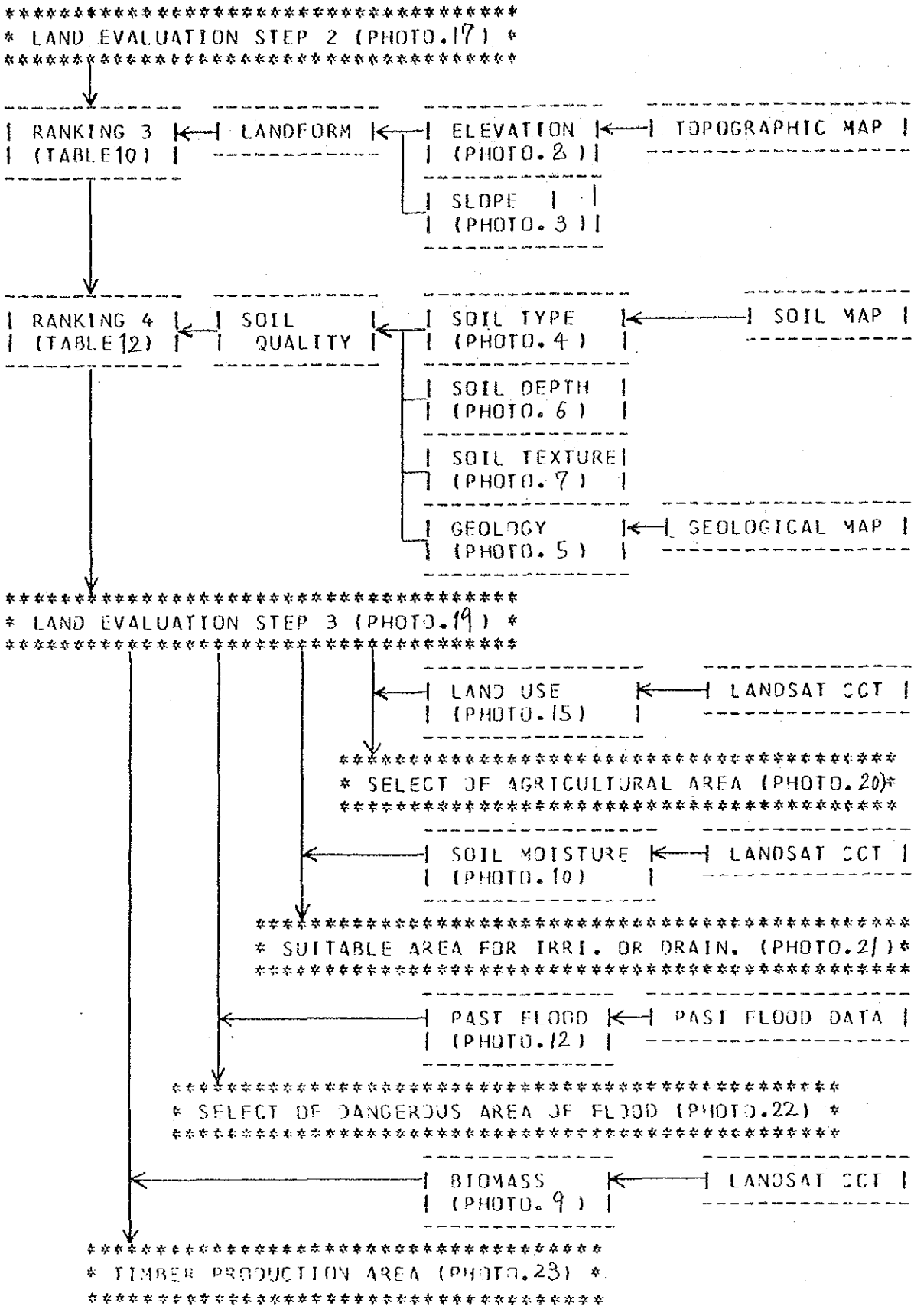


FIG. 9 FLOW OF LAND EVALUATION BY RANKING METHOD (STEP 3)

In this report, we tried to make the evaluation maps such as distribution of existing agricultural land (Photo 20), areas needed drainage or irrigation (Photo 21), water flood dangerous area (Photo 22) and timber production area (Photo 23).

4-3-3 Land evaluation by the PATTERN Method

Two evaluation results were obtained in this process. One is the results from analysis using 11 thematic maps, and the other is the results from selected 4 thematic maps. The tree structure applied in the first analysis (11 maps) and the weights imposed in each category of the process are shown in Fig. 10 and Table 14, respectively. In this analysis, 4 intermediate evaluations were produced. They were resulted from grouping of 11 thematic maps such as landform condition, soil quality condition, land surface condition and soil moisture condition (Photos 24 to 27). The final evaluation result is presented in Photo 28.

On the other hand, assuming the case that less thematic maps are available, four key themes such as elevation, soil type, land cover and soil reflectance were selected for the PATTERN Analysis. The tree structure and the weight are shown in Fig. 11 and Table 15, respectively, The final evaluation results is appeared in Photo 29. The tendency of the two analyzing results (Photo 28 and Photo 29) are very similar in many points.

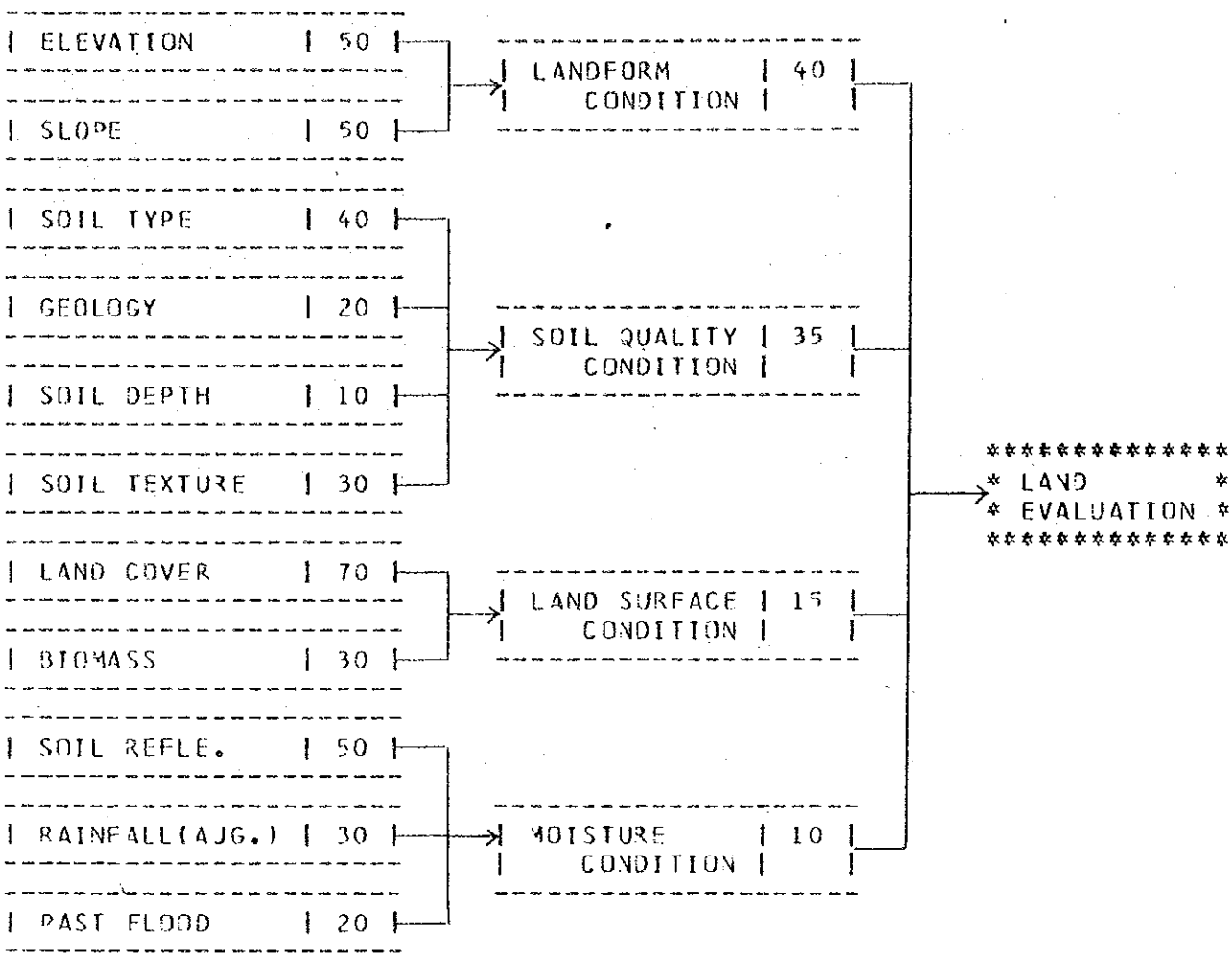


FIG.10 LAND EVALUATION BY PATTERN METHOD (STEP 3)
(USING 11 THEMATIC MAPS)

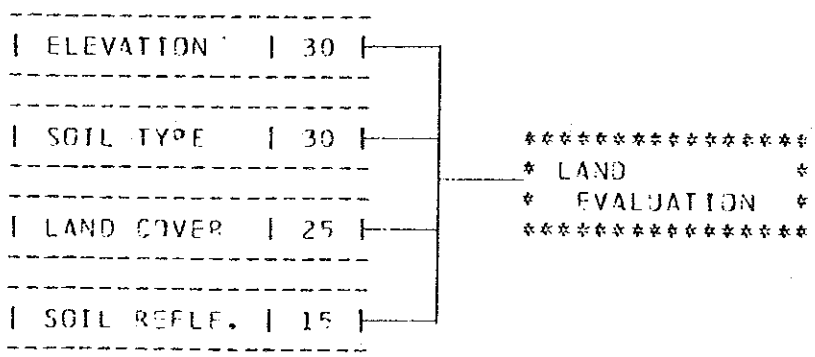


FIG.11 LAND EVALUATION BY PATTERN METHOD (STEP 3)
(USING SELECTED 4 THEMATIC MAPS)

5. EXAMINATION OF EVALUATION RESULTS

5-1 Character of the Three-Step Land Evaluation System

From the results of this evaluation system on the North Sumatera Area, the feature of this system was clarified. That is to say, the meaning of the output is easily understand in this system, because kind of used data and Analysis Method are clearly divided in each Step. Besides, it is possible to combine the previous results into the following Step, which is effective for advancement of evaluation precision. Further, in the 3-Step Land Evaluation System we can choose appropriate Step according through the analysis which are depending upon the actual circumstances.

5-2 Land Evaluation Using Vegetation Information

In Step 1 and Step 2 of the proposed evaluation system, information of vegetation cover mainly obtained from LANDSAT data is used. The North Sumatera Training Area has already developed in some degree except mountain or swamp areas, and covered with secondary forests or agricultural land at present. However, even from these secondary vegetation we can estimate the land condition such as landform, soil type and climate. For example, as is seen in Fig. 8, Gray Hydromorphic Soil and Latozol (origin from igneous rock) appeared mainly of paddy field or plantation area, but on the contrary, on Gley Humic Soil, plantation appeared rarely, even though paddy field dominated on it.

Further, coconut very often grows on high humid areas of the central plain as is seen in Tables 14 and 15.

In the analysis of Step 2, in addition to land cover map detected from LANDSAT data, land evaluation was carried out basing on the evaluation results was used effectively on the pre-evaluation in the subsequently Step.

5-3 Comparison of the Ranking Method and the PATTERN Method

Both the Ranking Method and the PATTERN method were adopted for the evaluation at each Step in this system. Evaluation results obtained by the Ranking Method have a merit can be easily understand the consequence. On the other hand, in the PATTERN Method, it is easy to understand the comparative merits and demerits of the land because the results appeared as a score ranging from 0 to 99, however, it needs to combine the score and the characteristics of agricultural use.

In order to avoid this difficulty, we came to the conclusion that the PATTERN Method should be utilized in parallel with the Ranking Method introducing the merits from both sides. Basing upon this reason, land evaluation results obtained in the PATTERN Method were expressed as classes containing 6 evaluation levels adding the land evaluation results of the Ranking Method.

5-4 Examiniation of Evaluation Precision

- Comparing with field check data -

Distribution of the existed agricultural land such as paddy and plantation area has already become clear by field check survey (see Appendix). It can be say that these already developed areas often exist on suitable land. Comparing the results of distribution of existing agriculture land with the evaluation results of Step 3 (Photos 15 and 19), it was concluded that the land evaluation maps in Step 3 are feasible enough for regional assessment. At the same time, to confirm the analysis precision more clearly, further investigation on different land condition is required.

ACKNOWLEDGEMENT

We would like to express our grateful thanks to all the members of Remote Sensing Project of Indonesia who suggested and encouraged us at all times. We would like to express our thanks especially Ir. Tubagus Haedar Ali and Drs. Suroso for giving special convenience to the work.

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At last, but at the most, we are grateful to Mr. M.Mine and Mr.S.Sakai, Mr. T.Ueda and Mr. K.Mima for support and development of software and hardware.

LIST OF TABLES

Table 1 Main forest types in the tropical east Asia in connection with site factors

(Whitmore, 1975)

Climate	Soil moisture	Location	Soils	Altitude	Forest formation type*	
High moisture in all seasons	Dry land	Inland	Zonal soil	Lowland -1200 m	1	Tropical lowland evergreen rain forest
				Hilly (750) 1200 -1500 m	2	Tropical low-mountain rain forest
				(600) 1500 -3000 m	3	Tropical upper-mountain rain forest
				(3000) 3500 m to forest limit	4	Tropical sub-alpine forest
			Podzolic sand	Mainly lowland	5	Heath forest
			Limestone	Mainly lowland	6	Limestone forest
			Ultrabasic rock	Mainly lowland	7	Serpentin forest
		Coast			8	Coastal forest
		Salt water swamp			9	Mangrove forest
		Brackish water swamp			10	Brackish water swamp forest
		Fresh water swamp	Poor fertile peat		11	Peat swamp forest
			Fertile soil (organic and inorganic)	Wet	12a	Fresh water swamp forest
				Periodically wet	12b	Seasonal swamp forest
Seasonally dry	Causes moderate water deficit seasonally				13	Tropical semi-evergreen rain forest
	Causes severe water deficit seasonally				14	Tropical moist deciduous forest
					15	Other formation types according with the increment of dry season

*1-13: Tropical rain forests, 14-15: Monsoon forests.

Table 2 Agricultural production in North Sumatera Province

Crop name	Harvested area x 1000 Ha	Production x 1000 T	Productivity T / Ha	Price x 1000 Rp / T	Price x 1000 Rp / T
Rubber	337	305	0.91	1231	1114
Oil palm	191	698	3.65	454	1656
Coconut	78	70	0.90	155	139
Coffee	23	13	0.55	1935	1070
Tea	11	22	2.06	1339	2756
Clove	7	12	1.69	7109	11986
Paddy (wet)	477	1762	3.69	141	519
Paddy dry	155	218	1.90	141	268

(Kantor Statistik Propinsi Sumatera Utara, 1981)

*) 1 Rp. (rupiah) is equivalent to 0.25 yen.

TABLE 3 RANKING TABLE (STEP-1)

<FN><FT><FM> OF HADER FILE.: ASAHAN EVALOIID A
<FN><FT><FM> OF IMAGE FILE.: ASAHAN EVALOIMP F
DATA DESCRIPTION.....: ASAHAN EVALUATION MP (VG-TP 11CLASSES)
DESCRIPTION ON LEGENDS

LEG.NO.	RANGE	DESCRIPTION
1	1- 1	EXCELLENT FOR PADDY
2	2- 2	SUITABLE FOR PADDY
3	3- 3	GOOD FOR PADDY AND PLANTATION
4	4- 4	GOOD FOR PADDY AND COCONUTS
5	5- 5	POSSIBLE FOR PADDY, PLANTATION AND COCONUTS
6	5- 6	GOOD FOR DRY FIELD, POSSIBLE FOR PADDY, PLAN.
7	7- 7	SPECIAL USAGE CROPS
8	8- 8	UNSUITABLE AREA FOR AGRICULTURAL DEVELOPMENT
9	9- 9	SEA RIVER LAKE URBAN
10	10- 10	CLOUD AND SHADOW
11	11- 11	UNDECIDED

EVALUATION CRITERIA BASED ON RANKING METHOD

	FILE1	FILE2	FILE3	FILE4	FILE5	FILE6	FILE7
HEADER FILE	ASAHAN VEG11ID A	ASAHAN TOP13ID A					
IMAGE OUT CLASS	ASAHAN VEGMAP3 FIL F	ASAHAN MAJORTOP F					
1	9- 9	3- 3	-	-	-	-	-
2	1- 1	3- 3	-	-	-	-	-
2	1- 1	5- 5	-	-	-	-	-
2	9- 9	5- 5	-	-	-	-	-
3	1- 1	1- 1	-	-	-	-	-
3	1- 1	3- 5	-	-	-	-	-
3	4- 4	1- 1	-	-	-	-	-
3	4- 4	3- 5	-	-	-	-	-
3	9- 9	1- 1	-	-	-	-	-
3	9- 9	3- 5	-	-	-	-	-
4	1- 1	1- 7	-	-	-	-	-
4	1- 1	10- 10	-	-	-	-	-
4	4- 6	1- 7	-	-	-	-	-
4	4- 6	10- 10	-	-	-	-	-
4	9- 9	1- 7	-	-	-	-	-
4	9- 9	10- 10	-	-	-	-	-
5	4- 7	3- 6	-	-	-	-	-
5	7- 7	1- 1	-	-	-	-	-
5	7- 7	10- 10	-	-	-	-	-

(Table 3-2)

6	1- 2	8- 8	-	-	-	-	-	-
6	2- 2	1- 1	-	-	-	-	-	-
6	2- 2	3- 3	-	-	-	-	-	-
6	2- 2	5- 5	-	-	-	-	-	-
6	4- 4	8- 8	-	-	-	-	-	-
6	9- 9	8- 8	-	-	-	-	-	-
7	1- 3	5- 5	-	-	-	-	-	-
7	1- 3	8- 10	-	-	-	-	-	-
8	8- 8	3- 3	-	-	-	-	-	-
8	8- 8	5- 6	-	-	-	-	-	-
9	10- 10	1- 13	-	-	-	-	-	-
10	1- 11	11- 13	-	-	-	-	-	-
10	1- 11	8- 9	-	-	-	-	-	-
2	1- 13	5- 6	-	-	-	-	-	-
2	1- 13	9- 9	-	-	-	-	-	-
11	0-255	0-255	-	-	-	-	-	-

TABLE 4 USING FILE FOR RANKING (STEP-1)

//
INPUT THEMATIC DATA FILE - 1
//
<FN><FT><FM> OF HADER FILE.: ASAHAN VEG1ID A
<FN><FT><FM> OF IMAGE FILE.: ASAHAN VEGMAP3 F
DATA DESCRIPTION.....: ASAHAN VEGETATION MAP (AFTER MAJORITY)
DISCRIPTION ON LEGENDS

LEG.NO.	RANGE	DESCRIPTION
1	1- 1	TROPICAL LOWLAND EVERGREEN RAIN FOREST A
2	2- 2	TROPICAL LOWLAND EVERGREEN RAIN FOREST B
3	3- 3	TROPICAL LOW MOUNTAIN EVERGREEN RAIN FOREST
4	4- 4	COASTAL FOREST
5	5- 5	MANGROVE FOREST
6	6- 6	PEAT SWAMP FOREST A
7	7- 7	PEAT SWAMP FOREST B
8	8- 8	PEAT SWAMP FOREST C
9	9- 9	FRESH WATER SWAMP FOREST
10	10- 10	SEA RIVER LAKE URBAN
11	11- 11	CLOUD SHADOW

//
INPUT THEMATIC DATA FILE - 2
//
<FN><FT><FM> OF HADER FILE.: ASAHAN TOP13ID A
<FN><FT><FM> OF IMAGE FILE.: ASAHAN MAJORTOP F
DATA DESCRIPTION.....: ASAHAN TOPOGRAPH MAP (AFTER MAJORITY)
DISCRIPTION ON LEGENDS

LEG.NO.	RANGE	DESCRIPTION
1	1- 1	COASTAL PLAIN
2	2- 2	ISLAND
3	3- 3	ALLUVIAL PLAIN
4	4- 4	NON-DRAINAGED-PLAIN
5	5- 5	PLAIN
6	6- 6	SWAMP AREA
7	7- 7	DEVELOPED SWAMP AREA (PADDY FIELD)
8	8- 8	FOOT SLOPE
9	9- 9	MOUNTAIN
10	10- 10	BASIN
11	11- 11	LAKE
12	12- 12	SEA
13	13- 13	CLOUD COVER

TABLE 5 RANKING TABLE AT <<< RANKING 1 >>>

<FN><FT><FM> OF HADER FILE.: ASAHAN EVLMO1ID A
<FN><FT><FM> OF IMAGE FILE.: ASAHAN EVLMO1MP F
DATA DESCRIPTION.....: ASAHAN LAND CONDITION (TOPO + LAND COVER)
DISCRIPTION ON LEGENDS

LEG.NO.	RANGE	DESCRIPTION
1	1- 1	CLOUD COVER
2	2- 2	SEA , WATER
3	3- 3	MOUNTAIN TREE
4	4- 4	SUITABLE FOR SPECIAL CROP
5	5- 5	PLANTATION
6	6- 6	SWAMP DEVELOPMENT (FIRST STAGE)
7	7- 7	SWAMP DEVELOPMENT (SECOND STAGE)
8	8- 8	PADDY FIELD AREA
9	9- 9	SUITABLE FOR PADDY FIELD
10	10- 10	SUITABLE FOR PADDY OR DRY FIELD
11	11- 11	NOT SUITABLE FOR AGRICULTURE
12	12- 12	OTHERS

EVALUATION CRITERIA BASED ON RANKING METHOD

	FILE1	FILE2	FILE3	FILE4	FILE5	FILE6	FILE7
HEADER FILE	ASAHAN TOP13ID A	ASAHAN LCOVID A					
IMAGE OUT CLASS	ASAHAN MAJORTOP F	ASAHAN LCOVMP F					
1	1- 13	1- 1	-	-	-	-	-
2	1- 13	2- 2	-	-	-	-	-
3	9- 9	4- 4	-	-	-	-	-
3	13- 13	4- 4	-	-	-	-	-
4	3- 10	5- 9	-	-	-	-	-
5	3- 5	5- 7	-	-	-	-	-
5	8- 8	5- 7	-	-	-	-	-
6	1- 13	11- 11	-	-	-	-	-
7	1- 13	12- 12	-	-	-	-	-
8	1- 13	10- 10	-	-	-	-	-
8	1- 13	14- 14	-	-	-	-	-
9	1- 13	5- 8	-	-	-	-	-
10	1- 13	4- 4	-	-	-	-	-
10	1- 13	9- 9	-	-	-	-	-
11	1- 13	1- 14	-	-	-	-	-
12	0-255	0-255	-	-	-	-	-

TABLE 6 USING FILE AT <<< RANKING 1 >>>

//
INPUT THEMATIC DATA FILE - 1
//
<FN><FT><FM> OF HADER FILE.: ASAHAN TOP13ID A
<FN><FT><FM> OF IMAGE FILE.: ASAHAN MAJORTOP F
DATA DESCRIPTION.....: ASAHAN TOPOGRAPH MAP (AFTER MAJORITY)
DISCRIPTION ON LEGENDS

LEG.NO.	RANGE	DESCRIPTION
1	1- 1	COASTAL PLAIN
2	2- 2	ISLAND
3	3- 3	ALLUVIAL PLAIN
4	4- 4	NON-DRAINAGED-PLAIN
5	5- 5	PLAIN
6	6- 6	SWAMP AREA
7	7- 7	DEVELOPED SWAMP AREA (PADDY FIELD)
8	8- 8	FOOT SLOPE
9	9- 9	MOUNTAIN
10	10- 10	BASIN
11	11- 11	LAKE
12	12- 12	SEA
13	13- 13	CLOUD COVER

//
INPUT THEMATIC DATA FILE - 2
//
<FN><FT><FM> OF HADER FILE.: ASAHAN LCOVID A
<FN><FT><FM> OF IMAGE FILE.: ASAHAN LCOVMP F
DATA DESCRIPTION.....: ASAHAN LANDCOVER MAP (2-ED, 15CLASSES)
DISCRIPTION ON LEGENDS

LEG.NO.	RANGE	DESCRIPTION
1	1- 1	CLOUD , SHADOW
2	2- 2	WATER , SHADOW
3	3- 3	CITY , TOWN , OTHERS
4	4- 4	MOUNTAIN TREE
5	5- 5	RUBBER
6	6- 6	PARM OIL , RUBER
7	7- 7	PARM OIL
8	8- 8	COCONUT MIX
9	9- 9	DRY FIELD , SECOND STAGE TREE
10	10- 10	PADDY FIELD
11	11- 11	SWAMP (AROUND)
12	12- 12	SWAMP (MIDDLE)
13	13- 13	SWAMP (CENTER)
14	14- 14	GRASS LAND , STRIP GROUND
15	15- 15	OTHERS

TABLE 7 RANKING TABLE AT <<< RANKING 2 >>>

<FN><FT><FM> OF HADER FILE.: ASAHAN EVLM02ID A
<FN><FT><FM> OF IMAGE FILE.: ASAHAN EVLM02MP F
DATA DESCRIPTION.....: ASAHAN PRE-EVAL OF AGRI. SUITABILITY
DISCRIPTION ON LEGENDS

LEG.NO.	RANGE	DESCRIPTION
1	1- 1	CLOUD COVER
2	2- 2	SEA , WATER
3	3- 3	PLANTATION AREA
4	4- 4	SUITABLE FOR SPECIAL CROP (HIGH LAND DRY FIELD)
5	5- 5	LAND IMPROVEMENT OF PADDY FIELD
6	6- 6	SUITABLE FOR PADDY FIELD
7	7- 7	SUITABLE FOR PADDY FIELD (SWAMP , FIRST STAGE DEV.)
8	8- 8	SUITABLE FOR PADDY FIELD (SWAMP , SECOND STAGE DEV.)
9	9- 9	SUITABLE FOR PADDY OR DRY FIELD (MAINLY PADDY FIELD)
10	10- 10	SUITABLE FOR PADDY OR DRY FIELD (MAINLY DRY FIELD)
11	11- 11	NOT SUITABLE FOR AGRICULTURE
12	12- 12	OTHERS

EVALUATION CRITERIA BASED ON RANKING METHOD

	FILE1	FILE2	FILE3	FILE4	FILE5	FILE6	FILE7
HEADER FILE	ASAHAN EVLM01ID A	ASAHAN PLTPCTID A	ASAHAN PDYPCTID A	ASAHAN CMXPCTID A			
OUT CLASS	IMAGE FIL ASAHAN EVLM01MP F	ASAHAN PLTPCT F	ASAHAN PDYPCT F	ASAHAN CMXPCT F			
1	1- 1	1- 10	1- 10	1- 10	-	-	-
2	1- 2	1- 10	1- 10	1- 10	-	-	-
3	4- 5	6- 10	1- 10	1- 10	-	-	-
4	4- 4	1- 10	1- 5	1- 2	-	-	-
5	4- 10	1- 10	6- 10	1- 10	-	-	-
6	5- 10	1- 10	3- 5	1- 10	-	-	-
6	5- 10	1- 10	1- 10	6- 10	-	-	-
7	6- 6	1- 10	1- 10	1- 10	-	-	-
8	7- 7	1- 10	1- 10	1- 10	-	-	-
9	5- 10	1- 10	1- 10	3- 10	-	-	-
10	4- 10	1- 10	1- 10	1- 10	-	-	-
11	3- 11	1- 10	1- 10	1- 10	-	-	-
12	0-255	0-255	0-255	0-255	-	-	-

TABLE 8 USING FILE AT <<< RANKING 2>>>

//
INPUT THEMATIC DATA FILE - 1
//

<FN><FT><FM> OF HADER FILE.: ASAHAN EVLM01ID A
<FN><FT><FM> OF IMAGE FILE.: ASAHAN EVLM01MP F
DATA DESCRIPTION.....: ASAHAN LAND CONDITION (TOPO + LAND COVER)
DISCRIPTION ON LEGENDS

LEG.NO.	RANGE	DESCRIPTION
1	1- 1	CLOUD COVER
2	2- 2	SEA , WATER
3	3- 3	MOUNTAIN TREE
4	4- 4	SUITABLE FOR SPECIAL CROP
5	5- 5	PLANTATION
6	6- 6	SWAMP DEVELOPMENT (FIRST STAGE)
7	7- 7	SWAMP DEVELOPMENT (SECOND STAGE)
8	8- 8	PADDY FIELD AREA
9	9- 9	SUITABLE FOR PADDY FIELD
10	10- 10	SUITABLE FOR PADDY OR DRY FIELD
11	11- 11	NOT SUITABLE FOR AGRICULTURE
12	12- 12	OTHERS

//
INPUT THEMATIC DATA FILE - 2
//

<FN><FT><FM> OF HADER FILE.: ASAHAN PLTPCTID A
<FN><FT><FM> OF IMAGE FILE.: ASAHAN PLTPCT F
DATA DESCRIPTION.....: ASAHAN PLANTATION PERCENTAGE MAP
DISCRIPTION ON LEGENDS

LEG.NO.	RANGE	DESCRIPTION
1	1- 1	00-- 10% PLANTATION
2	2- 2	10-- 20% PLANTATION
3	3- 3	20-- 30% PLANTATION
4	4- 4	30-- 40% PLANTATION
5	5- 5	40-- 50% PLANTATION
6	6- 6	50-- 60% PLANTATION
7	7- 7	60-- 70% PLANTATION
8	8- 8	70-- 80% PLANTATION
9	9- 9	80-- 90% PLANTATION
10	10- 10	90--100% PLANTATION

//
INPUT THEMATIC DATA FILE - 3
//

<FN><FT><FM> OF HADER FILE.: ASAHAN PDYPCTID A
<FN><FT><FM> OF IMAGE FILE.: ASAHAN PDYPCT F
DATA DESCRIPTION.....: ASAHAN PADDY FIELD PERCENTAGE MAP

(Table 8-2)

DISCRIPTION ON LEGENDS

LEG.NO.	RANGE	DESCRIPTION
1	1- 1	00-- 10% PADDY FIELD
2	2- 2	10-- 20% PADDY FIELD
3	3- 3	20-- 30% PADDY FIELD
4	4- 4	30-- 40% PADDY FIELD
5	5- 5	40-- 50% PADDY FIELD
6	6- 6	50-- 60% PADDY FIELD
7	7- 7	60-- 70% PADDY FIELD
8	8- 8	70-- 80% PADDY FIELD
9	9- 9	80-- 90% PADDY FIELD
10	10- 10	90--100% PADDY FIELD

//
INPUT THEMATIC DATA FILE - 4
//

<FN><FT><FM> OF HADER FILE.: ASAHAN CMXPCTIO A
<FN><FT><FM> OF IMAGE FILE.: ASAHAN CMXPCT F
DATA DESCRIPTION.....: ASAHAN COCONUT MIX PERCENTAGE MAP
DISCRIPTION ON LEGENDS

LEG.NO.	RANGE	DESCRIPTION
1	1- 1	00-- 10% COCONUT MIX
2	2- 2	10-- 20% COCONUT MIX
3	3- 3	20-- 30% COCONUT MIX
4	4- 4	30-- 40% COCONUT MIX
5	5- 5	40-- 50% COCONUT MIX
6	6- 6	50-- 60% COCONUT MIX
7	7- 7	60-- 70% COCONUT MIX
8	8- 8	70-- 80% COCONUT MIX
9	9- 9	80-- 90% COCONUT MIX
10	10- 10	90--100% COCONUT MIX

TABLE 9 SCORE FOR EACH CLASS IN THEMATIC MAPS (PATTERN METHOD)
(CASE OF 4 THEMATIC MAPS FROM LANDSAT)

***** TOPOGRAPHY *****
ABSOLUTE WEIGHT OF THIS THEMMATIC DATA= 20

NO.LEG.	RANGE(MIN-MAX)		DESCRIPTION(30 CHR)	REL. WEIGHT
1	1	1	COASTAL PLAIN	80
2	2	2	ISLAND	30
3	3	3	ALLUVIAL PLAIN	99
4	4	4	NON-DRAINAGED PLAIN	60
5	5	5	PLAIN	90
6	6	6	SWAMP AREA	20
7	7	7	DEVELOPED SWAMP AREA	60
8	8	8	FOOT SLOPE	40
9	9	9	MOUNTAIN	10
10	10	10	BASIN	50
11	11	11	LAKE	0
12	12	12	SEA	0
13	13	13	CLOUD	0

ENDTHEME

***** VEGTATION *****
ABSOLUTE WEIGHT OF THIS THEMMATIC DATA= 30

LEG.NO.	RANGE(MIN-MAX)		DESCRIPTION(50 CHR)	REL. (WEIGHT)
1	1	1	LOWLAND EVERGREEN RAIN FOREST A	85
2	2	2	LOWLAND EVERGREEN RAIN FOREST B	70
3	3	3	LOW MOUNTAIN EVERGREEN RAIN FOREST	20
4	4	4	COASTAL FOREST	70
5	5	5	MANGROVE FOREST	40
6	6	6	PEAT SWAMP FOREST A	50
7	7	7	PEAT SWAMP FOREST B	30
8	8	8	PEAT SWAMP FOREST C	10
9	9	9	FRESH WATER SWAMP FOREST	99
10	10	10	SEA, RIVER, LAKE AND URBAN	0
11	11	11	CLOUD AND SHADOW	0

ENDTHEME

***** LAND COVER (UNSUPERVISED) *****
ABSOLUTE WEIGHT OF THIS THEMMATIC DATA= 30

LEG.NO.	RANGE(MIN-MAX)		DESCRIPTION(50 CHR)	REL. (WEIGHT)
1	1	1	CLOUD	0
2	2	2	WATER	0
3	3	3	URBAN	0
4	4	4	MOUNTAIN FOREST	20
5	5	5	RUBBER	75
6	6	6	PALM OIL + RUBBER	80
7	7	7	PALM OIL	85
8	8	8	COCONUT MIX	60

(Table 9-2)

9	9	9	DRY FIELD	70
10	10	10	PADDY FIELD	99
11	11	11	SWAMP (AROUND)	50
12	12	12	SWAMP (MIDDLE)	30
13	13	13	SWAMP (CENTER)	5
14	14	14	GRASSLAND AND BARE SOIL	80
15	15	15	OUT OF AREA	0

ENDTHEME

***** SOIL REFLECTANCE *****
ABSOLUTE WEIGHT OF THIS THEMMATIC DATA= 20

LEG.NO.	RANGE(MIN-MAX)		DESCRIPTION(50 CHR)	REL. (WEIGHT)
1	1	1	DRY	40
2	2	2	SLIGHTLY DRY	70
3	3	3	MEDIUM	99
4	4	4	SLIGHTLY WET	70
5	5	5	WET	40

ENDTHEME

TABLE 10 RANKING TABLE AT <<< RANKING 3 >>>

<FN><FT><FM> OF HADER FILE.: EVALSYS EVLM03ID A
<FN><FT><FM> OF IMAGE FILE.: EVALSYS EVLM03MP F
DATA DESCRIPTION.....: ASAHAN EVALUATIONMAP NO.3
DISCRIPTION ON LEGENDS

LEG.NO.	RANGE	DESCRIPTION
1	1- 1	CLOUD COVER
2	2- 2	GOOD (PADDY, DRY FIELD OR PLANTATION)
3	3- 3	MODERATE 1 (PADDY OR DRY FIELD)
4	4- 4	MODERATE 2 (DRY FIELD)
5	5- 5	SWAMP (FIRST STAGE DEVELOPMENT)
6	6- 6	SWAMP (SECOND STAGE DEVELOPMENT)
7	7- 7	SWAMP AREA
8	8- 8	POOR FOR AGRICULTURAL USE
9	9- 9	NOT AGRICULTURAL USE
10	10- 10	OTHERS

EVALUATION CRITERIA BASED ON RANKING METHOD

	FILE1	FILE2	FILE3	FILE4	FILE5	FILE6	FILE7
HEADER FILE	ASAHAN EVLM02ID A	EVALSYS LNDFRMID A					
OUT CLASS / IMAGE FIL	ASAHAN EVLM02MP F	EVALSYS LNDFRMMP F					
1	1- 1	0-255	-	-	-	-	-
2	2- 3	1- 2	-	-	-	-	-
2	5- 5	1- 2	-	-	-	-	-
2	5- 6	1- 1	-	-	-	-	-
3	2- 6	1- 2	-	-	-	-	-
3	9- 10	1- 2	-	-	-	-	-
4	2- 6	1- 3	-	-	-	-	-
4	9- 10	1- 3	-	-	-	-	-
5	7- 7	1- 1	-	-	-	-	-
6	8- 8	1- 1	-	-	-	-	-
7	11- 11	1- 1	-	-	-	-	-
8	2- 11	1- 4	-	-	-	-	-
3	2- 2	1- 1	-	-	-	-	-
3	3- 11	0-255	-	-	-	-	-
9	2- 11	1- 5	-	-	-	-	-
10	0-255	0-255	-	-	-	-	-

TABLE 11 USING FILE AT <<< RANKING 3 >>>

```
////////////////////////////////////////////////////////////////////////////////
    INPUT THEMATIC DATA FILE - 1
////////////////////////////////////////////////////////////////////////////////
<FN><FT><FM> OF HADER FILE.: ASAHAN  EVLM02ID A
<FN><FT><FM> OF IMAGE FILE.: ASAHAN  EVLM02MP F
DATA DESCRIPTION.....: ASAHAN  PRE-EVAL OF AGRI. SUITABILITY
DISCRIPTION ON LEGENDS
```

LEG.NO.	RANGE	DESCRIPTION
1	1- 1	CLOUD COVER
2	2- 2	SEA , WATER
3	3- 3	PLANTATION AREA
4	4- 4	SUITABLE FOR SPECIAL CROP (HIGH LAND DRY FIELD)
5	5- 5	LAND IMPROVEMENT OF PADDY FIELD
6	6- 6	SUITABLE FOR PADDY FIELD
7	7- 7	SUITABLE FOR PADDY FIELD (SWAMP , FIRST STAGE DEV.)
8	8- 8	SUITABLE FOR PADDY FIELD (SWAMP , SECOND STAGE DEV.)
9	9- 9	SUITABLE FOR PADDY OR DRY FIELD (MAINLY PADDY FIELD)
10	10- 10	SUITABLE FOR PADDY OR DRY FIELD (MAINLY DRY FIELD)
11	11- 11	NOT SUITABLE FOR AGRICULTURE
12	12- 12	OTHERS

```
////////////////////////////////////////////////////////////////////////////////
    INPUT THEMATIC DATA FILE - 2
////////////////////////////////////////////////////////////////////////////////
<FN><FT><FM> OF HADER FILE.: EVALSYS LNDFRMID A
<FN><FT><FM> OF IMAGE FILE.: EVALSYS LNDFRMMP F
DATA DESCRIPTION.....: ASAHAN LANDFORM EVALJATION MAP
DISCRIPTION ON LEGENDS
```

LEG.NO.	RANGE	DESCRIPTION
1	1- 1	GOOD FOR PADDY FIELD
2	2- 2	MODERATE FOR PADDY OR DRY FIELD
3	3- 3	MODERATE FOR DRY FIELD
4	4- 4	POOR
5	5- 5	NOT AGRICULTURAL USE
6	6- 6	OTHERS

EVALUATION CRITERIA BASED ON RANKING METHOD

	FILE1	FILE2	FILE3	FILE4	FILE5	FILE6	FILE7
HEADER FILE	ASAHAN ELEVATIDG	ASAHAN SLOPEEIDG					
IMAGE FILE	ASAHAN ELEVATMP	ASAHAN SLOPEEMP					
OUT							

(Table II-2)

CLASS	N	N						
1	1- 1	1- 1	-	-	-	-	-	-
2	1- 2	1- 2	-	-	-	-	-	-
3	1- 6	1- 3	-	-	-	-	-	-
4	1- 6	1- 4	-	-	-	-	-	-
5	7- 7	1- 4	-	-	-	-	-	-
6	0-255	0-255	-	-	-	-	-	-

//
INPUT THEMATIC DATA FILE - 1
//

<FN><FT><FM> OF HADER FILE.: ASAHANR ELEVATID 0
<FN><FT><FM> OF IMAGE FILE.: ASAHANR ELEVATMP 0
DATA DESCRIPTION.....: ASAHAN ELEVATIE CLASSIFICATION MAP
DISCRIPTION ON LEGENDS

LEG.NO.	RANGE	DESCRIPTION
1	1- 1	0 - 50 FEET
2	2- 2	50 - 250 FEET
3	3- 3	250 - 500 FEET
4	4- 4	500 - 1000 FEET
5	5- 5	1000 - 2000 FEET
6	6- 6	2000 - 3500 FEET
7	7- 7	> 3500 FEET

//
INPUT THEMATIC DATA FILE - 2
//

<FN><FT><FM> OF HADER FILE.: ASAHANR SLOPESID 0
<FN><FT><FM> OF IMAGE FILE.: ASAHANR SLOPEEMP 0
DATA DESCRIPTION.....: ASAHAN SLOPESID CLASSIFICATION MAP
DISCRIPTION ON LEGENDS

LEG.NO.	RANGE	DESCRIPTION
1	1- 1	0 - 2 %
2	2- 2	2 - 8 %
3	3- 3	8 - 15 %
4	4- 4	15 - 30 %

TABLE 12 RANKING TABLE AT <<< RANKING 4 >>>

<FN><FT><FM> OF HADER FILE.: EVALSYS EVLM04ID A
<FN><FT><FM> OF IMAGE FILE.: EVALSYS EVLM04MP F
DATA DESCRIPTION.....: ASAHAN EVALUATIONMAP NO.4
DISCRIPTION ON LEGENDS

LEG.NO.	RANGE	DESCRIPTION
1	1- 1	CLOUD COVER
2	2- 2	GOOD (PADDY, DRY FIELD OR PLANTATION)
3	3- 3	MODERATE 1 (PADDY OR DRY FIELD)
4	4- 4	MODERATE 2 (DRY FIELD)
5	5- 5	SWAMP (FIRST STAGE DEVELOPMENT)
6	6- 6	SWAMP (SECOND STAGE DEVELOPMENT)
7	7- 7	SWAMP AREA
8	8- 8	POOR FOR AGRICULTURAL USE
9	9- 9	NOT AGRICULTURAL USE
10	10- 10	OTHERS

EVALUATION CRITERIA BASED ON RANKING METHOD

	FILE1	FILE2	FILE3	FILE4	FILE5	FILE6	FILE7
HEADER FILE	EVALSYS EVLM03ID A	EVALSYS SOIQUAID A					
IMAGE FIL	EVALSYS EVLM03MP F	EVALSYS SOIQUAMP F					
OUT CLASS							
1	1- 1	0-255	-	-	-	-	-
2	2- 2	1- 5	-	-	-	-	-
3	2- 3	1- 3	-	-	-	-	-
3	2- 3	5- 5	-	-	-	-	-
4	2- 4	1- 5	-	-	-	-	-
5	5- 5	0-255	-	-	-	-	-
6	6- 6	0-255	-	-	-	-	-
7	7- 7	0-255	-	-	-	-	-
8	2- 8	1- 6	-	-	-	-	-
3	2- 4	0-255	-	-	-	-	-
3	0-255	1- 3	-	-	-	-	-
9	2- 9	1- 6	-	-	-	-	-
10	0-255	0-255	-	-	-	-	-

TABLE 13 USING FILE AT <<< RANKING 4 >>>

//
INPUT THEMATIC DATA FILE - 1
//

<FN><FT><FM> OF HADER FILE.: EVALSYS EVLM03ID A
<FN><FT><FM> OF IMAGE FILE.: EVALSYS EVLM03MP F
DATA DESCRIPTION.....: ASAHAN EVALUATIONMAP NO.3
DISCRIPTION ON LEGENDS

LEG.NO.	RANGE	DESCRIPTION
1	1- 1	CLOUD COVER
2	2- 2	GOOD (PADDY, DRY FIELD OR PLANTATION)
3	3- 3	MODERATE 1 (PADDY OR DRY FIELD)
4	4- 4	MODERATE 2 (DRY FIELD)
5	5- 5	SWAMP (FIRST STAGE DEVELOPMENT)
6	6- 6	SWAMP (SECOND STAGE DEVELOPMENT)
7	7- 7	SWAMP AREA
8	8- 8	POOR FOR AGRICULTURAL USE
9	9- 9	NOT AGRICULTURAL USE
10	10- 10	OTHERS

//
INPUT THEMATIC DATA FILE - 2
//

<FN><FT><FM> OF HADER FILE.: EVALSYS SOIQUAID A
<FN><FT><FM> OF IMAGE FILE.: EVALSYS SOIQUAMP F
DATA DESCRIPTION.....: ASAHAN SOIL QUALITY EVALUATION MAP
DISCRIPTION ON LEGENDS

LEG.NO.	RANGE	DESCRIPTION
1	1- 1	GOOD
2	2- 2	MODERATE 1 (LIM. ON SOIL TYPE)
3	3- 3	MODERATE 2 (LIM. ON SOIL TYPE,(OR AND) SOIL DEPTH)
4	4- 4	MODERATE 3 (LIM. ON SOIL TYPE, DEPTH, TEXTURE)
5	5- 5	POOR (PEAT SOIL , SWAMP)
6	6- 6	POOR
7	7- 7	OTHERS

EVALUATION CRITERIA BASED ON RANKING METHOD

	FILE1	FILE2	FILE3	FILE4	FILE5	FILE6	FILE7
HEADER FILE	ASAHAN SOITYPID:G	ASAHAN SOIDEPID:G	ASAHAN SOITEXID:A	ASAHAN GEOLOGID:G			
IMAGE FIL CLASS	ASAHAN SOITYPMP:N	ASAHAN SOIDEPMP:N	ASAHAN SOITEXMP:N	ASAHAN GEOLOGMP:N			

(Table 13-2)

1	2- 4	1- 2	2- 2	1- 2	-	-	-	
1	2- 4	1- 2	2- 2	7- 7	-	-	-	
2	2- 9	1- 2	2- 2	1- 8	-	-	-	
2	12- 12	1- 2	2- 2	1- 8	-	-	-	
3	2- 9	1- 3	2- 2	1- 8	-	-	-	
3	12- 12	1- 3	2- 2	1- 8	-	-	-	
4	2- 9	1- 3	1- 3	1- 8	-	-	-	
4	12- 12	1- 3	1- 3	1- 8	-	-	-	
5	1- 1	0-255	0-255	0-255	-	-	-	
6	1- 15	1- 4	1- 3	1- 8	-	-	-	
7	0-255	0-255	0-255	0-255	-	-	-	

//
INPUT THEMATIC DATA FILE - 1
//

<FN><FT><FM> OF HADER FILE.: ASAHANR SOITYPID 0
<FN><FT><FM> OF IMAGE FILE.: ASAHANR SOITYPMP 0
DATA DESCRIPTION.....: ASAHAN SOILTYPE CLASSIFICATION MAP
DISCRIPTION ON LEGENDS

LEG.NO.	RANGE	DESCRIPTION
1	1- 1	ORGANIC SOIL
2	2- 2	ALLUVIAL
3	3- 3	GLEY HUMIC
4	4- 4	GREY HYDROMORPH
5	5- 5	LATOSOL (FROM IGNEOUS ROCK)
6	6- 6	LATOSOL AND R.Y. PODZOLIC
7	7- 7	LATOSOL (FROM VOLCANIC ROCK)
8	8- 8	RED YELLOW PODZOLIC (SEDIMENTARY ROCK)
9	9- 9	RED YELLOW PODZOLIC (ALLUVIAL)
10	10- 10	RED YELLOW PODZOLIC, LATOSOL, LITHOSOL COMPLEX
11	11- 11	BROWN PODZOLIC, LATOSOL, LITHOSOL COMPLEX
12	12- 12	REGOSOL, LATOSOL
13	13- 13	LITHOSOL, REGOSOL
14	14- 14	GREY BROWN PODZOLIC

//
INPUT THEMATIC DATA FILE - 2
//

<FN><FT><FM> OF HADER FILE.: ASAHANR SOIDEPID 0
<FN><FT><FM> OF IMAGE FILE.: ASAHANR SOIDEPMP 0
DATA DESCRIPTION.....: ASAHAN SOILDEPT CLASSIFICATION MAP
DISCRIPTION ON LEGENDS

LEG.NO.	RANGE	DESCRIPTION
1	1- 1	> 90 CM
2	2- 2	60 - 90 CM
3	3- 3	30 - 60 CM
4	4- 4	< 30 CM

(Table 13-3)

//
INPUT THEMATIC DATA FILE - 3
//
<FN><FT><FM> OF HADER FILE.: ASAHAN SOITEXID A
<FN><FT><FM> OF IMAGE FILE.: ASAHAN SOITEXMP N
DATA DESCRIPTION.....: ASAHAN SOIL TEXTURE MAP
DISCRIPTION ON LEGENDS

LEG.NO.	RANGE	DESCRIPTION
1	1- 1	FINE (CLAY)
2	2- 2	MEDIUM(LOAM)
3	3- 3	COASE (SANDY)

//
INPUT THEMATIC DATA FILE - 4
//
<FN><FT><FM> OF HADER FILE.: ASAHANR GEOLOGID 0
<FN><FT><FM> OF IMAGE FILE.: ASAHANR GEOLOGMP 0
DATA DESCRIPTION.....: ASAHAN GEOLOGI CLASSIFICATION MAP
DISCRIPTION ON LEGENDS

LEG.NO.	RANGE	DESCRIPTION
1	1- 1	OUT OF AREA
2	2- 2	YOUNG ALLUVIUM
3	3- 3	OLDER ALLUVIUM
4	4- 4	PETANI FORMATION
5	5- 5	SIHAPAS FORMATION
6	6- 6	TAPANULI GROUP UNDIFF.
7	7- 7	KUALU FORMATION
8	8- 8	TOBA TUFF
9	9- 9	SAMOSIR FORMATION

TABLE 14 SCORE FOR EACH CLASS IN THEMATIC MAP (PATTERN METHOD)
(CASE OF 11 THEMATIC MAPS)

***** ELEVATION *****
ABSOLUTE WEIGHT OF THIS THEMMATIC DATA= 50

NO.LEG.	RANGE(MIN-MAX)	DESCRIPTION(30 CHR)	REL. WEIGHT
1	1 1	0 - 50 FEET	99
2	2 2	50 - 250 FEET	80
3	3 3	250 - 500 FEET	70
4	4 4	500 - 1000 FEET	60
5	5 5	1000 - 2000 FEET	50
6	6 6	2500 - 3500 FEET	30
7	7 7	> 3500 FEET	5

ENDTHEME

***** SLOPE *****
ABSOLUTE WEIGHT OF THIS THEMMATIC DATA= 50

LEG.NO.	RANGE(MIN-MAX)	DESCRIPTION(50 CHR)	REL. (WEIGHT)
1	1 1	0 - 2 %	99
2	2 2	2 - 15 %	75
3	3 3	15 - 30 %	50
4	4 4	> 30 %	10

ENDTHEME

***** SOIL TYPE *****
ABSOLUTE WEIGHT OF THIS THEMMATIC DATA= 40

LEG.NO.	RANGE(MIN-MAX)	DESCRIPTION(50 CHR)	REL. (WEIGHT)
1	1 1	ORGANIC SOIL	5
2	2 2	ALLUVIAL	90
3	3 3	GLEY HUMIC	70
4	4 4	GREY HYDROMORPHIC	80
5	5 5	LATOSOL I.R.	50
6	6 6	LATOSOL R.Y.POD.	45
7	7 7	LATOSOL V.R.	40
8	8 8	R.Y. POD. S.R.	40
9	9 9	R.Y. POD. ALLUVIAL	70
10	10 10	R.Y. POD.LATO.LITHO.	10
11	11 11	BROWN POD.PODZ.LITHO.	10
12	12 12	REGOSOL LATO.	75
13	13 13	LITHO.REGOSOL	5
14	14 14	GREY BROWN POD.	20

ENDTHEME

***** GEOLOGY *****
ABSOLUTE WEIGHT OF THIS THEMMATIC DATA= 20

LEG.NO.	RANGE(MIN-MAX)	DESCRIPTION(50 CHR)	REL. (WEIGHT)

(Table 14-2)

1	1	1	YOUNGER ALLUVIUM	90
2	2	2	OLDER ALLUVIUM	60
3	3	3	PETANI FORM.	20
4	4	4	SIHAPAS FORM.	5
5	5	5	TAPANULI GROUP	30
6	6	6	KUALU FORM.	40
7	7	7	TOBA TUFF	70
8	8	8	SAMOSIR FORM.	50

ENDTHEME- -

***** SOIL DEPTH *****

ABSOLUTE WEIGHT OF THIS THEMMATIC DATA= 10

LEG.NO.	RANGE(MIN-MAX)		DESCRIPTION(50 CHR)	REL. (WEIGHT)
1	1	1	> 90 CM	99
2	2	2	60 - 90 CM	90
3	3	3	30 - 60 CM	70
4	4	4	< 30 CM	20

ENDTHEME- -

***** SOIL TEXTURE *****

ABSOLUTE WEIGHT OF THIS THEMMATIC DATA= 30

LEG.NO.	RANGE(MIN-MAX)		DESCRIPTION(50 CHR)	REL. (WEIGHT)
1	1	1	FINE	75
2	2	2	MEDIUM	99
3	3	3	COARSE	50

ENDTHEME- -

***** LAND COVER *****

ABSOLUTE WEIGHT OF THIS THEMMATIC DATA= 70

LEG.NO.	RANGE(MIN-MAX)		DESCRIPTION(50 CHR)	REL. (WEIGHT)
1	1	1	PADDY FIELD	99
2	2	2	PADDY + DRY FIELD	90
3	3	3	PALM OIL	90
4	4	4	RUBBER	80
5	5	5	GRASS, BUSH AND SHRUB	70
6	6	6	COCONUT +	70
7	7	7	MIX GARDEN	80
8	8	8	SWAMP + SWAMP FOREST	10
9	9	9	UPLAND FOREST	10
10	10	10	CLOUD	0

ENDTHEME- -

***** BIOMASS *****

ABSOLUTE WEIGHT OF THIS THEMMATIC DATA= 30

LEG.NO.	RANGE(MIN-MAX)		DESCRIPTION(50 CHR)	REL. (WEIGHT)
1	1	1	< 2 KG	99
2	2	2	2- 9	99

(Table 14-3)

```
    3    3    3            9-  17                          70
    4    4    4           17-  24                          70
    5    5    5           24-  32                          80
    6    6    6           > 32                             90
ENDTHEME- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -

***** SOIL REFLECTANCE ******
ABSOLUTE WEIGHT OF THIS THEMMATIC DATA= 50
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
LEG.NO.  RANGE(MIN-MAX)     DESCRIPTION(50 CHR)          REL. (WEIGHT)

    1    1    1         DRY                              40
    2    2    2         SLIGHTLY DRY                     70
    3    3    3         MEDIUM                           99
    4    4    4         SLIGHTLY WET                     70
    5    5    5         WET                              40
ENDTHEME- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -

***** RAIN FALL (IN AUGUST) *****
ABSOLUTE WEIGHT OF THIS THEMMATIC DATA= 30
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
LEG.NO.  RANGE(MIN-MAX)     DESCRIPTION(50 CHR)          REL. (WEIGHT)

    1    1    1          100 - 150 MM                     60
    2    2    2          150 - 200 MM                     80
    3    3    3          200 - 300 MM                     99
ENDTHEME- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -

***** PAST FLOOD *****
ABSOLUTE WEIGHT OF THIS THEMMATIC DATA= 20
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
LEG.NO.  RANGE(MIN-MAX)     DESCRIPTION(50 CHR)          REL. (WEIGHT)

    1    1    1          LESS THAN ONCE                   99
    2    2    2          ONCE A YEAR                      80
    3    3    3          MORE THAN TWICE                  60
ENDTHEME- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
```

TABLE 15 SCORE FOR EACH CLASS IN THEMATIC MAPS (PATTERN METHOD)
(CASE OF SELECTED 4 THEMATIC MAPS)

***** ELEVATION *****
ABSOLUTE WEIGHT OF THIS THEMMATIC DATA= 30

NO.LEG.	RANGE(MIN-MAX)		DESCRIPTION(30 CHR)	REL. WEIGHT
1	1	1	0 - 50 FEET	99
2	2	2	50 - 250 FEET	80
3	3	3	250 - 500 FEET	70
4	4	4	500 - 1000 FEET	60
5	5	5	1000 - 2000 FEET	50
6	6	6	2500 - 3500 FEET	30
7	7	7	> 3500 FEET	5

ENDTHEME

***** SOIL TYPE *****
ABSOLUTE WEIGHT OF THIS THEMMATIC DATA= 30

LEG.NO.	RANGE(MIN-MAX)		DESCRIPTION(50 CHR)	REL. (WEIGHT)
1	1	1	ORGANIC SOIL	5
2	2	2	ALLUVIAL	90
3	3	3	GLEY HUMIC	70
4	4	4	GREY HYDROMORPHIC	80
5	5	5	LATOSOL I.R.	50
6	6	6	LATOSOL R.Y.POD.	45
7	7	7	LATOSOL V.R.	40
8	8	8	R.Y. POD. S.R.	40
9	9	9	R.Y. POD. ALLUVIAL	70
10	10	10	R.Y. POD.LATO.LITHO.	10
11	11	11	BROWN POD.PODZ.LITHO.	10
12	12	12	REGOSOL LATO.	75
13	13	13	LITHO.REGOSOL	5
14	14	14	GREY BROWN POD.	20

ENDTHEME

***** LAND COVER *****
ABSOLUTE WEIGHT OF THIS THEMMATIC DATA= 25

LEG.NO.	RANGE(MIN-MAX)		DESCRIPTION(50 CHR)	REL. (WEIGHT)
1	1	1	PADDY FIELD	99
2	2	2	PADDY + DRY FIELD	90
3	3	3	PALM OIL	90
4	4	4	RUBBER	80
5	5	5	GRASS, BUSH AND SHRUB	70
6	6	6	COCONUT +	70
7	7	7	MIX GARDEN	80
8	8	8	SWAMP + SWAMP FOREST	10
9	9	9	UPLAND FOREST	10
10	10	10	CLOUD	0

ENDTHEME

(Table 15-2)

***** SOIL REFLECTANCE *****
ABSOLUTE WEIGHT OF THIS THEMMATIC DATA= 15

LEG.NO.	RANGE(MIN-MAX)		DESCRIPTION(50 CHR)	REL. (WEIGHT)
1	1	1	DRY	40
2	2	2	SLIGHTLY DRY	70
3	3	3	MEDIUM	99
4	4	4	SLIGHTLY WET	70
5	5	5	WET	40

ENDTHEME

LIST OF PHOTOGRAPHS

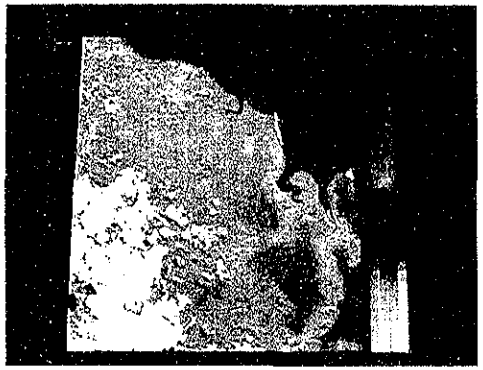


PHOTO. 1 LANDSAT COLOR COMPOSITE IMAGE (FALSE COLOR IMAGE)
>>> APRIL, 29, 1977 <<<
>>> BAND 4 : BLUE , BAND 5 : GREEN , BAND 7 : RED <<<

PHOTO. 3 THEMATIC MAP FOR <<< SLOPE >>>

<KEY><CR><END OF IMAGE FILE: ASHIWA SLOPEMP 3

LEGEND	RANGE	DESCRIPTION
1	1- 1	0 - 2 °
2	2- 2	2 - 8 °
3	3- 3	8 - 15 °
4	4- 4	15 - 30 °

PHOTO. 2 THEMATIC MAP FOR <<< ELEVATION >>>

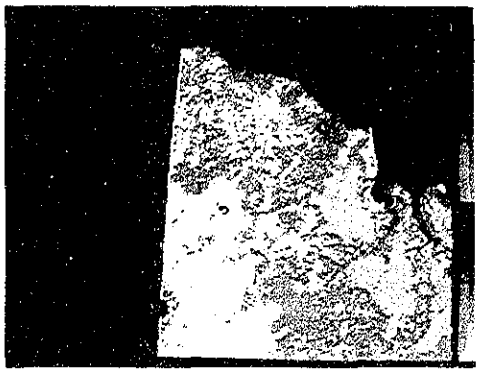
<KEY><CR><END OF IMAGE FILE: ASHIWA ELEVAMP 3

LEGEND	RANGE	DESCRIPTION
1	1- 1	0 - 82 FEET
2	2- 2	100 - 262 FEET
3	3- 3	262 - 820 FEET
4	4- 4	820 - 1312 FEET
5	5- 5	1312 - 2297 FEET
6	6- 6	2297 - 3609 FEET
7	7- 7	3609 - 3609 FEET

PHOTO. 4 THEMATIC MAP FOR <<< SOIL TYPE >>>

<KEY><CR><END OF IMAGE FILE: ASHIWA SOILTYPMP 3

LEGEND	RANGE	DESCRIPTION
1	1- 1	ORGANIC SOIL
2	2- 2	ALLUVIAL
3	3- 3	GLEY HUMIC
4	4- 4	GREY HYDROMORPH
5	5- 5	LATOSOL (FROM IGNEOUS ROCK)
6	6- 6	LATOSOL AND R.Y. PODZOLIC
7	7- 7	LATOSOL (FROM VOLCANIC ROCK)
8	8- 8	RED YELLOW PODZOLIC (SEDIMENTARY ROCK)
9	9- 9	RED.YELLOW PODZOLIC (ALLUVIUM)
10	10- 10	RED YELLOW PODZOLIC, LATOSOL, LITHOSOL COMPLEX
11	11- 11	BROWN PODZOLIC, LATOSOL, LITHOSOL COMPLEX
12	12- 12	PODOSOL, LATOSOL
13	13- 13	LITHOSOL, ARGOSOL
14	14- 14	GREY BROWN PODZOLIC



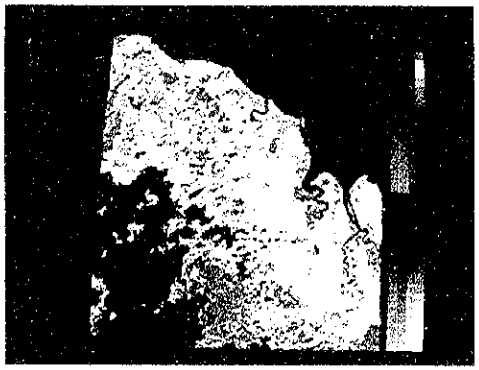


PHOTO. 9 THEMATIC MAP FOR <<< BIOMASS >>>

<ENDOFTX><END OF IMAGE FILE:: ASAHAN BIOMASP 9

LEGEND	RANGE	DESCRIPTION
1	1- 1	< 2 KG/M2
2	2- 2	3 - 9 KG/M2
3	3- 3	10-17 KG/M2
4	4- 4	18-25 KG/M2
5	5- 5	26-32 KG/M2
6	6- 6	> 32 KG/M2

PHOTO. 13 THEMATIC MAP FOR <<< SOIL REFLECTANCE >>>

<ENDOFTX><END OF IMAGE FILE:: ASAHAN SOILREFP 13

LEGEND	RANGE	DESCRIPTION
1	1- 1	SKY
2	2- 2	SLIGHTLY DRY
3	3- 4	MODERA
4	5- 6	SLIGHTLY WET
5	7- 8	WET

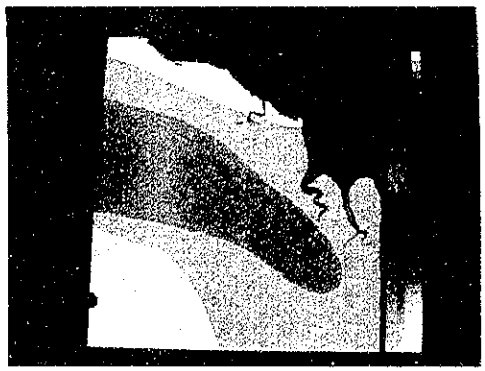


PHOTO. 11 THEMATIC MAP FOR <<< RAINFALL IN AUGUST >>>

<ENDOFTX><END OF IMAGE FILE:: ASAHAN RAINAUMP 11

LEGEND	RANGE	DESCRIPTION
1	1- 1	100-150MM/AUGUST
2	2- 2	150-200
3	3- 4	200-300

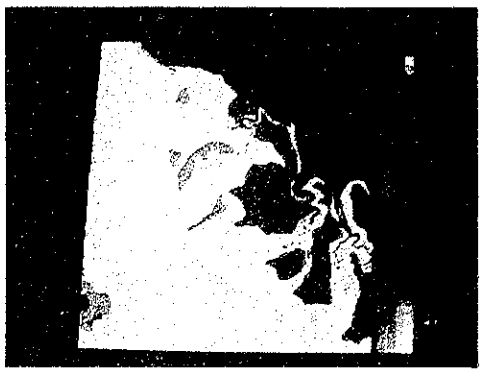


PHOTO. 12 THEMATIC MAP FOR <<< BASE FLOOD >>>

<ENDOFTX><END OF IMAGE FILE:: ASAHAN FLOODFNP 12

LEGEND	RANGE	DESCRIPTION
1	1- 1	NON
2	2- 2	ONCE/YEAR
3	3- 4	TWICE /YEAR

FIGURE 13 - THEMATIC MAP FOR <<< TOPOGRAPHY >>>

<KEY/DESCRIPTION OF IMAGE FILE: ASAMAN.MAJORTOP >

CLASS/VALUE	RANGE	DESCRIPTION
1	1- 1	COASTAL PLAIN
2	2- 2	LOWLAND
3	3- 3	ALLUVIAL PLAIN
4	4- 4	UNDRAINED/POOR DRAINED PLAIN
5	5- 5	PLAIN
6	6- 6	SWAMP AREA
7	7- 7	POORLY DRAINED SWAMP AREA (MARSH ETC.)
8	8- 8	FOOT SLOPE
9	9- 9	MOUNTAIN
10	10- 10	VALLEY
11	11- 11	SLOPE
12	12- 12	TOP
13	13- 13	HILLTOP RIDGE

FIGURE 14 - THEMATIC MAP FOR <<< VEGETATION >>>

<KEY/DESCRIPTION OF IMAGE FILE: ASAMAN.VEGMAJOR >

CLASS/VALUE	RANGE	DESCRIPTION
1	1- 1	TROPICAL EVERGREEN RAIN FOREST
2	2- 2	TROPICAL EVERGREEN RAIN FOREST
3	3- 3	TROPICAL LOW MOUNTAIN EVERGREEN RAIN FOREST
4	4- 4	DECIDUOUS FOREST
5	5- 5	MANGROVE THICKET
6	6- 6	PEAT SWAMP FOREST
7	7- 7	PEAT SWAMP FOREST
8	8- 8	PEAT SWAMP FOREST
9	9- 9	FRESH WATER SWAMP FOREST
10	10- 10	OPEN GRASS LAND (PADI)
11	11- 11	SAWAH

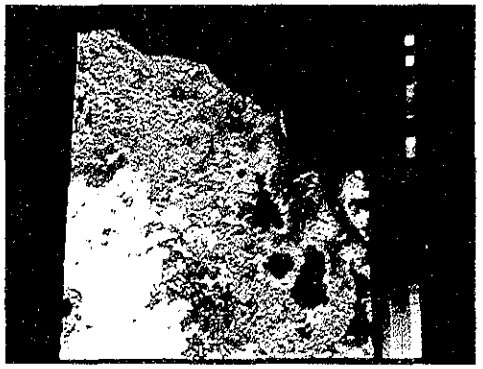


FIGURE 15 - THEMATIC MAP FOR <<< LAND COVER >>>
(BY POSTCLASSIFICATION)

<KEY/DESCRIPTION OF IMAGE FILE: ASAMAN.LCOVMAP >

CLASS/VALUE	RANGE	DESCRIPTION
1	1- 1	FOREST
2	2- 2	WATER
3	3- 3	CITY
4	4- 4	UNDEFINED
5	5- 5	PADI
6	6- 6	BARE SOIL
7	7- 7	MIXED
8	8- 8	CONIFER MIX
9	9- 9	DRY FIELD
10	10- 10	PADDY FIELD
11	11- 11	UNKNOWN
12	12- 12	UNKNOWN
13	13- 13	UNKNOWN
14	14- 14	UNKNOWN
15	15- 15	UNKNOWN

PHOTO. 16 LAND EVALUATION MAP AT STEP-2 (PARALLEL METHOD)

KEYBOARD ENTRY OF IMAGE FILE : ASAHAN EVALUEMJ.F
MEDIAN SMOOTHING (MAJOR) : ASAHAN EVALUEMJ.F

CLASS NO.	RANGE	DESCRIPTION
1	1- 1	EXCELLENT FOR PADDY
2	2- 2	SUITABLE FOR PADDY
3	3- 3	GOOD FOR PADDY AND PLANTATION
4	4- 4	FAIR FOR PADDY AND CROPLANDS
5	5- 5	IMPOSSIBLE FOR PADDY, PLANTATION AND CROPLANDS
6	6- 6	BE SET OF DRY FIELD, IMPOSSIBLE FOR PADDY, PLA...
7	7- 7	EXCELLENT DRY FIELD
8	8- 8	SUITABLE AREA FOR AGRICULTURE (P.P., DRY F...
9	9- 9	FOR A STATE LAND USAGE
10	10- 10	FOR A STATE
11	11- 11	NO DATA

PHOTO. 17 LAND EVALUATION MAP AT STEP-2 (PARALLEL METHOD)
USING 4 THEMATIC MAPS FROM LANDSAT DATA)

KEYBOARD ENTRY OF IMAGE FILE : ASAHAN EVALUEMJ.F
MEDIAN MAJOR, ACCESS : ASAHAN EVALUSMP.D

CLASS	RANGE (MIN-MAX)	DESCRIPTION
1	1 1	EXCELLENT
2	2 2	GOOD
3	3 3	MODERATE GOOD
4	4 4	MODERATE POOR
5	5 5	POOR
6	6 6	NOT SUITABLE

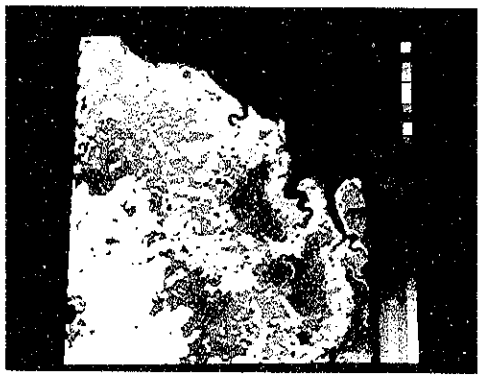


PHOTO. 18 LAND EVALUATION MAP AT STEP-3 (PARALLEL METHOD)

KEYBOARD ENTRY OF IMAGE FILE : ASAHAN EVALUEMJ.F
MEDIAN SMOOTHING (MAJOR) : ASAHAN EVALUEMJ.F

CLASS NO.	RANGE	DESCRIPTION
1	1- 1	CLOUD COVER
2	2- 2	SEA , WATER
3	3- 3	PLANTATION AREA
4	4- 4	SUITABLE FOR SPECIAL CROP (WET) AND DRY FIELD
5	5- 5	LAND IMPROVEMENT OF PADDY FIELD
6	6- 6	SUITABLE FOR PADDY FIELD
7	7- 7	SUITABLE FOR PADDY FIELD (GOOD) , FIRST STAGE DEVE...
8	8- 8	SUITABLE FOR PADDY FIELD (GOOD) , SECOND STAGE DEVE...
9	9- 9	SUITABLE FOR PADDY OR DRY FIELD (MAINLY PADDY FIELD)
10	10- 10	SUITABLE FOR PADDY OR DRY FIELD (MAINLY DRY FIELD)
11	11- 11	NOT SUITABLE FOR CULTIVATION
12	12- 12	NO DATA

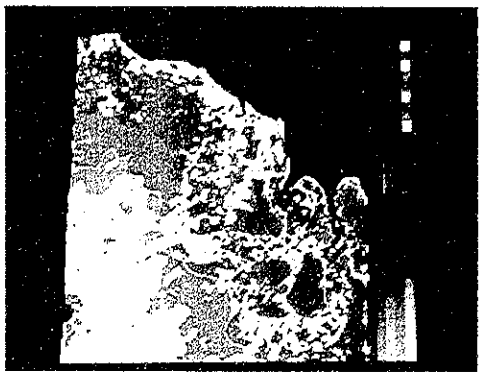


PHOTO. 19 LAND EVALUATION MAP AT STEP-3 (PARALLEL METHOD)
(BASIC EVALUATION)

KEYBOARD ENTRY OF IMAGE FILE : EVALUEMJ.F
MEDIAN SMOOTHING (MAJOR) : EVALUEMJ.F

CLASS NO.	RANGE	DESCRIPTION
1	1- 1	CLOUD COVER
2	2- 2	GOOD (PADDY, DRY FIELD OR PLANTATION)
3	3- 3	MODERATE 1 (PADDY OR DRY FIELD)
4	4- 4	MODERATE 2 (DRY FIELD)
5	5- 5	SWAMP (FOREST STAGE OF DEVELOPMENT)
6	6- 6	SWAMP (SPECIAL STAGE OF DEVELOPMENT)
7	7- 7	SWAMP AREA
8	8- 8	POOR FOR AGRICULTURAL USE
9	9- 9	NOT AGRICULTURAL USE
10	10- 10	DETAILS

PHOTO. 20 LAND EVALUATION MAP AT STEP-3 (RANKING METHOD)
(EFFECT OF AGRICULTURAL AREA)

CORRESPONDENCE OF IMAGE FILE : EVALSYS EVLM439U.F
AFTER SMOOTHING (MAJORITY) : EVALSYS EVLM439P.F

ELEG.NO.	RANGE	DESCRIPTION
1	1- 1	CLOUD COVER
2	2- 2	GOOD (PADDY, DRY FIELD OR PLANTATION)
3	3- 3	MODERATE 1 (PADDY OR DRY FIELD)
4	4- 4	MODERATE 2 (DRY FIELD)
5	5- 5	SWAMP (FIRST STAGE DEVELOPMENT)
6	6- 6	SWAMP (SECOND STAGE DEVELOPMENT)
7	7- 7	SWAMP AREA
8	8- 8	POOR FOR AGRICULTURAL USE
9	9- 9	NOT AGRICULTURAL USE
10	10-10	PLANTATION AREA (MORE THAN 30 PCT PARA)
11	11-11	PADDY FIELD AREA (LAND IMPROVEMENT AREA)
12	12-12	OTHERS

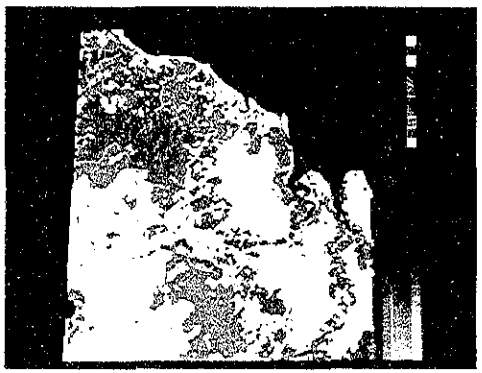


PHOTO. 21 LAND EVALUATION MAP AT STEP-4 (RANKING METHOD)
(SUITABLE AREA FOR CULTIVATION OF SOYBEANS)

CORRESPONDENCE OF IMAGE FILE : EVALSYS EVLM439U.F
AFTER SMOOTHING (MAJORITY) : EVALSYS EVLM439P.F

ELEG.NO.	RANGE	DESCRIPTION
1	1- 1	CLOUD COVER
2	2- 2	GOOD (PADDY, DRY FIELD OR PLANTATION)
3	3- 3	MODERATE 1 (PADDY OR DRY FIELD)
4	4- 4	MODERATE 2 (DRY FIELD)
5	5- 5	SWAMP (FIRST STAGE DEVELOPMENT)
6	6- 6	SWAMP (SECOND STAGE DEVELOPMENT)
7	7- 7	SWAMP AREA
8	8- 8	POOR FOR AGRICULTURAL USE
9	9- 9	NOT AGRICULTURAL USE
10	10-10	PLANTATION AREA (MORE THAN 30 PCT PARA)
11	11-11	PADDY FIELD AREA (LAND IMPROVEMENT AREA)
12	12-12	OTHERS

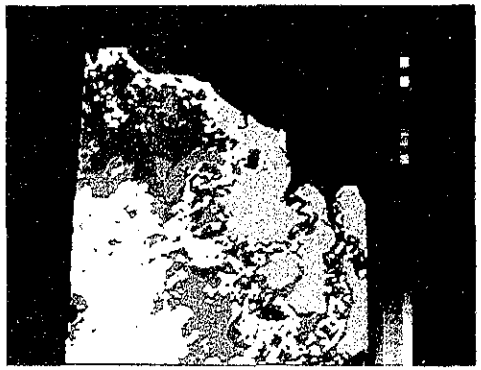


PHOTO. 22 LAND EVALUATION MAP AT STEP-3 (RANKING METHOD)
(EFFECT OF PANCHAJUU AREA OF FLOOD)

CORRESPONDENCE OF IMAGE FILE : EVALSYS EVLM439U.F
AFTER SMOOTHING (MAJORITY) : EVALSYS EVLM439P.F

ELEG.NO.	RANGE	DESCRIPTION
1	1- 1	CLOUD COVER
2	2- 2	GOOD (PADDY, DRY FIELD OR PLANTATION)
3	3- 3	MODERATE 1 (PADDY OR DRY FIELD)
4	4- 4	MODERATE 2 (DRY FIELD)
5	5- 5	SWAMP (FIRST STAGE DEVELOPMENT)
6	6- 6	SWAMP (SECOND STAGE DEVELOPMENT)
7	7- 7	SWAMP AREA
8	8- 8	POOR FOR AGRICULTURAL USE
9	9- 9	NOT AGRICULTURAL USE
10	10-10	PLANTATION AREA (MORE THAN 30 PCT PARA)
11	11-11	PADDY FIELD AREA (LAND IMPROVEMENT AREA)
12	12-12	OTHERS

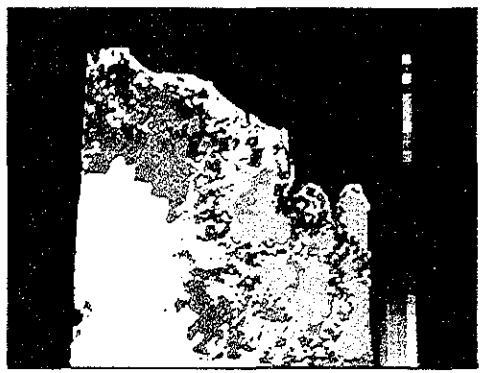


PHOTO. 23 LAND EVALUATION MAP AT STEP-4 (RANKING METHOD)
(SUITABLE AREA FOR CULTIVATION OF SOYBEANS)

CORRESPONDENCE OF IMAGE FILE : EVALSYS EVLM439U.F
AFTER SMOOTHING (MAJORITY) : EVALSYS EVLM439P.F

ELEG.NO.	RANGE	DESCRIPTION
1	1- 1	CLOUD COVER
2	2- 2	GOOD (PADDY, DRY FIELD OR PLANTATION)
3	3- 3	MODERATE 1 (PADDY OR DRY FIELD)
4	4- 4	MODERATE 2 (DRY FIELD)
5	5- 5	SWAMP (FIRST STAGE DEVELOPMENT)
6	6- 6	SWAMP (SECOND STAGE DEVELOPMENT)
7	7- 7	SWAMP AREA
8	8- 8	POOR FOR AGRICULTURAL USE
9	9- 9	NOT AGRICULTURAL USE
10	10-10	PLANTATION AREA (MORE THAN 30 PCT PARA)
11	11-11	PADDY FIELD AREA (LAND IMPROVEMENT AREA)
12	12-12	OTHERS

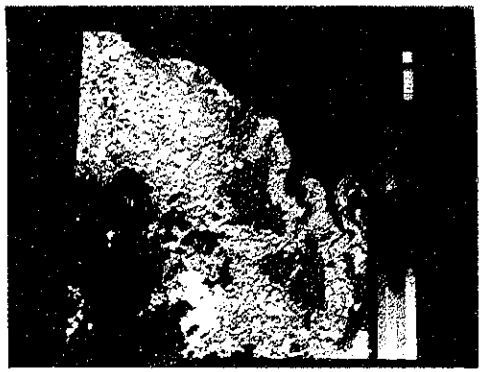


PHOTO. 27 — [illegible]

KEY/DESCRIPTORS OF IMAGE FILE: [illegible]

CLASS NO.	PATTERN-MARK	DESCRIPTION/COMMENT
1	1	[illegible]
2	2	[illegible]
3	3	[illegible]
4	4	[illegible]
5	5	[illegible]
6	6	[illegible]

PHOTO. 28 — [illegible]

KEY/DESCRIPTORS OF IMAGE FILE: [illegible]

CLASS NO.	PATTERN-MARK	DESCRIPTION/COMMENT
1	1	[illegible]
2	2	[illegible]
3	3	[illegible]
4	4	[illegible]
5	5	[illegible]
6	6	[illegible]

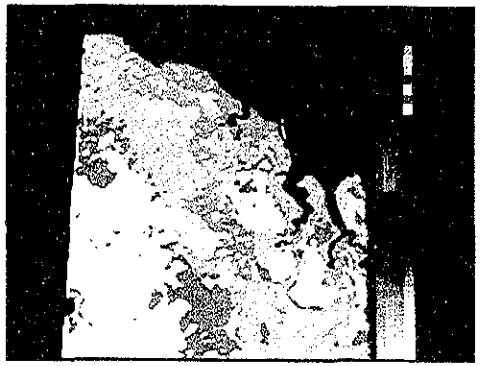


PHOTO. 29 — [illegible]

KEY/DESCRIPTORS OF IMAGE FILE: [illegible]

CLASS NO.	PATTERN-MARK	DESCRIPTION/COMMENT
1	1	[illegible]
2	2	[illegible]
3	3	[illegible]
4	4	[illegible]
5	5	[illegible]
6	6	[illegible]