Analysis method of the satellite data are based on the statistical approach through the digital processing where the CCT's count was used as the basic data.

To process the above data, the new system of ERDAS and ARC/INFO software equipped in PUSDATA supported by SUN Engineering Workstation and personal computer were used. Besides, IBM Mainframe 4341 also with indispensable software were used for the satellite data analysis.

2.2 Data Processing

The final outputs of the analysis consist of the following;

1) Color composite image
2) Land cover
3) Soil moisture
4) Elevation map
5) Slope map
6) Geological map

The overall process to acquire the outputs mentioned above are as follows;

1) Color composite image

The color composite image is made through the combination of three bands. The most common color composite is false color or infra-red color image. The process to produce the false color composite image is;

i) Pre-processing of Satellite data
ii) Geometric correction to convert the satellite data into a georeferenced system, i.e. UTM coordinate system
iii) Enhancement processing to improve the image performance through the digital improvement of the data distinctness
iv) Determination of level slicing which corresponds to the minimum and maximum data values for each band
v) Digital cartographic design and completion of marginal map information
vi) Combine these three banda with their appropriate filter as CH2:blue, CH3:green and CH4:red
vii) Conversion of digital data file into negative film through film write device
viii) Hard copy printing at appropriate scale

2) Land cover

Land cover classification image is produced in the following procedure;

i) Samples selection based on or guided by the groundtruth data. Naming of classification items such as paddy field,

uncultivated rubber, rubber plantation, bareland, etc.

ii) Regrouping the samples to classify an appropriate number of categories

iii) Digital cartographic design and completion of annotation and marginal map information

iv) Symbol (color) assignment for each category and other annotation and marginal map information

v) Conversion of digital data file into negative film through film writer device

vi) Hard copy printing at appropriate scale

3) Soil moisture map

In general, soil moisture presents only the soil wetness at the ground surface or just below the surface. The analysis of wetness is carried out based on the satellite data. However, there exists constraints and limitations to assess soil moisture due to high dense forest, cloud, slope-shadow, steep slope, etc. Therefore, the degree of soil moisture will be assessed by applying the Fukuhara Model. Such factors as water content, organic matter, soil type, parent material, etc. affect on the brightness or darkness of soil reflectance.

Soil moisture map is produced in accordance with the following considerations;

i) Variation of spectral characteristics due to change of vegetation growth, vegetation cover and soil condition can be expressed in two dimensional features through the relationship between Red(R) and Infra-red(IR) spectral bands.

ii) Reflectance index of IR/R is sensitive to vegetation growth, biomass and vegetation cover. It also tends to normalize the effects to varying of soil types, organic matter contents and moisture contents.

iii) The reflectance index shows the feature that the coordinate of each soil reaches to a coordinate of 100% of vegetation cover as point P(x=PR, y=PIR). PR and PIR area red and near infrared reflectance of vegetation,respectively.

iv) Regrouping the classes to classify an appropriate number of categories.

v) Digital cartographic design and completion of annotation and marginal map information.

vi) Symbol (color) assignment for each category and other annotation and marginal map information

vii) Conversion of digital data file into negative film through film writer device

viii) Hard copy printing at appropriate scale

4) Elevation map

The elevation map is created based on the topographic maps with scale of 1:250,000 according to the following procedure;

i) Contour line tracing with designated interval, i.e. at

elevation of 50m, 100m, 300m, 600m, 900m, 1,200m, 1,500m, 1,800m, 2,100m and 2,400m.

ii) Digitize the contour lines using the facility of ARC/INFO, afterwards convert into ERDAS file to produce raster data(image).

iii) Determination of elevation classes as 0-50m, 50-100m, 100-300m, 300-600m, 600-900m, 900-1,200m, 1,200m-1,500m, 1,500-1,800m, 1,800-2,100m, 2,100-2,400m and more than 2,400m.

iv) Symbol (color) assignment for each category and other annotation and marginal map information.

v) Conversion of digital data file into hard copy through film write device.

vi) Negative film development.

vii) Hard copy printing at appropriate scale.

5) Slope map

The slope map is created based on the digital elevation maps prepared in 4) above and in accordance with the following procedure;

i) Elevation data in the elevation maps do not give the actual height in every point(pixel) but give the value in some range. As the optimum method to estimate slopes from the elevation maps, the maximum slope among every directions is taken.

ii) In this analysis, slopes of every 5 degree of azimuth are calculated to select the maximum value among them.

iii) Determination of slope classes as less than 0.1%, 0.1-0.25%, 0.25-0.5%, 0.5-0.75%, 0.75-1.0%, 1.0-2.0%, 2.0-3.0%, 3.0-5.0%, 5.0-7.0%, 7.0-10.0%, 10.0-15.0%, 15.0-20.0%, 20.0-30.0%, 30.0-40.0%, and more than 40.0%.

iv) Digital cartographic design and completion of annotation and marginal map information.

v) Symbol (color) assignment for each category and other annotation and marginal map information

vi) Conversion of digital data file into negative film through film writer device

vii) Hard copy printing at appropriate scale

6) Geological map

The geological map of the study area is prepared based on the geological map of Dumai, Pekanbaru, Lubuksikaping, and Padangsidempuan quadrangles with scale of 1:250,000.

The following procedure is taken in order to provide the geological map;

i) Tracing the surface material boundaries on the geological maps, drawn on transparent paper.

ii) Each item of the surface material is assigned as a certain category. These boundaries are then digitized using the facility of ARC/INFO, afterwards convert into ERDAS file to produce raster data(image).

iii) Digital cartographic design and completion of annotation and marginal map information.
iv) Symbol (color) assignment for each category and other annotation and marginal map information
v) Conversion of digital data file into negative film through film writer device
vi) Hard copy printing at appropriate scale

2.3 Processed Outputs

1) Color composite image(TM data bands 2,3 and 4 are used)

The color composite image consists of three color components, red(band 4), green(band 3) and blue(band 2), it is so called as "false color map". These colors, in greater or lesser degree, indicate the condition of the earth surface features likeliness. The red color corresponds to chlorophyll contents or greenery, the green color is related to rare growth of plants and slightly wet, and the blue color corresponds to water or wetness. These three categories have gradation in accordance with their ground condition when the data were taken.

In the Study Area, the dark red color indicates the dense forest and the brighter one shows less dense of greenery ranging from rare forest to bush. Meanwhile, the green color corresponds to the undulating area covered by alang-alang and blue or bluish color indicates paddy field and other wetland or wet-bareland.

2) Color composite image(TM data bands 2,4 and 5 are used)

In this color composite image, the green color corresponds to forest land, like natural sense. It offers easier visual classification of land. Shading due to undulation of land is more clear than that in false color map. Since plants with much moisture contents and active plants are indicated as bright red color, the dense greenery such as alang-alang can be identified.

3) Land cover map

The land cover map shows the condition of natural land cover in relation with the present land use in the Study Area by classifying 16 categories for each UTM(100mm x 100mm) giving different colors. The categories are as follows;

- Natural forest : natural growth which is composed of various type of trees with certain height and density, located in the high mountain or in the area unlikely to be inundated.
- Swamp forest : natural growth composed of various type of trees with certain height located in the swamp area.

- Secondary forest : natural growth which proceeds to the deforestation and is composed of various type of trees with certain height and less dense.

- Mixed garden : something like garden but type of trees, or sparse forest including rubber plantation, located nearby villages and along the roads.

- Oil palm plantation : areas being cultivated for oil palm trees, which covers an huge area. It appears in the TM image with the special pattern. It is clearly distinct from the other plantation as rubber, cocoa, etc.

- Alang-alang and paddy : area covered with alang-alang and in some places are being cultivated for rainfed paddy. The area of alang-alang is more dominant than paddy. The non-irrigated paddy field in dry season can be classified clearly from alang-alang.

- Alang-alang : area completely covered with alang-alang and can be clearly recognized.

- Alang-alang and bush : areas where are previously forest and then processed by deforestation and became alang-alang and bush after a certain time. Some places were cultivated and have been left as it is and invaded by alang-alang.

- Alang-alang and grass : area covered with alang-alang and grass.

- Grass : area covered with grass only.

- Bare land : an open land without any kind of growth or lack of vegetation coverage.

- Wetland and shadow : area with higher moisture content than surrounding area due to lack of drainage and area shaded by clouds or valleys.

- Water : areas composed of rivers, reservoirs, ponds and sea.

The results of land cover classification analysis are shown below.

Table 2.1 Land Cover Classification for the Study Area

No.	Category	Area(ha)	Percentage(%)
1	Natural Forest	930,648	21.40
2	Swamp Forest	310,342	7.10
3	Secondary Forest	743,988	17.10
4	Mixed Garden	354,777	8.20
5	Oil Palm Plantation	118,935	2.70
6	Alang-alang & Paddy	15,600	0.40
7	Alang-alang	60,682	1.40
8	Alang-alang & Bush	181,254	4.20
9	Alang-alang & Grass	0	0.00
10	Grass	266,198	6.10
11	Grass & Rough	156,246	3.60
12	Bareland	19,409	0.40
13	Wetland & Shadow	104,350	2.40
14	Water	19,862	0.50
15	Haze	209,280	4.80
16	Cloud	329,305	7.60
	Total	4,351,298	100.00

3) Soil moisture map

The soil moisture map shows relative wetness of the ground surface at the time the data were taken. The soil moisture contents are divided into four(4) wetness categories, i.e. wet, slightly-wet, slightly-dry and dry. Water and unknown are distinguished from 4 categories because of inaccessibility to the ground surface from the satellite view, such for high dense forest, shadow by clouds, steep slopes, etc.

The area for each category is presented in Table 2.2.

Table 2.2 Area Classification by Soil Moisture in the Study Area

No.	Category	Area(ha)	Percentage(%)
1	Wet	758,064	17.40
2	Slightly-wet	182,241	4.20
3	Slightly-dry	358,453	8.20
4	Dry	572,281	13.20
5	Water	198,862	0.50
6	Unknown	1,779,574	40.90
7	Others	680,520	15.60
	Total	4,351,298	100.00

Source : 1. Analysis LANDSAT TM data, 1989
2. The Riau Province map, scale 1:250,000

Table2.2 shows that 2,460,094 ha (56.6%) of the Study Area is out of 4 categories, i.e. unknown and other categories. The unknown category reflects such condition as natural forest, swamp forest and others which correspond to clouds and haze. The wet category, more or less, corresponds to paddy field, shrub in the swamp land, etc. The slightly-wet and slightly-dry may correspond to alang-alang, farmland, oil palm plantation, etc., while dry category corresponds to bareland, roads, concrete, oil field, etc.

4) Elevation map

The elevation map which is produced based on the topographic maps with scale of 1:250,000, consists of nine(9) categories. The results of the analysis show that nearly one-fourth of the Study Area is low land with its elevation of less than 25m. About 50% is undulating land with its elevation between 25m - 50m. The rest are covered with high forest and bush.

5) Slope map

It is considered that areas with rather gentle slope is important for planning of irrigation project. Areas with their slope of less than 3% are divided into seven(7) classes.

6) Geological map

In general, the Study Area is covered with pre-tertiary sedimentary, cainozoic sedimentary and igneous rock. The pre-tertiary sedimentary rock belongs to the Tapanuli Group such as Bohorok and Kuanta Formations. The lithology of this formation mostly consist of conglomeratic wackes, while cainozoic sedimentary is mostly located in the lower part of the Study Area and along rivers, which consists of Younger Alluvium, Older Alluvium, Minas, Petani, Telisa and Sihapas. Lithology of this formation is mostly composed of mud, sand gravel, mudstone and siltstone and thin limestone.

The lithologic alluvium, either younger or older is mostly composed of mud, sand, gravel, clay, sand and gravel with much vegetational debris. Major outcrops of this formation are found in the flood plains and meander belts of large rivers and low lying interfluves.

3. USE OF ANALYZED OUTPUT

The results of the remote sensing analysis are used for the following study.

1) To grasp the present topographic conditions of the Study Area such as elevation, slope, etc.,

2) To grasp vegetation, road conditions, location of the existing transmigration schemes, etc.,

3) To refer for the preparation of the present land use map, soil map, and geological map,

4) To identify swamp area and agricultural potential area,

5) To collect basic information for environmental assessment taking into account the secular change, and

6) To grasp change of river condition.