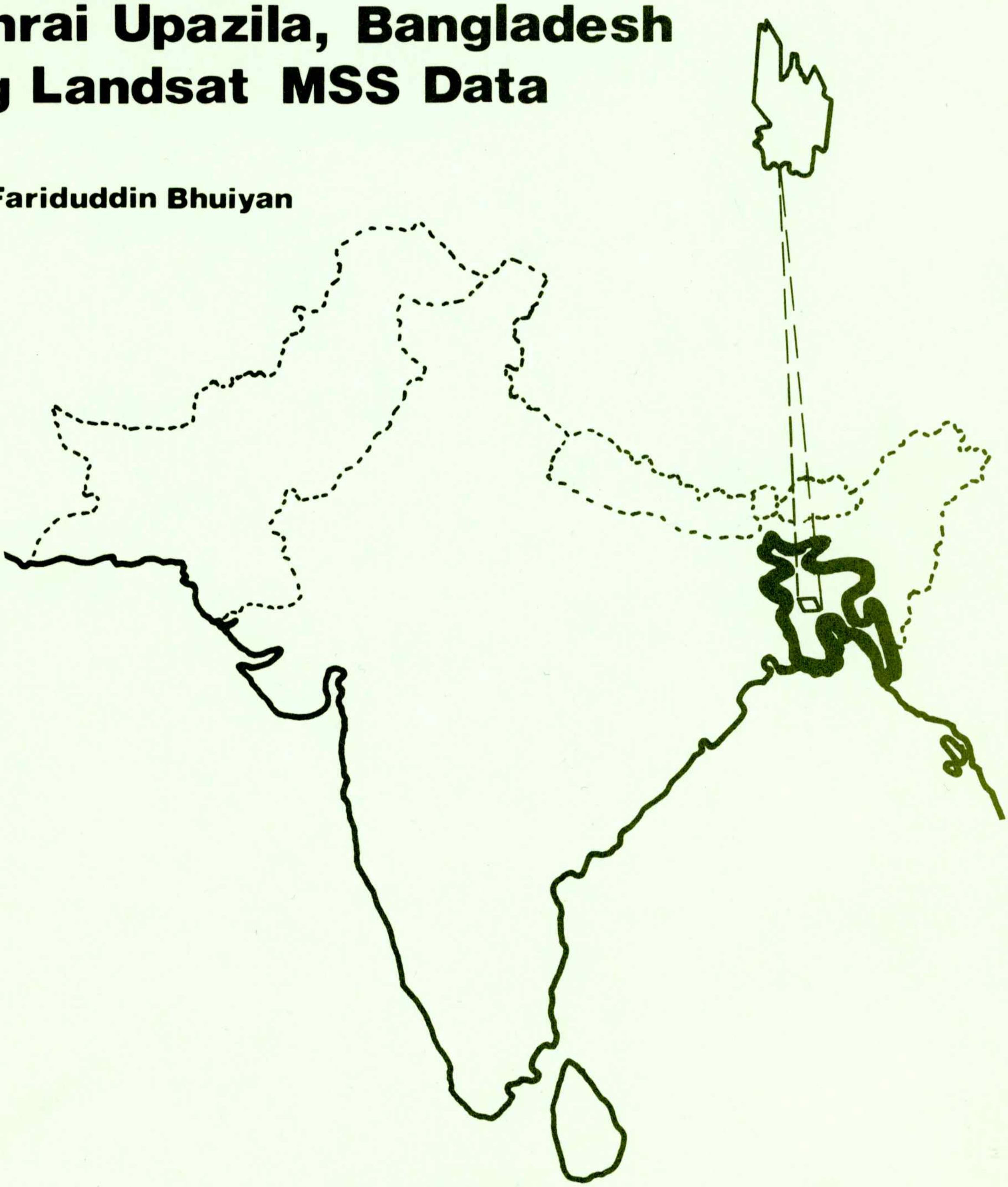
LARS Technical Report 030385

Digital Analysis of Land Cover Classification of Dhamrai Upazila, Bangladesh Using Landsat MSS Data

A. K. M. Fariduddin Bhuiyan



March 1985

Bangladesh Space Research and Remote Sensing Organization
Laboratory for Applications of Remote Sensing
Purdue University, West Lafayette, Indiana, USA

LARS Contract Report 030385

DIGITAL ANALYSIS OF LAND COVER CLASSIFICATION OF DHAMRAI UPAZILA, BANGLADESH USING LANDSAT MSS DATA

MARCH, 1985

BY

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Principal Scientific Officer

Bangladesh Space Research and Remote Sensing Organization (SPARRSO)

Science and Technology Division
Ministry of Education
Government of The People's Republic Of Bangladesh

A Report Prepared While in Training With:
Visiting Scientist Program for Remote Sensing

Laboratory for Applications of Remote Sensing
Purdue University
West Lafayette, Indiana USA

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PURDUE UNIVERSITY LABORATORY FOR APPLICATIONS OF REMOTE SENSING

February 28, 1985

FORWARD

I have had the pleasure to work with Mr. A. K. M. F. Bhuiyan, Visiting Scientist from SPARRSO (Space Research and Remote Sensing Organization) of Bangladesh, as instructor of the short course on Numerical Analysis of Digital Remote Sensing Data and supervisor of his training and research activities, during the period between September 10, 1984 and March 8, 1985.

During his training at the Laboratory for Applications of Remote Sensing (LARS)/Purdue University, Mr. Bhuiyan demonstrated a high degree of interest in learning the digital image processing technology through long hours of work at the computer terminal and reviewing pertinent literature on the subject. Furthermore, the analyst/instructor assigned to supervise and monitor Mr. Bhuiyan's day-to-day training and research activities has kept me informed regarding Mr. Bhuiyan's continuous progress and concerning his accomplishments in the area of multispectral classification of Landsat MSS digital data obtained over the Bengali territory.

Finally, I would like to add that Mr. Bhuiyan's friendly attitude towards his instructors, peers and the entire LARS staff has provided a delightful setting for working with him. I sincerely believe that when Mr. Bhuiyan returns to his country, he will be a definite asset to SPARRSO's endeavors and he will leave indeed a void among the LARS/Purdue personnel.

My best wishes,

Luis A. Bartolucci

Dr. Luis A. Bartolucci
Technical Director
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PREFACE

This six months training program, September 13, 1984 to March 8, 1985 at the Laboratory for Applications of Remote Sensing (LARS), Purdue University, West Lafayette, Indiana, USA was in fact an initial part of a total nine months training program organized and financed by the Food and Agriculture Organization (FAO) of the United Nations. The purpose of this program was to acquire an advanced knowledge in the application of digital remote sensing processing systems.

In the beginning of this training program LARS initiated a three week short course from September 13 to October 3, 1984. The nucleus of this short course was a series of lectures, and workshops following a numerical analysis sequence of multispectral Landsat data. Essential digital remote sensing data analysis concepts and algorithms were presented and illustrated by experienced scientists of LARS using LARSYS software as an example of many current digital remote sensing processing systems. This short course included a "hands-on practice" on computer option. Then the author was introduced to the IBM/370/158 computer and the CMS environment, the creation of files from LARSYS control cards and the display of Landsat image of January 3, 1977 of the study area, on the IBM/7350 HACIENDA for complex computer analysis.

The author attended all the classes (both theoretical and practical) on Monitoring and Surveying Agronomic Resources during the Fall Semester of 1984 in the Department of Agronomy at Purdue University, West Lafayette, Indiana, USA. The author also attended a seminar on "Soil and Atmospheric Sciences" of Butler University, Indianapolis, the capital city of Indiana, USA, on November 2, 1984 and delivered a lecture on "Soil and Agriculture of Bangladesh" in the Morning Session.

March 1985 A.K.M.F.B.

ACKNOWLEDGEMENTS

The author would first like to acknowledge the Bangladesh Space Research and Remote Sensing Organization (SPARRSO) under the Science and Technology Division, Ministry of Education, Government of the People's Republic of Bangladesh, and the Food and Agriculture Organization (FAO) of the United Nations for making this training program possible at the Laboratory for Applications of Remote Sensing (LARS), Purdue University, West Lafayette, Indiana, USA.

The author wishes to express his thanks to Dr. Marion F. Baumgardner, Director of the Laboratory for Applications of Remote Sensing (LARS) for his interest in this study and for his encouragement and for extending all the facilities of the Institute during the training period.

The author also wishes to express his deep appreciation and gratitude to Dr. Stevan J. Kristof, Soil Scientist of LARS, who with his great patience and vast experience helped to process and analyze the Landsat CCT of the Study Area with the IBM370/158 computer using LARSYS. Without his cordial guidance and help, it would not have been easy to complete this report.

The author also would like to acknowledge his deep appreciation and indebtedness to Dr. Luis A. Bartolucci, Technical Director of LARS, who with his all-round effort has been constantly helping with his valuable suggestions and advice during the training program.

The author also wishes to express his thanks to Mr. Carlos R. Valenzuela who with his great patience helped to process and analyze the Study Area with the IBM/7350 HACIENDA.

The author wishes to express his special thanks to Mr. Douglas B. Morrison for his all sorts of cooperation and coordination during the training period. The author also appreciates the cooperation received from the staff members of LARS and a special thanks to Marilyn Elkin for typing this report.

The author wishes to express his thanks to Dr. F. A. Khan, Chairman, Bangladesh Space Research and Remote Sensing Organization (SPARRSO) and Mr. M. A. H. Pramanik, Director of SPARRSO and National Director of FAO, Dhaka, for enabling him to have this training opportunity.

Lastly, the author also wishes to express his thanks to his wife, Sofia Khatun for giving him all sorts of encouragement during the training period.

ABSTRACT

In Bangladesh, the Dhamrai Upazila study area is located along the shore of the Bansi River. It has a tropical monsoon climate. The soils are derived mainly from alluvial deposits. During the monsoon season most of the area is inundated. The major food crops are rice, wheat, maize, potato, mustard, oilseeds, spices and vegetables. The cash crops are jute, sugarcane, tobacco and bananas. Bamboo, jackfruit, mangoes, coconut, and bananas are commonly grown on small areas in and around the villages.

The land cover of the study area was first spectrally classified by computer-implemented LARS techniques using geometrically corrected Landsat multispectral scanner (MSS) data collected on January 3, 1977.

Fifteen spectral classes and the acreage percentage of four general land use classes from the above collected data were classified and displayed in color-coded digital format on a digital image display. Different colors were assigned to each class. The area is relatively flat, and the fields are generally small, seldom larger than two or three hectares. Classification results of Landsat MSS data with a resolution of approximately 60x80m (<0 5 Ha) were limited in delineating individual fields, but were successful in delineating soils with slight differences in elevation and internal drainages. Results were also successful in delineating in general land cover vegetation with differences in growth condition. The better drained soils are highly-correlated with the cultivation of wheat and mustard, the poorly drained soils with rice.

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INTRODUCTION

1.1 Background

Even with the greater emphasis on industrialization, since the beginning of the Industrial Revolution, man's dependence for food from the natural resources in recent decades has increased monsterously. FAO's World Soil Charter of November, 1982 reveals in its "forward" that by the year 2000, simply to meet the present nutritional levels, 50 percent more food needs to be grown. However, to battle famine, malnutrition and other natural calamities an obvious need of additional supplies will be required. Needless to say that land has its own painful limits and this limit is intensified by the triple factors of soil, climate and management. Decreased productivity is the gross result of any mining of land beyond these limits. Hence, the demand for the natural resources is enormously increasing all over the world, and Bangladesh can be taken as a unique specimen. Bangladesh is predominantly an agricultural country with more than 85% of the population living in its 68,000 villages. It has an area of 143,998 square kilometers (55,598 sq. mi.) with a population of over 94 million and evidently the present foodgrains production is not sufficient for the country. The man-land ratio is constantly fluctuating because of the population boom. To minimize the present foodgrains deficit or to achieve self-sufficiency in food grains production, the country needs proper agricultural planning. That is why the Government has given maximum emphasis on agricultural research to improve the present food situation of the country. Moreover, the Government initiated and organized the Food Planning and Monitoring Unit (FPMU) under the Economic Division of the Planning Commission. Its purpose was to develop an early warning system for providing the Bangladesh Government with an early and accurate estimate of foodgrains production. To continue this program, landuse data are fundamentally essential. Moreover, these sorts of data are the basic prerequisites for all agricultural developmental planning. These data are difficult to collect when using conventional methods which require extensive field survey and need enough time and expense. Another technique for collecting this type of data is areal photography, which is not only expensive, but which also fails to provide a panoramic view of the entire area. Landsat on the other hand, provides an opportunity to collect maximum land cover information with a minimum time and without excessive cost. Application of this modern technology is the most effective and efficient means for collecting all sorts of land resources information. In this study, Landsat computer compatible tape (CCT) was used in image analysis for determining land cover classification. Before explaining the methodology of this study, it is indispensable to explain briefly about Remote Sensing and the LARS system.

1.2 Remote Sensing

Remote Sensing is the science of acquiring information about distant objects from measurements made without coming into contact with the object.

These measurements are, in fact, measurements of variations in field strengths, electromagnetic force and acoustical wave fields are common examples. Three important types of electromagnetic field variations are:

* spectral variations - changes in the intensity of radiation at a given wavelength(s), i.e., differences in color.

* spatial variations - changes in radiation from one location to another; i.e., differences in shape and position.

* temporal variations - changes in radiation from one time to another; i.e., differences over time.

1.2.1 LANDSAT

Since 1972, data and images from Earth observation satellites launched by the U.S. National Aeronautics and Space Administration (NASA) have been distributed and used in many countries around the world (Table 1).

1.2.2 LANDSAT Sensors

The satellites (Figure 1) circle the earth in a nearly north to south orbit. Landsat 1, 2 and 3 were in nominal altitude of 920 kilometers and had a repeat cycle of 18 days. The sensor of all Landsats cover a swath width of 185 kilometers.

The Landsat Multispectral Scanner (MSS) is an optical mechanical scanning system (Figure 2). The MSS have collected vast quantities of high quality data about the surface of the earth. Reflected energy from the earth is measured in four wavelength bands, two in the visible portion of the spectrum and two in the near-infrared spectrum. Thus the data from Landsat describes individual areas on the ground of 0•5 hectares (1•1 acres) by means of four relative radiance values. The assigned values range from 0 to 127 discrete radiance levels for the lower three bands and from 0 to 63 for the fourth bands.

The digital information is recorded on a magnetic tape and transmitted to the earth when the satellite passes over a ground receiving station. Before analysis, it is corrected at Goddard Space Flight Center for distortions caused by spacecraft instabilities and sensor variabilities. For convenience in handling, the MSS data are also divided into frames, each representing an approximately square ground scene 185 km (115 mi) on a side. These data are recorded either on computer compatible tape (CCT) or as black and white and simulated color infrared imagery. Basic specification for the sensors of Landsat 1 through 5 are given in Table 2.

SATELLITE	LAUNCH DATE	DATE OF TERMINATION OF DATA ACQUISITION BY THE SENSORS
Landsat 1 MSS	23 July 1972	January 1978
Landsat 2 MSS	22 January 1975	January 1980
Landsat 3 MSS	5 March 1978	September 1983
Landsat 4 MSS TM	14 July 1982	 operational February 1983
Landsat 5 MSS TM	1 March 1984	 operational operational

TABLE 1. Dates of Launch and Length of Data Acquisition Service Provided by Landsat 1 to 5

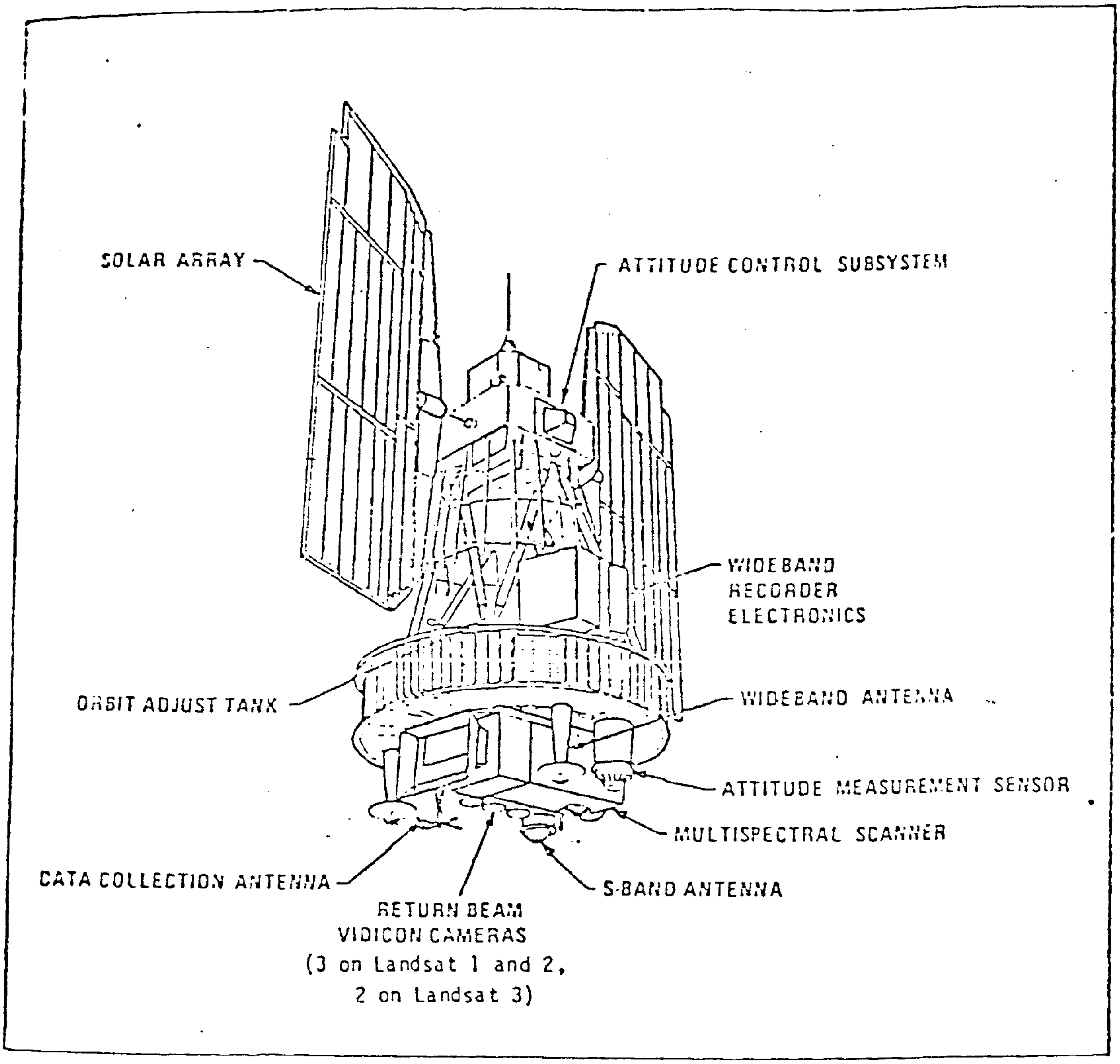

Figure 1: Landsat Spacecraft Configuration Showing Subsystem (Source: NASA, 1976)

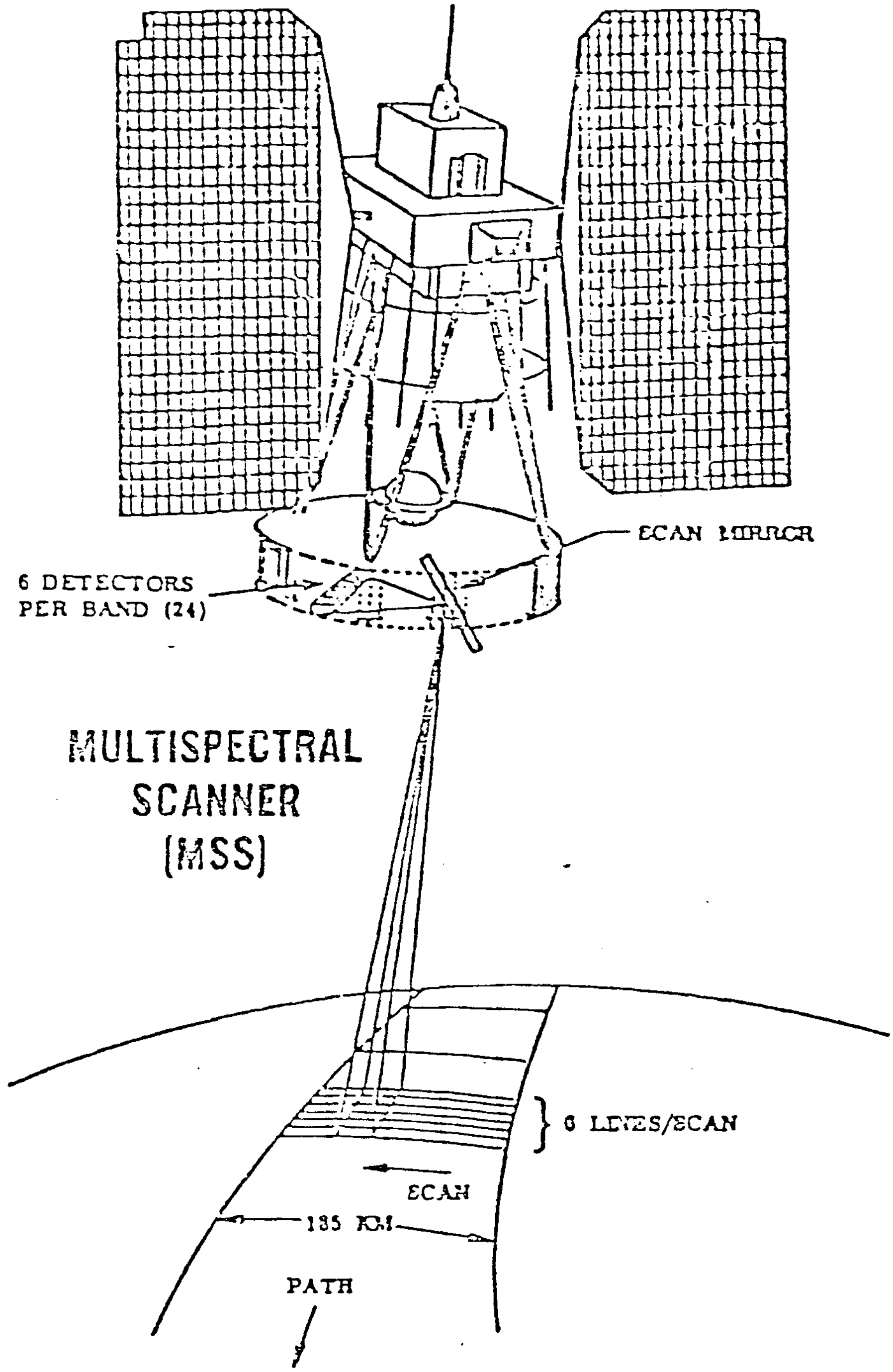

Figure 2: Multispectral Scanner System Pattern

(Source: NASA, 1972)

LANDSAT	SENSOR	SPECTRAL BANDS (μm)	DESCRIPTION	SPATIAL RESOLUTION (m)
1,2	RBV	0•475–0•575	Visible Blue, Green	80
		0•580–0•680	Visible Orange, Red	80
		0•690–0•830	Near infrared	80
3		0•505–0•750		80
1,2,3,4,5	MSS	0•5–0•6	Visible green	80
		0•6–0•7	Visible red	80
		0•7–0•8	Near infrared	80
		0•8–1•1	Near infrared	80
3		10•4–12•6	Thermal infrared	240
4,5	TM	0•45–0•52	Visible blue	30
		0•52–0•60	Visible green	30
		0•63–0•69	Visible red	30
		0•76–0•90	Near infrared	30
		1•55–1•75	Middle infrared	30
		2•08–2•35	Middle infrared	30
		10•40–12•50	Thermal infrared	120

TABLE 2. Specifications of the return beam vidieon (RBV), multispectral scanners (MSS) and Thematic Mapper (TM) on Landsat 1, 2, 3, 4 and 5.

In this study of the numerical data analysis, the following steps are very important for the land cover classification.

1) Spectral Characteristics of Earth's Surface Features (soil, water and vegetation).

2) Nature of the data.

3) Algorithms (Transformations of data using each processor of LARSYS).

2. Spectral Characteristics on the Earth's Surface Features

Identifying features on the earth's surface through remote sensing depends in large measure on the varying ways surface materials reflect the sun's energy. It is these variations in reflectance that both photographic sensors and multispectral scanners record.

The amount of energy reflected by a material is a function of three factors: how much of the sun's energy reaches it, how much is absorbed by it, and how much is transmitted through it. This relationship can be expressed as:

$$R_\lambda = I_\lambda - (A_\lambda + T_\lambda)$$

That is, the reflectance (R) at a specific wavelength is equal to the incident energy at that wavelength (I_λ) minus the sum of the energy absorbed A_λ) and transmitted (T_λ) at that wavelength.

2.1 For vegetation -- relatively low reflectance in the visible wavelength, where the effects of the pigmentation in the leaf determine the shape of the curve. For example, chlorophyll absorbs energy in the blue and red wavelengths, but reflects it in the green band (0·50 - 0·55 μm), making it appear green to our eyes. This high reflectance can be seen in the rise of the curve in Figure 3. Healthy vegetation gives higher reflectance in the near-infrared and lower reflectance in the middle infrared.

2.2 For soils -- soils reflect very differently depending on their color, moisture, surface condition, and the amounts of organic matter and iron oxide present. General characteristics to note are that soils tend to reflect more energy than vegetation in the visible wavelengths and in the middle infrared. Moist soils generally have a lower reflectance throughout the spectrum than dry soils, and exhibit the effects of the water absorption bands.

2.3 For water -- A significant reflectance characteristic of water is its distinct decrease in reflectance in moving from the visible (Band 4) to the near-infrared (Band 7) image. Both clear water and turbid water behave in this way. In the visible wavelength, river water generally reflects more energy than clear lake water because of its turbidity.

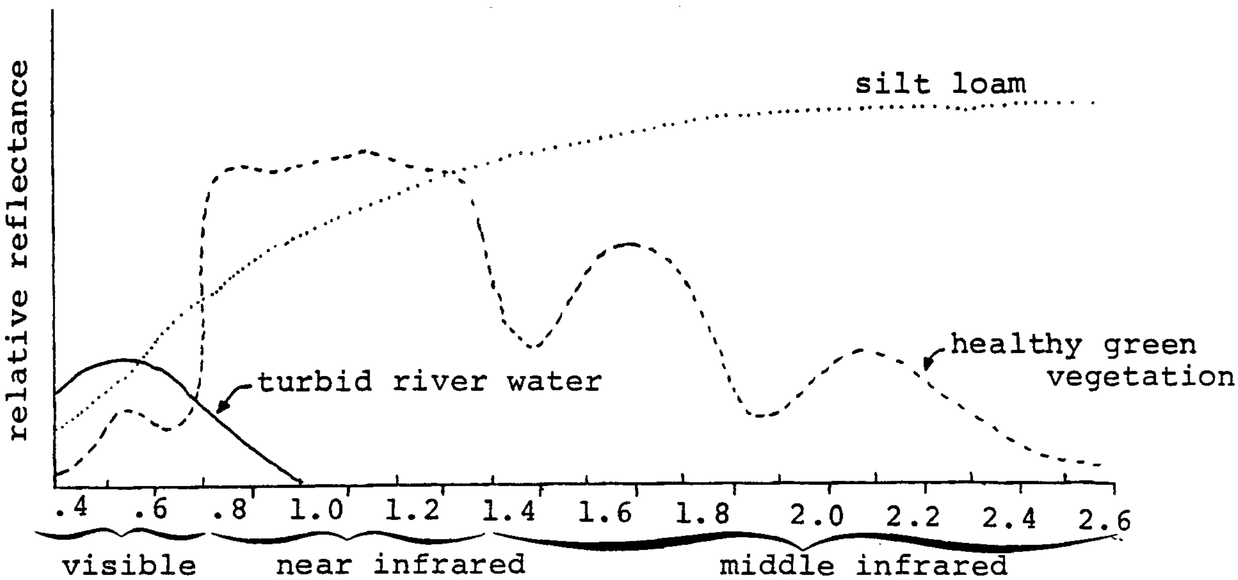

Figure 3: Typical spectral reflectance curves for three earth surface materials.

Although basic reflectance characteristics make possible the spectral identification of specific cover materials, these generalized curves vary in many ways and for many reasons. In addition, these spectral characteristics are not static, but vary with time.

3. Nature of the Data

The Landsat MSS data are primarily quantitative and numerical in nature. As a secondary attribute, these data can be displayed also as an image or picture. These images are composed of a large number of radiation measurements composed of radiation in four different spectral bands in the visible and near infrared portions of the electromagnetic spectrum. For example, each one of the four MSS spectral band images is composed of 7,605,000 radiation measurements. These measurements are stored in a digital format on computer compatible tapes (CCTs). Thus permitting their analysis using digital computer and pattern recognition software.

4. Algorithms (Transformation of data using each process of LARSYS.)

4.1 LARSYS

LARSYS is a software system of an integrated set of computer programs for analyzing remote sensing data. But in fact, LARSYS is much more than that. LARSYS is an entire approach to the conversion of remote sensing data into information useful for monitoring and inventorying earth resources (Figure 4). Again, before explaining the analysis process of the study area by using the LARSYS software system, the author likes to explain the important steps of the LARSYS flow chart (Figure 5).

4.2 PICTUREPRINT

The Pictureprint function reads data from a multispectral image storage tape and produces alphanumeric pictorial printouts of the data for each channel that is specified. The pictorial printout is normally used to check data quality and to select subsets (rectangular fields) of the data that will be used as test and training fields for other functions, usually statistics, Classifypoints, or Printresults. The fields are identified by comparing a photograph to the Pictureprint pictorial printout and selecting the line and column (sample) numbers that define the field corners. These line and column numbers are then keypunched onto Field Description Cards for use as input to the other functions. Pictureprint also has the capability of reading Field Description Cards and printing the field boundaries on the pictorial printout so the user can check his field selection.

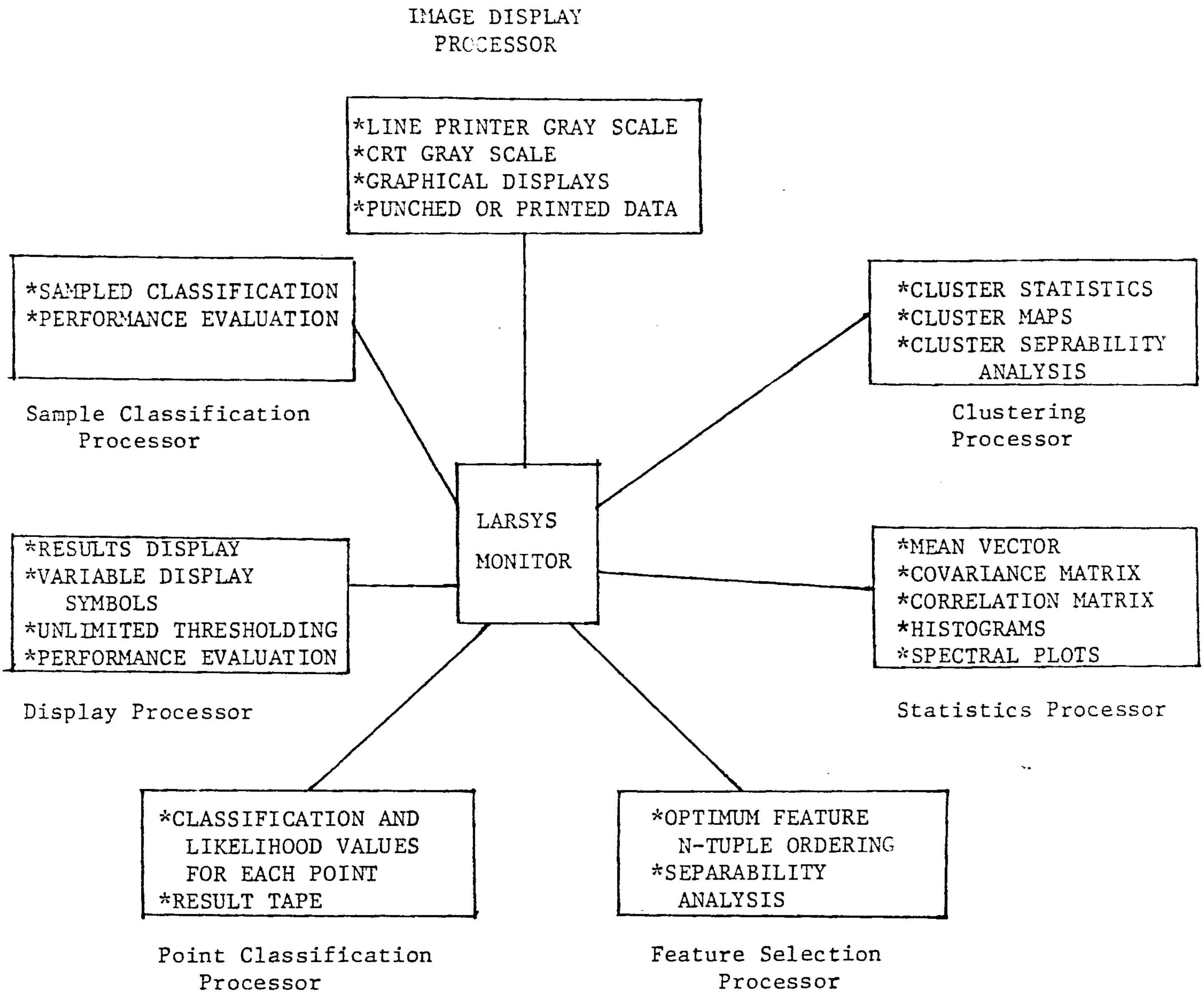

FIGURE 4 : Analysis Functions of the LARSYS Software System

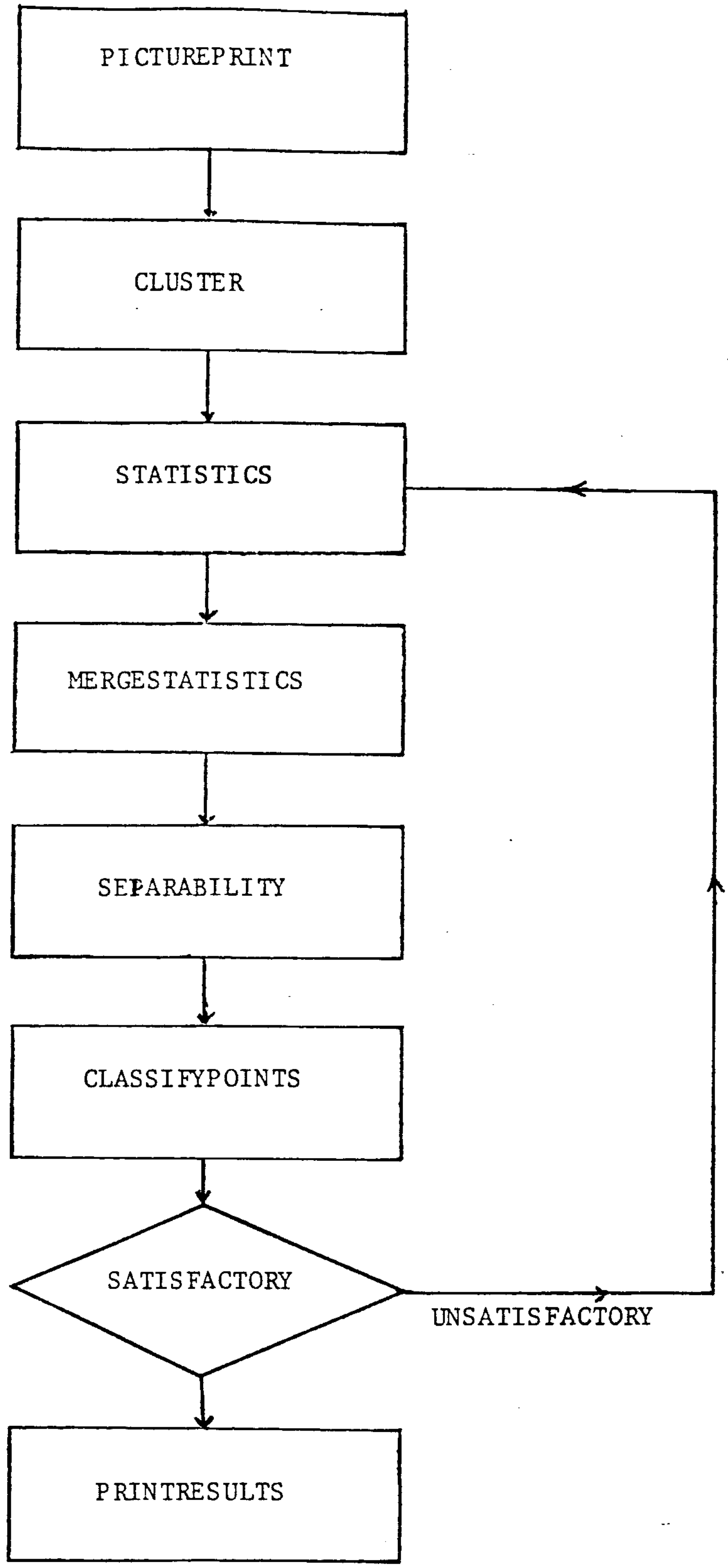

Figure 5: Analysis LARSYS Flow Chart For Land Cover Classification.

The pictorial map uses alphanumeric symbols to simulate gray scale tones. Experience has shown that 10 symbols, each of which has an equal probability of appearing, best accomplishes this purpose. Pictureprint allows for the use of 2 to 16 symbols. The symbols may be taken from a pre-defined set or may be specified by the user.

Pictureprint:

Display Run (number), line (x,y,z), col (x,y,z)
Channels 1,2,3,4
Symbols
Histogram compute
Block Run (number), line (x,y,z), col (x,y,z)
End.

Display - containing run number, the line and column numbers and they have respective intervals; lines (x,y,z), column (x,y,z) where x is a first line or column, y the last line or column, z is the interval.

Channels - channels are selected.

Symbols - can be used pre-defined or specified - symbols can be 16 (dark to light).

Histogram - user has a choice to select histograms that can be used. There are four possible choices.

1) Histogram may be calculated from the data area that is specified on the display or block cards.
2) Histogram that has been stored previously on the disk and it can be used.
3) Histogram can be read in card form.
4) The user may assign own data ranges for each symbol.

Block - Block is used to compute histogram from selected area. If the block is omitted, the data will see histogramed from the same data run specified on the display card.

16 specified symbols for Pictureprint (from darkest to lightest). They replace the functions of pre-defined symbols.

User may specify a different number of symbols to be used.

4.1.2 CLUSTER

Clustering is a computer aided data analysis method which using reflectance values from all channels, group the data into classes and displays the results on the printer or simply clustering is a process that groups pixels into pre-defined number clusters (groups) specified by the user.

The algorithm is based upon the relationship between each point and centers of groups of points (clusters) (Figure 6).

It calculates the Euclidean distance between each sample (pixel) and each cluster center. Assigns the sample to the cluster with the minimum distance. This causes the samples to be partitioned into groups of samples around each cluster center (Figure 7).

Input - Data from storage (data) tape. Cards to identify the area or areas to be clusterd.

Number of clusters desired.

Channels control card.

End

Options - Punch, Print, Id number, symbols cards

Control of processing -

Maxclass - Parameter establishes the maximum number of clusters to be produced.

Minclass - Parameter establishes the mimimum number of clusters to be produced.

INTV and CONV - Parameters can be used to reduce the amount of time required to complete the clustering process.

Output - Number of classes
Total number of vectors
Channel information
Number of points per cluster
(Table 3)

The means and variances for each cluster for all four channels are printed out. A cluster map which pictorially represents each area that was clustered and summary of the number of points assigned to each cluster (Figure 8).

Tabular output, statistics and field description cards are also available.

4.1.3 STATISTICS FILE

Produced by cluster is identical in format to the file produced by the STATISTICS Processor (Table 4).

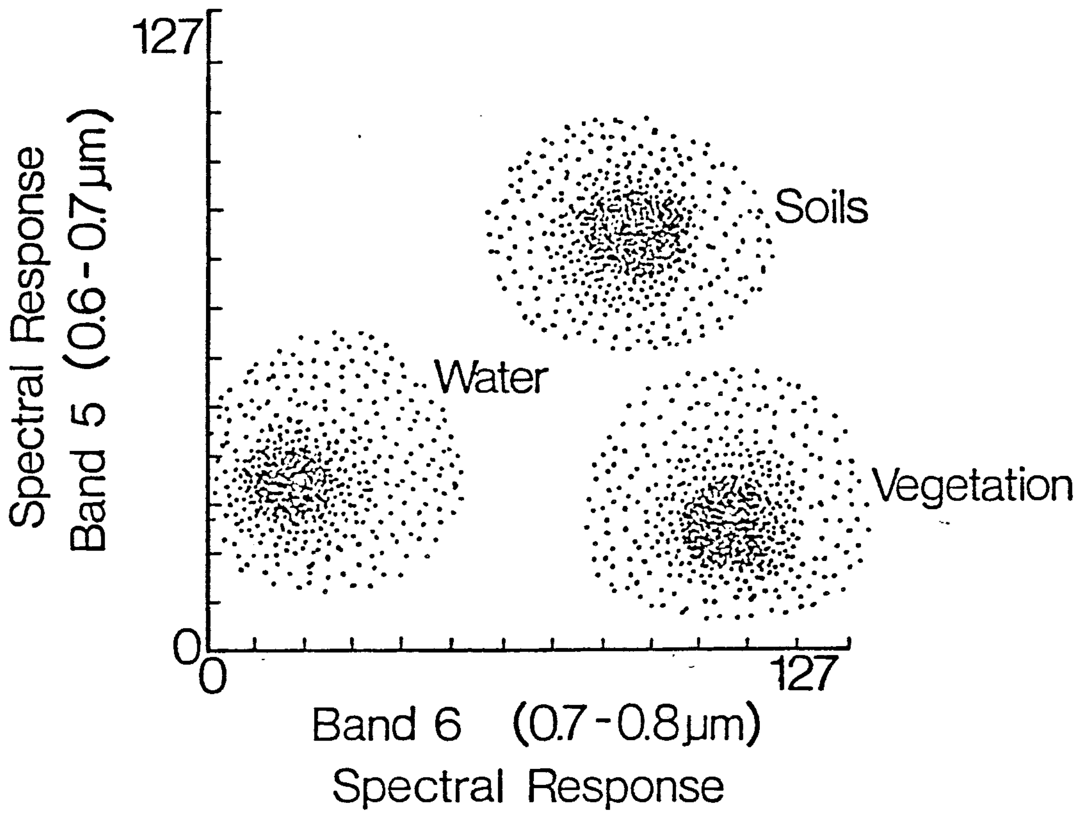

Figure 6: Typical plot of the spectral responses of water, soils and vegetation in Landsat bands 5 and 6

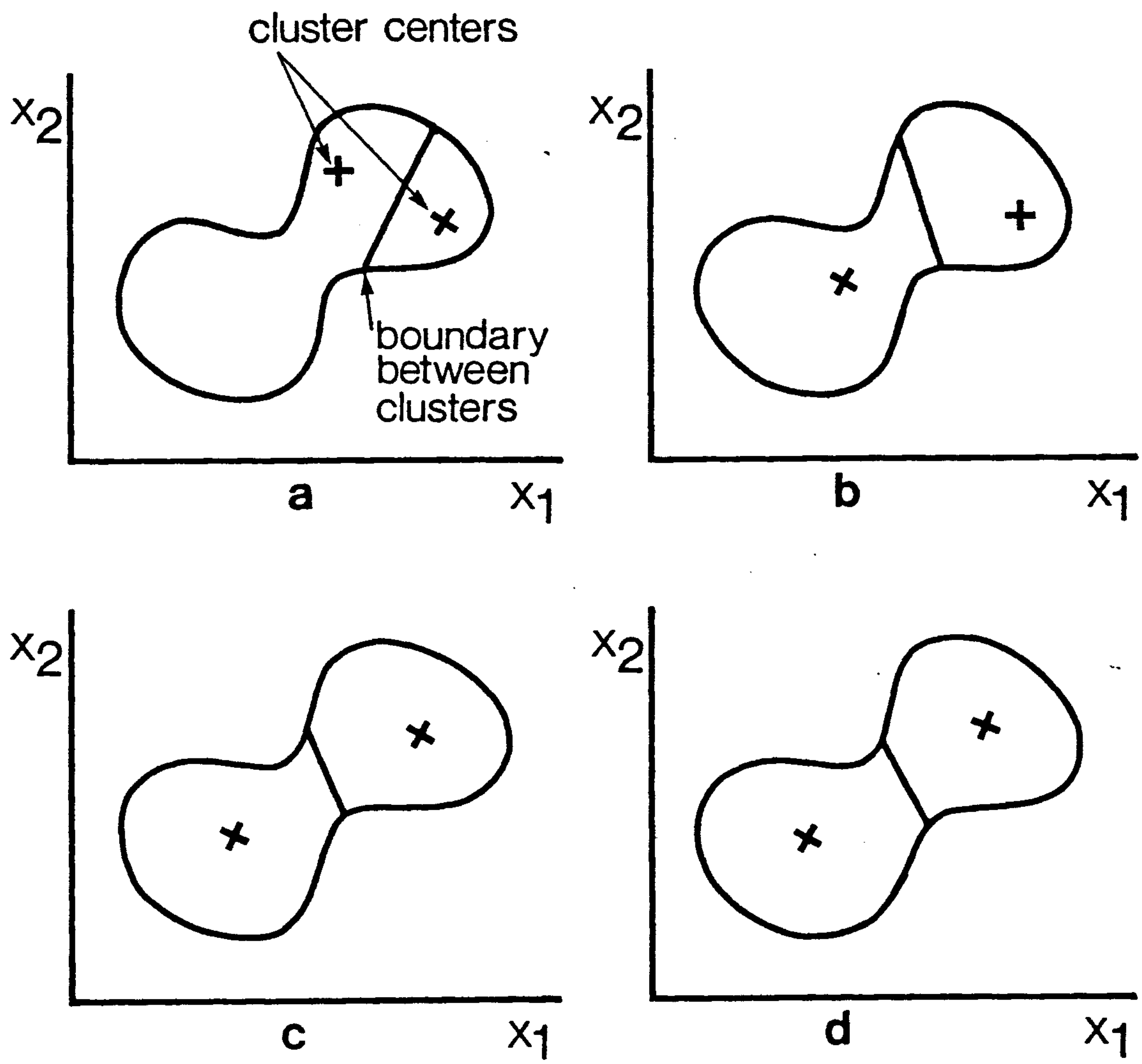

Figure 7: Sequence of clustering interactions: a) initial clustering centers; b) and c) intermediate steps; and d) final center configuration.

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DHAMRAI AREA JAN 3 1977

LABORATORY FOR APPLICATIONS OF REMOTE SENSING
PURDUE UNIVERSITY

JAN 18, 1985
01 41 12 PM
LARSYS VERSION 3

CLUSTERING INFORMATION

NUMBER OF CLUSTERS = 16   CLUSTERING UNIT SIZE = 6912   CLUSTERING INTERVAL = 1

CHANNEL NUMBER 1 SPECTRAL RANGE 0.50 TO 0.60 MICROMETERS CALIBRATION CODE 1
CHANNEL NUMBER 2 SPECTRAL RANGE 0.60 TO 0.70 MICROMETERS CALIBRATION CODE 1
CHANNEL NUMBER 3 SPECTRAL RANGE 0.70 TO 0.80 MICROMETERS CALIBRATION CODE 1
CHANNEL NUMBER 4 SPECTRAL RANGE 0.80 TO 1.10 MICROMETERS CALIBRATION CODE 1

CLUSTER	POINTS	MEANS CH(1)	CH(2)	CH(3)	CH(4)
1	122	19.75	20.68	40.90	18.26
2	426	17.34	17.71	36.30	16.68
3	554	17.23	17.77	32.66	14.73
4	542	18.35	20.49	33.06	14.00
5	691	17.61	18.58	30.47	13.12
6	83	23.24	27.42	31.04	11.72
7	870	18.85	21.41	29.75	12.29
8	728	17.49	18.71	28.20	12.07
9	370	20.41	23.88	27.06	10.66
10	338	18.99	21.54	22.96	8.53
11	635	18.38	20.98	26.79	10.87
12	371	16.53	15.82	27.30	11.99
13	390	17.29	18.52	24.46	10.34
14	296	15.72	15.03	23.85	10.52
15	376	17.53	18.32	19.52	6.51
16	120	15.89	14.42	12.52	3.30

CLUSTER VARIANCES

	CH(1)	CH(2)	CH(3)	CH(4)
1	1.94	2.00	5.68	2.08
2	0.74	2.31	1.84	1.72
3	0.49	1.13	0.93	0.90
4	1.09	0.95	1.38	0.95
5	0.50	0.92	0.64	0.74
6	7.80	12.93	4.67	1.08
7	0.97	1.12	0.97	0.70
8	0.54	0.71	0.63	0.65
9	1.51	1.42	1.73	1.03
10	1.48	1.56	1.86	1.30
11	0.80	0.58	0.95	0.65
12	0.76	1.02	1.13	0.88
13	0.58	0.99	1.41	1.25
14	1.14	0.98	1.98	1.24
15	1.27	2.71	2.78	1.69
16	1.96	2.45	9.08	2.63

Table 3. Cluster points, means and variances.

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FIELD INFORMATION

FIELD
RUN NO. 77006902
OTHER INFORMATION

TYPE
NO. OF SAMPLES 2400

LINES 50- 148 (BY 2)
COLUMNS 40- 135 (BY 2)

```
        000000000000000000000000000000011111111111111111
        444445555566666777778888899999000001111122222333
        024680246802468024680246802468024680246802468024

 50     ZZA4040MUAAAIFYZZOIZIFFZZZIOZ=/-IFZ-O/=8Z/Z=OI-O
 52     IIFIZOAAAIOZAFAIIZZIFZ/OZ=IA/88=4FY==/OUUO=--=FYO
 54     OZ440AZOO/-04ZF4ZFYF=FA-/-=FFO=--/IZF--/OJA//--O
 56     /OOIOOOF04ZZUOYFOIIFY=I-==II=ZZF-/=FZF4-=/088+YY
 58     ZZ4YAO//IO=ZAUIAA===//O/=A/8/O-=OI-ZFF=Y-///---/
 60     F8FA4I8=///AY/OUO80=/-=OO8AUA080=II/IY/=/===-=-/
 62     Z=084ZOOO/IZ40/UCOI/=IFFYF=/8IAI/OA80ZZI//=---I-
 64     O/FOZZAA////I/O2OZZOZ//IIIIF=-=ZZAAA4YIOZIZZAIZ-
 66     IZIZIZA=/I=I/ZYIAOAA8=OZIIIIF==OAOZOZY/8AOIAAIZZ
 68     =OOIOZAZ=AIAAZZYFFO8AIO/8=-ZZFIZ/OOO/OO22UI2IZOZ
 70     =OFZOFOZAIZAFA=OAFZOO=IZYF==FZIOFYZO/8OO//O-OZZ4
 72     ZZOI=ZA/OFFYYZO4ZYZ/==FFFYF///A/IYYIOA88OOZ=FFF2
 74     O82U2JJJJJJOOOZZ/F/O-ZOIIOI=ZZUZMMMUOAZ2OUOZYYYO
 76     UZ28A8A48/JJUMO8I===-=IO/OUM82ZIO=A2UIOOZAI4FY=I
 78     ZAIOOOZOOI/JJJM28OI=I=IAMJJJZIIO/OA8UOZYAFFO42II
 80     ZAIAYIIZZOAIAOOMAI/IZ=M88O/IIAO/ZI=O2AZZIZZFYYOF
 82     OIFZFFOO4I=/-OOZMI4O/MO/AZAOF4F4ZAMMYOI422ZOZOIF
 84     ZYFIFFFFOO4IZI==YUZJJYYZAZZAAZZ/2J8OY4YOZAI/IOOZ
 86     =FF4AI===FI-4==4=4MM4ZIOZO4A4A/=JJ8ZYYFYI=4AIAAA
 88     IF=A-O==III/I===-OAZFZZZZ8ZAOZI/8888/Y=O88/OFOZZ
 90     ZOZ-I/ZZ===IIZZZI8/FIAOZ4OZIAOZI28J8AYZZ828IAIFF
 92     OO/-O8ZZZZF4IOIZ88IF=IZAFIOAOO/AZUJJOFF==8O8=YZ/
 94     IZ8O/-/=-FAAFIOZZZ=AII=O4YZ2UZ/JOZZAUFFI=2IO=YF/
 96     -IO8=YZY=ZYYIAOOO=ZAZ84AIIA8O22O/OO/OJ2OIAZ/=I=M
 98     I==U=4=FZ=IOIIZZZOAIAAOOOZ88O82O=/Z2II88YAIAIO2O
100     =O8FU4==ZYYYIOOIZI4ZOAIIAZAOOOOO==ZUYMAJ24ZI44JO
102     ZI-O4F//-IFOFFI==O4F=OYZIOFA=IO2OZZMUMUZO4IOZ8OA
104     =-=-O-I--8I==FYFFF=ZZAIFFIOZOIO/OAOA4UAZI=UAAU8O
106     Z//=--I--=II=FI==FZFOOOYZ4ZFOOOO/AZZZI=/ZIUFZUA4
108     ZZZIO==ZF-=A=-==AAYZF//YFYOIOOOOI8OI=IFOZFIM4AUZ
110     Y4OAIIFI======/=4=ZFFOZOOZ===OOZOIOFO/YFIAOUJ8UI
112     ZFII//IY--FF-OZ-==AYFYZ=OOOO8ZY/-=OOOOOF/==YYFOA
114     -I/II==YY=/=--IA/OI=YFYI8AIIFI4YI/-OAA--FFFYYZOO
116     F=OA=-FF=I-ZIO==F4===I=YIO2=YYY=IFF=FZI==Z4FZO/-
118     IOA/II/-/=--=--/ZF--===YYYZ4FYFYYFYYY=AAA4YYY/=/
120     FZO=4-/-O=--=I=/IAI4--/IO4Z4YYYF4FFYIZUZZFAII---
122     FF-O4MZZ=O=-Z44OI2OI=O-=IIFFFYIZUYI-/AIZOU/-O884
124     FZI=I=U4IAA2I4-===ZIOAA/O84I/4FZZ4I=OZ=F/A8O8/OO
126     O==ZUZZI==OO4F4UZY444UU/IY4ZIOZ=-=-A////OIIIZ===
128     II/4U---ZO-OZF/F=MFUMUI/FYA=OIZIOZII//O8IIOFIIZ-
130     ZI=ZY=-/-/--/F4I4=IY=YZFZZ/ZIZ4YZI=8/OOOII//=4IF
132     FFZI--=+I----=-I/ZZZF=/Y4AO-=/-A=O-8AZIOAU//JO/--
134     FYI---F-------=Z/=I/IAA4F-=ZZ-FZII=FFIYIZZZ///O88
136     /F=--IIF-I---/FZ=--/Z==-I/FA=ZYZ888OFFZF4FFOOOOO
138     YI=Z--IZO=OF=I=Z=F-==-2U=A=OI/4FFIO/UFYYUYIF/O88
140     FZFOYIZ=ZI-FIIOOIIIYY-UUU==FYFA=ZA=FYO/YFO-/-8OO
142     ZOUUUY4IIFOZ4OUO=OZYI-I222OOYYAYFYFZ=I==//-O/-/O
144     IZ8OOIY/ZZII=2UUU8AAO=I/OFY4JZJZ=ZOYY//8/O8AZOI/
146     O/AA8ZAOAIZZO8OA88AZOFAZZM8OOAZFYA884FO//O=OA//O
148     IIO888AOA8JIO8AOU8OI-AI/ZAUA4Z4OAAOAZY8IOI/=I//A
```

NUMBER OF POINTS PER CLUSTER

CLUSTER	1	2	3	4	5	6	7	8	9	10
SYMBOL	+	-	=	/	I	J	O	Z	8	2
POINTS	2	152	245	188	303	32	348	300	101	37

CLUSTER	11	12	13	14	15	16
SYMBOL	A	F	4	Y	U	M
POINTS	179	200	93	133	62	25

Figure 8: Cluster map of Dhamrai Upazila area using 4 channels and 16 cluster classes.

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****************************** ORDERED BY CLASS ******************************

NO.	SYMBOLS	CLASS	CHAN 1	CHAN 2	CHAN 3	CHAN 4	MAGNITUDE	VIS/IR	PCT. VIS	PCT. IR
1	+	NS- 1/16	19.75	20.68	40.90	18.26	99.60	0.6834	40.60	59.40
2	-	NS- 2/16	17.34	17.71	36.30	16.68	88.03	0.6616	39.82	60.18
3	=	NS- 3/16	17.23	17.77	32.66	14.73	82.39	0.7386	42.48	57.52
4	/	NS- 4/16	18.35	20.49	33.06	14.00	85.89	0.8254	45.22	54.78
5	I	NS- 5/16	17.61	18.58	30.47	13.12	79.79	0.8304	45.37	54.63
6	J	NS- 6/16	23.24	27.42	31.04	11.72	93.42	1.1848	54.23	45.77
7	O	NS- 7/16	18.85	21.41	29.75	12.29	82.30	0.9578	48.92	51.08
8	Z	NS- 8/16	17.49	18.71	28.20	12.07	76.48	0.8990	47.34	52.66
9	8	NS- 9/16	20.41	23.88	27.06	10.66	82.01	1.1743	54.01	45.99
10	2	NS-10/16	18.99	21.54	22.96	8.53	72.01	1.2873	56.28	43.72
11	A	NS-11/16	18.38	20.98	26.79	10.87	77.02	1.0453	51.11	48.89
12	F	NS-12/16	16.53	15.82	27.30	11.99	71.64	0.8235	45.16	54.84
13	4	NS-13/16	17.29	18.52	24.46	10.34	70.61	1.0289	50.71	49.29
14	Y	NS-14/16	15.72	15.03	23.85	10.52	65.11	0.8948	47.22	52.78
15	U	NS-15/16	17.53	18.32	19.52	6.51	61.88	1.3780	57.95	42.05
16	M	NS-16/16	15.89	14.43	12.52	3.30	46.14	1.9157	65.70	34.30

****************************** ORDERED BY MAGNITUDE ******************************

NO.	SYMBOLS	CLASS	CHAN 1	CHAN 2	CHAN 3	CHAN 4	MAGNITUDE	VIS/IR	PCT. VIS	PCT. IR
16	M	NS-16/16	15.89	14.43	12.52	3.30	46.14	1.9157	65.70	34.30
15	U	NS-15/16	17.53	18.32	19.52	6.51	61.88	1.3780	57.95	42.05
14	Y	NS-14/16	15.72	15.03	23.85	10.52	65.11	0.8948	47.22	52.78
13	4	NS-13/16	17.29	18.52	24.46	10.34	70.61	1.0289	50.71	49.29
12	F	NS-12/16	16.53	15.82	27.30	11.99	71.64	0.8235	45.16	54.84
10	2	NS-10/16	18.99	21.54	22.96	8.53	72.01	1.2873	56.28	43.72
8	Z	NS- 8/16	17.49	18.71	28.20	12.07	76.48	0.8990	47.34	52.66
11	A	NS-11/16	18.38	20.98	26.79	10.87	77.02	1.0453	51.11	48.89
5	I	NS- 5/16	17.61	18.58	30.47	13.12	79.79	0.8304	45.37	54.63
9	8	NS- 9/16	20.41	23.88	27.06	10.66	82.01	1.1743	54.01	45.99
7	O	NS- 7/16	18.85	21.41	29.75	12.29	82.30	0.9578	48.92	51.08
3	=	NS- 3/16	17.23	17.77	32.66	14.73	82.39	0.7386	42.48	57.52
4	/	NS- 4/16	18.35	20.49	33.06	14.00	85.89	0.8254	45.22	54.78
2	-	NS- 2/16	17.34	17.71	36.30	16.68	88.03	0.6616	39.82	60.18
6	J	NS- 6/16	23.24	27.42	31.04	11.72	93.42	1.1848	54.23	45.77
1	+	NS- 1/16	19.75	20.68	40.90	18.26	99.60	0.6834	40.60	59.40

****************************** ORDERED BY RATIO ******************************

NO.	SYMBOLS	CLASS	CHAN 1	CHAN 2	CHAN 3	CHAN 4	MAGNITUDE	VIS/IR	PCT. VIS	PCT. IR
2	-	NS- 2/16	17.34	17.71	36.30	16.68	88.03	0.6616	39.82	60.18
1	+	NS- 1/16	19.75	20.68	40.90	18.26	99.60	0.6834	40.60	59.40
3	=	NS- 3/16	17.23	17.77	32.66	14.73	82.39	0.7386	42.48	57.52
12	F	NS-12/16	16.53	15.82	27.30	11.99	71.64	0.8235	45.16	54.84
4	/	NS- 4/16	18.35	20.49	33.06	14.00	85.89	0.8254	45.22	54.78
5	I	NS- 5/16	17.61	18.58	30.47	13.12	79.79	0.8304	45.37	54.63
14	Y	NS-14/16	15.72	15.03	23.85	10.52	65.11	0.8948	47.22	52.78
8	Z	NS- 8/16	17.49	18.71	28.20	12.07	76.48	0.8990	47.34	52.66
7	O	NS- 7/16	18.85	21.41	29.75	12.29	82.30	0.9578	48.92	51.08
13	4	NS-13/16	17.29	18.52	24.46	10.34	70.61	1.0289	50.71	49.29
11	A	NS-11/16	18.38	20.98	26.79	10.87	77.02	1.0453	51.11	48.89
9	8	NS- 9/16	20.41	23.88	27.06	10.66	82.01	1.1743	54.01	45.99
6	J	NS- 6/16	23.24	27.42	31.04	11.72	93.42	1.1848	54.23	45.77
10	2	NS-10/16	18.99	21.54	22.96	8.53	72.01	1.2873	56.28	43.72
15	U	NS-15/16	17.53	18.32	19.52	6.51	61.88	1.3780	57.95	42.05
16	M	NS-16/16	15.89	14.43	12.52	3.30	46.14	1.9157	65.70	34.30

******************** VARIANCES ********************

NO.	SYMBOLS	CLASS	CHAN 1	CHAN 2	CHAN 3	CHAN 4	NO. POINTS
1	+	NS- 1/16	1.94	2.00	5.68	2.08	122
2	-	NS- 2/16	0.74	2.31	1.84	1.72	426
3	=	NS- 3/16	0.49	1.13	0.93	0.90	554
4	/	NS- 4/16	1.09	0.95	1.38	0.95	542
5	I	NS- 5/16	0.50	0.92	0.64	0.74	691
6	J	NS- 6/16	7.80	12.93	4.67	1.08	83
7	O	NS- 7/16	0.97	1.12	0.97	0.70	870
8	Z	NS- 8/16	0.54	0.71	0.63	0.65	728
9	8	NS- 9/16	1.51	1.42	1.73	1.03	370
10	2	NS-10/16	1.48	1.56	1.86	1.30	338
11	A	NS-11/16	0.80	0.58	0.95	0.65	635
12	F	NS-12/16	0.76	1.02	1.13	0.88	371
13	4	NS-13/16	0.58	0.99	1.41	1.25	390
14	Y	NS-14/16	1.14	0.98	1.98	1.24	296
15	U	NS-15/16	1.27	2.71	2.78	1.69	376
16	M	NS-16/16	1.96	2.45	9.08	2.63	120

IO103 CPU TIME USED WAS 1.457 SECONDS. (LARSMN)

Table 4. Statistics Obtained From Cluster Spectral Classes Using Four Wavelengths.

4.1.4 RATIO

Processor produced table of statistics in all four channels using the mean vectors of classes in a statistics deck, calculates and prints the ratio of the values for the specified channels and the sum for each class.

4.1.5 MERGESTATISTICS

Mergestatistics processor is used to combine more than one statistics deck into one deck. This processor is also used to delete, pool or include spectral classes. One option of this processor is the possibility to generate a bi-spectral plot, which is very helpful in the analysis and definition of the spectral classes that will be used in training the classifier.

4.1.6 SEPARABILITY

Separability processor function allows the user to calculate transformed divergence between all class pairs for every set of channels. It also determines which classes are similar and what is the probability of correct classification. Transformed divergence (D_T) is a multivariate measure of statistical distance (Figure 9) and perform well in estimating the probability of correct classification between pairs of classes. Results of plotting probability of correct classification versus transformed divergence for data are shown in the graph (Figure 10). The graph shows that class pair with larger transformed divergence values (D_T) also achieved a higher classification accuracy (P_c) although the relationship is not perfectly linear. This graph can help in determining what the minimum acceptable transformed divergence value between pairs of classes should be. According to the graph, to achieve 85% accuracy, it shows that the final training classes should have transformed divergence values between about 800 and 1800, with transformed divergence of 800 would achieve 85% accuracy only infrequently. But at 1800, 85% accuracy could almost always be obtained. Most simply, the transformed divergence is a number between 0 and 2000, where 2000 is "complete separability."

It has also been found that if the cluster classes with transformed divergence greater than 1700 are combined, the results may be a combination of more than one type into the same spectral class. But on the other hand, cluster classes with transformed divergence values of less than 1500 have a high probability of representing the same cover type due to their spectral similarity. The lower the transformed divergence, the cluster classes are spectrally similar.

Input - control cards to select processing and output options, statistics files (cards and disks) from statistics function (mean vector and covariance matrices) for each class.

Output - separability results.

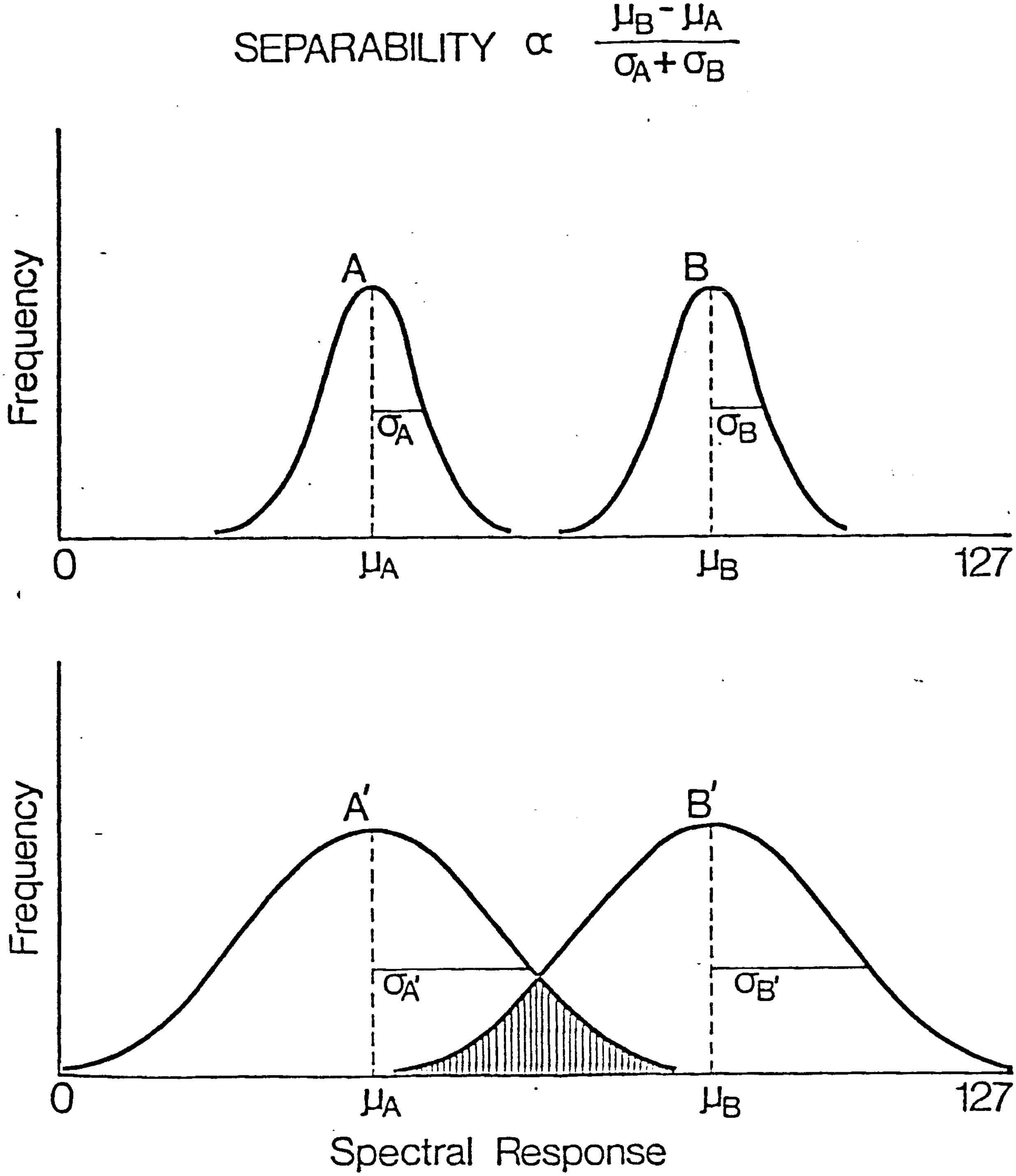

Figure 9: Graphical Representation of the Relationship Between the Spectral SEPARABILITY and the Means (μ) and Standard Deviations (σ) of Spectral Class Distributions.

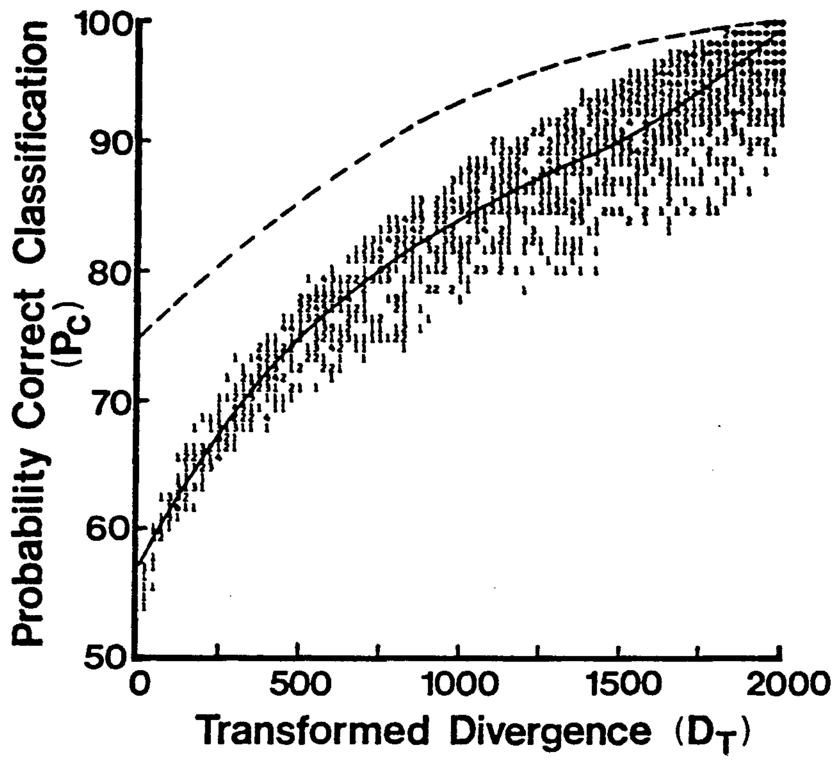

Figure 10: Observed values of probability of correct classification versus transformed divergence.

4.1.7 CLASSIFYPOINTS

The classification algorithm used in this step is to assign each pixel in a user selected area using maximum likelihood algorithm and store the results on the results file. This process known as a maximum likelihood classification uses the training classes mean vectors and covariance matrices along with the likelihood of that point belonging to each of the training classes. There are various types of classification algorithms - maximum likelihood, ECHO, and minimum distance etc. Maximum likelihood means that the computer compares the spectral values of each pixel in the raw data file with each of the statistically defined classes in the statistics file. The computer then calculates the probability that a pixel belongs to each class in the STATISTICS file, and assigns the pixel to the class to which it is statistically closest. The calculation is performed for each pixel in the raw data file.

4.1.8 PRINTRESULTS

Printresults processor is used by placing the classification results in a computer file and by assigning different symbols to each class. The results can be displayed in several formats according to the user needs and specification. There are two major types of display formats: 1) pictorial and 2) tabular. The different classes (ground cover types) can be represented by (i) alphanumeric symbols, (ii) graphic symbols, (iii) gray levels, (iv) boundary lines, or (v) different colors. The tabular format can be utilized when a user requires only information such as percentage of acreage or percentageof each one of the different cover types present in the study area.

5. IBM/7350 HACIENDA Digital Display

Hacienda digital system is used to display classification results in color coded digital format. Different colors are assigned to each class.

5.1 IBM/7350 HACIENDA

High Level Image Processing System (HLIPS) - a high resolution, high function color graphic system. The 7350 system allows the interactive processing and display of color images generated from digital data. The system consists of a control unit and a dual-display work station. It can be channel-attached to IBM System/370, 4300, and 30xx Processors (up to 4096 color hues can be selected for display).

6. OBJECTIVES

The principal objective of this program was to acquire (learn) digital image processing technology for quantitative analysis of remotely sensed multispectral data. To meet this objective, three different research tasks were carried out.

6.1 Classification of land cover within the study area.

6.2 Determination of the areal extent of different land use classes within the study area.

6.3 Delineation of the different soil classes within the study area.

7. GENERAL DESCRIPTION OF THE STUDY AREA (DHAMRAI UPAZILA)

7.1 LOCATION

The study area lies between 23°49′ and 24°02′06″ north latitude and 90°01′ and 90°15′ east longitude. It is situated about 38 kilometers to the northwest of the Dhaka City - along the shore of the Bansi River. This area consists of a total of sixteen unions, 307 mouzas and over 43,000 households and the total area is about 191·5 square kilometer (119 sq. mi). The study area (Figure 11) has a net cropped area about 70,500 acres and total cropped area is about 111,700 acres. Most of the study areas are seasonally flooded to different depths, and this in turn influences the agriculture of the area.

7.2 CLIMATE

The study area has a tropical monsoon climate. There are two distinguished seasons: The rainy season or Kharif season from May to October, during which more than 85 percent of the total annual rainfall occurs; and the dry season or Rabi season from November to April. The climatic data of eighteen years average for the study area are given in Tables 6a and 6b.

7.3 GEOLOGY

The soils of small patches of eastern part of the study area are developed over unconsolidated alluvial rediments. These are of two main ages: Tertiary (or Pleistocene), and Holocene (Recent). The area known as the Madhupur Jungle Tract, there are compact clays, previously called Pleistocene clays, but now thought possibly to be of Dupi Tila (Miocene) age and now called Madhupur clay. These clays have been uplifted tectonically to form a terrace generally standing 10-20 feet above the adjoining floodplains. This terrace has been dissected by valleys, most of which are streamless. Substantial level terrace areas remain between the valleys, but there are also large areas of closely dissected, rolling topography of low relief. The highest point on the Madhupur tract is 59 feet above mean sea level. The floodplain sediments are probably less than 1,000 years old. The oldest are heavy clays which are exposed extensively in the south and in the deeper valleys dissecting Madhupur tract. They may be of tidal swamp origin. These clay typically contain three buried organic layers, with radio-carbon ages of 5,280, 6,700, 2,790 and 1,430 years before the present time respectively.

DHAMRAI UPAZILA MAP

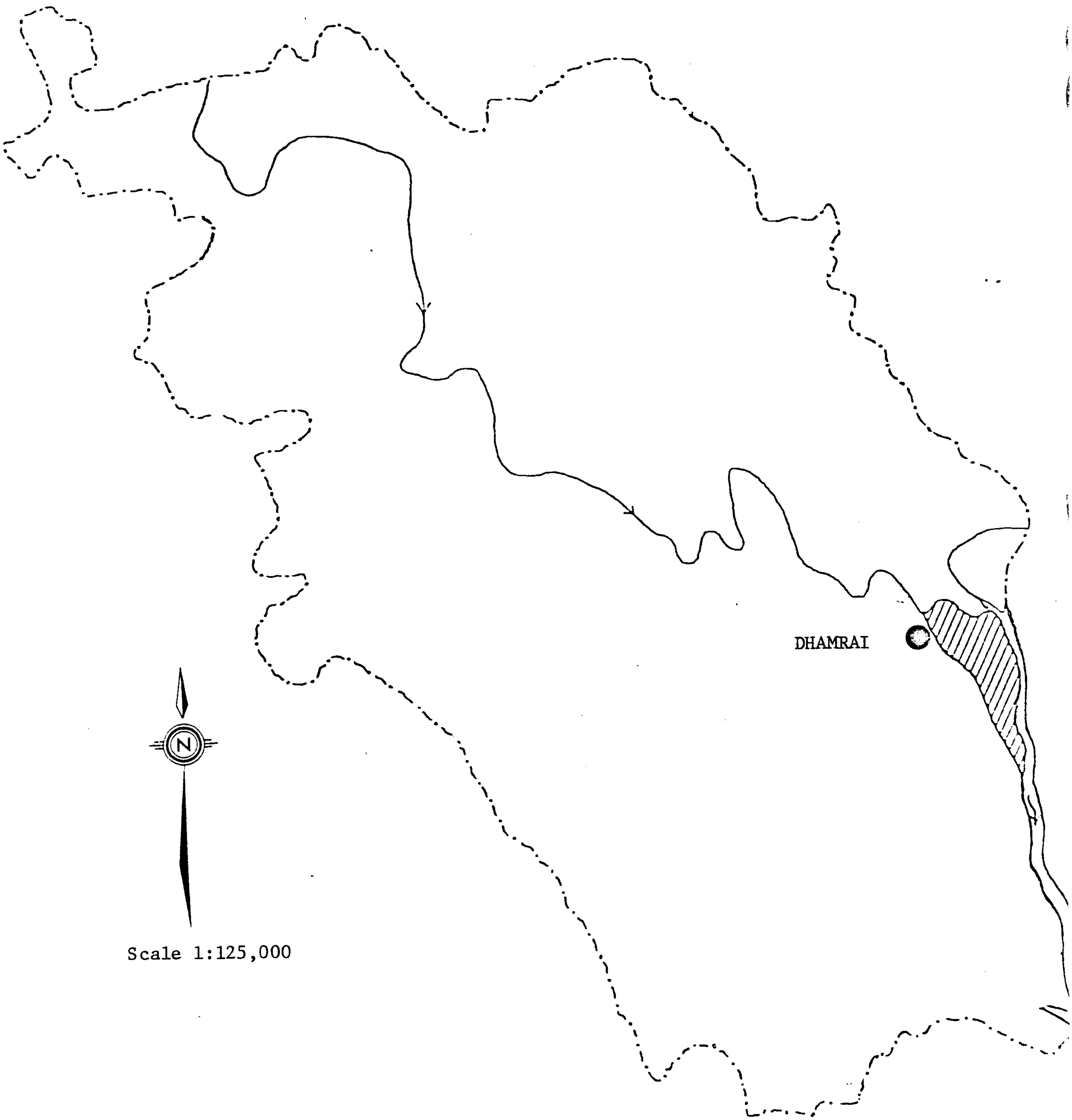

FIGURE 11 STUDY AREA

TIME PERIOD	RAINFALL (in mm)	TEMPERATURE (in deg. C)			RELATIVE HUMIDITY (%)	EVAPORATION (in mm)
		MAX	MIN	MEAN		
APRIL	136•4	34•13	23•49	28•8	70	106•4
MAY	260•9	32•87	24•58	28•7	78	88•4
JUNE	330•3	31•26	25•80	28•5	86	76•9
JULY	383•2	31•05	24•71	27•9	86	77•4
AUGUST	339•8	30•89	26•00	28•4	85	84•8
SEPTEMBER	272•8	31•41	25•72	28•5	84	76•9
OCTOBER	151•7	28•97	23•58	26•2	80	74•4
NOVEMBER	25•7	28•83	18•46	23•6	74	72•8
DECEMBER	8•3	25•82	13•48	19•6	73	61•9
JANUARY	3•7	23•92	11•18	17•5	68	59•9
FEBRUARY	15•4	26•52	14•74	20•6	63	65•0
MARCH	33•7	30•01	18•86	24•4	61	107•4

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TABLE 5. CLIMATE DATA OF DHAMRAI UPAZILA

The floodplain soils are relatively young and all sediments were deposited by the Brahmaputra, the Meghna, the Ganges and the Dhaleswari Rivers. In the study area, river deposits also came down the by Dansi River. In the eastern side of the study area, these clays are overlain by sediments deposited on the old Meghna estuarine floodplain. This floodplain has been buried by sediments deposited by the Brahmaputra River before it changed its course to the west of the Madhupur tract some 200 years ago. Young Meghna sediments have partially buried old Brahmaputra sediments in the east side. To the west, the older clays appear to pass into old sediments of the Ganges River which do not contain organic layers. To the north, these older formations have been buried by young Brahmapatra sediments brought down by the Jamuna and the Dhaleswari Rivers in the past 200 years; active sedimentation is still continuing. Young mixed Ganges and Brahmaputra sediments overlie the older sediments in a narrow strip to the southern part. After changing course, the Brahmaputra River brought large amounts of new sediments into the western parts of the study area. In the northern parts of the area was buried by the older Brahmaputra deposits brought down by the Bansi River and perhaps also by the Jenai and other former channels.

The floodplain landscape generally comprises broad gentle ridges marking old levees and broad, almost level, basins between them. The younger floodplain areas generally have more broken relief, with irregular spill deposits. These irregular features such as abandoned channels and sandy ridges remain even on the oldest meander floodplain areas. Floodplain elevations range from maximum of 25-30 feet M.S.L. in the north of the Old Brahmaputra and the Jamuna floodplains to the minimum of less than 10 feet M.S.L. along the Meghna floodplain, the southern half of the Old Brahmaputra and the old Meghna floodplain.

7.4 HYDROLOGY

The most distinguished feature of the hydrology of the study area is the seasonal flooding which affects approximately 80 percent of the total area. Almost all floodplain areas are flooded for 3 to 6 months each year; some basin areas are flooded 8 months or longer and some small areas remain permanently under water. Flooding depth varies with topographical position of the study area. The floodplain ridges are flooded up to about 3 feet deep and some basins are above 15 feet deep. Flooding depths vary from year to year and also within the flood season. The flooding depends on the levels of the major rivers. All the major rivers are tidal in the dry season, the amplitude ranging from about 3 feet in the south to less than a foot in the north.

Although it is the rivers that control flood levels, it is not only river water that covers the whole floodplain during the monsoon season. Initial flooding of the basin areas generally begins in April-May from accumulation of local run-off during pre-monson storms. In this period, all the major river levels rise rapidly most probably only due to snow-melting water of the Himalayan region coming down to the Brahmaputra-Jamuna Rivers. As a result, waters enter adjoining basins through natural and artificial channels, sometimes taking in considerable silt with them. River levels generally remain highest between July and September and may then over-top their banks. So all floodplain areas are unable to drain out the accumulated rainwater in this period. The old and young Brahmaputra floodplains of the study area is mainly flooded by rain water. Ground waters are readily available at shallow depths throughout all floodplain areas.

7.5 IRRIGATION

The soils of the study area have the capability to produce all dry season crops if irrigation facilities are available.

At present the study area has 156 artificial canals, more than 5000 powerpumps, 1256 tilewells and 4000 doons (local irrigation system) for irrigation purposes but these are not sufficient for the dry season cultivation of the entire study area. The main sources of irrigation are from river, canals, bils and ground water. Irrigation is needed not only to make rabi crop production, but equally important for the safeguard against droughts in April-May and October-November. Both the floodplain and terrace lands of the area are very suitable for irrigation.

7.6 SOILS

According to the soil survey of Bangladesh, there are four diffrent soil associations within the study area (Figure 12). These are:

1) Khilgaon - Tejgaon - Gerua complex (30)
2) Sonatala - Dhamrai complex (55)
3) Dhamrai - Sabhar Bazar Association (56)
4) Kajla - Pagla Association (62)

These four soil association/complexes consist of eight individual soil series. Detail description of each series is given below:

KHILGAON SERIES

Acid Basic Clay

Madhurpur tract -mixed deep and shallow upland soils.

7.6.1 (30) Khilgaon - Tejgaon - Gerua complex

Khilgaon sines - Aeric Fluvaquentic Order - Entisols, Suborder - Aquents, Great Group - Haplaquents, Family - Silty Clay Loam.

The Khilgoan series comprises seasonally flooded, poorly drained soils developed in heavy alluvial clays occupying valleys within the Madhupur tract. Top soil is grey to dark grey differ from Karail series in lacking dark

SOIL ASSOCIATIONS MAP OF DHAMRAI UPAZILA

Scale 1:125,000

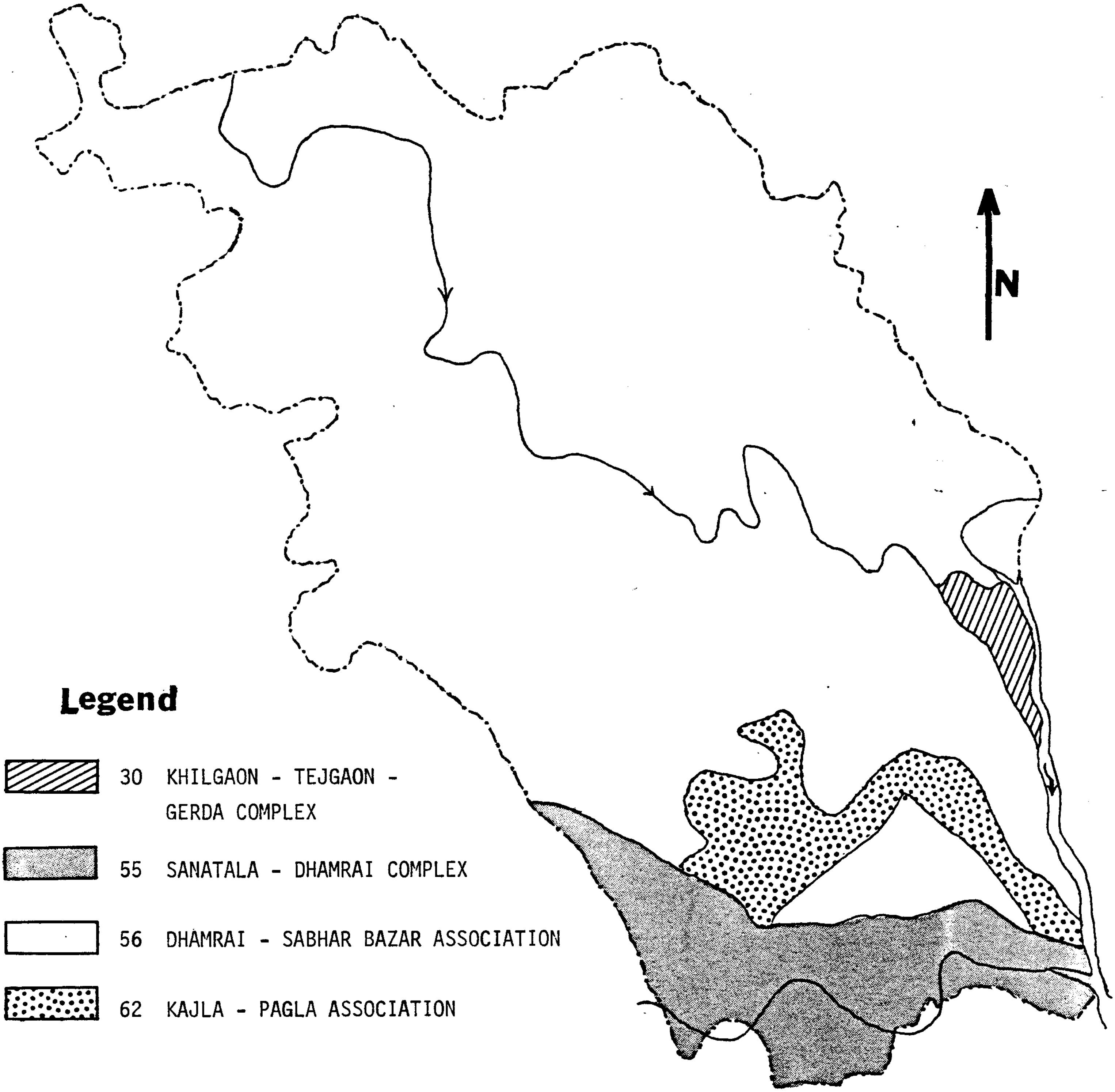


Figure 12

colored clay layers in the subsoil.

These soils are well suited for deep water Aman cultivation. In dry season the soils would be suitable for Boro cultivation. These soils are poorly suitable for the cultivation of other crops.

7.6.2 TEJGAON SERIES

Deep red-brown terrace soil.

Madhupur Tract - Mixed deep and shallow upland soils.

(30) Khilgaon-Tejgaon - Gerua complex.

Tejgaon Series - Typie Paleudults, Order - Ultisols, Suborder - Udults, Great Group - Paleudults, Family - Loam.

The Tejgaon Series of Madhupur Tract includes well to moderately well derived friable red clays occupying level upland sites. Soils are developed in sediments of late Pleistocene to Pliocene or possibly older. The loamy top soil is pale brown in color. The subsoil is red to dark brown and the substratum below is a clay. Moderately well drained soils. Moisture retention in dry periods is rather poor near the surface and moderate in low layers. These soils have a wide range of crop potentialities. Mainly Aus and dryland crops on the highland and broadcast Aman and Boro in the valleys. Excellent dryland crops could be grown throughout the year with irrigation.

7.6.3 GERUA SERIES

Shallow red-brown terrace soils

Madhupur Tract - Mixed deep and shallow upland soils

30 Khilgaon - Tejgaon - Gerua complex

Gerua Typic Paleustults, order - Ultisols

Sub-order - Ultults, Great group: Paleustults

Sub-group - Typic Paleustults, Family - clay loam

Gerua soil series includes shallow, moderately well drained, dark brown clays occupying gently undulating to rolling topography in closely dissected areas of the Madhupur Tract. The topsoil of one or two inches of pale brown to yellow brown silty clay loam. Gerua soils differ from Tejgaon soils in being less friable and in overlying heavy clay at shallow depth. These soils are highly erodible and have a poor soil-moisture holding capacity. These soils are mainly poorly suited for agriculture. Cultivated soils are used for Aus paddy but could be used for dryland crops such as mustard, legumes mainly on the deep phase.

7.6.4 SONATALA SERIES: Noncalcareous grey floodplain soils young - brahmaputra floodplain - active floodplain

55 Sonatala - Dhamrai complex

Sonatala Typic Fluvaquentic order - Entisols.

Sub-order - Aquents, Great group - Fluvaquents, Family - Silty clay loam

Sonatal soils almost very young waterlaid deposts that are mostly in wet places on floodplains. They do not have dark surface horizon, or if one is present, it is thin. Sonatala soils are developed in medium to moderately fine textured Brahmaputra alluvium on the upper slopes and ridges on the old and young Brahmaputra floodplains. Top soil is pale olive-brown in color. Drainage is somewhat poor. Seasonally flooded. When differ with silmondi soils being lighter in color. These soils are well suited for the cultivation of both transplanted and broadcast Aman, jute, sugarcane potatoes, pulses, vegetables and other dryland crops.

7.6.5 DHAMRAI SERIES

Noncalcareous grey floodplain soils.

Young Brahmaputra Floodplain - Young Meander Floodplain

56 Dhamrai - Sabhar Bazar Association

Dhamrai Typic Fluvaquentic, order - Entisols, Sub-order - Aquents, Great group - Fluvaquents, Sub-group - Typic Fluvaquents, Family - Silt loam

Dhamrai soil series includes grey loamy soils developed on floodplain ridges on the active and young meander floodplains. Shallow in depth so they appear grayer in overall color. The top soils consists of silt loam to silty clay. Subsoil is mottled brown or yellow-brown. Below subsoil is an olive gray stratified alluvium. Dhamrai differs from Sabhar Bazar to relatively higher topographical position. Seasonally flooded and poorly drained soils. These soils are well suited for mixed Aus and broadcast Aman, some jute but with irrigation, high-value crops could be grown on ridge soils, e.g. wheat, potato, maize, oil seeds, spices, tobacco and all sorts of vegetables and on the basin Boro could be grown.

7.6.6 SABHAR BAZAR SERIES

Noncalcareous Grey Floodplain Soils

Young Brahmaputra Floodplain - Young Meander Floodplain

56 Dhamrai - Sabhar Bazar Association

Sabhar Bazar Series - Aeric Fluvaquentic, order - Entisols, sub-order - Aquents, great group - Fluvaquents, family - Silty clay loam.

The soils are developed on the young meander floodplain or locally on the active and old meander floodplains. The topsoil consists of about 15 cm of light grey to olive grey, silty clay loam to silty clay. The subsoil consists of grey mottled brown silty clay to clay, which cracks into blocks on drying. Soils are almost level, slowly permeable, poorly drained and seasonally flooded and moderately retentive of moisture in the dry season. Differ from sonatala in their finer structure and heavier consistence. These soils are well suited for rice cultivation, moderately well suited for jute and dryland crops.

7.6.7 KAJLA SERIES

Noncalcareous Dark Grey Floodplain Soil

Young Brahmaputra Floodplain - Old Meander Floodplain

62 Kajla - Pagla Association

Kajla Series - Aeric Fluvaquents, order - Entisols, sub-order - Aquents, great group - Fluvaquents, sub-group - Aeric Fluvaquents, family - clay.

Kajla series developed in old basin clays (old Ganges and Jamuna alluvium) on the young Brahmaputra meander floodplain. Drainage poor, seasonally flooded. The topsoil consists of grey to dark grey·silty clay to clay, subsoil is deep clay, dark gray, mottled yellow, brown or red, cracking in small blocks on drying. Soils remain wet during dry season. Differ from associated Pagla soils is heavier in texture, and from other basin soils being acid. These soils are moderately well suited for deep water Aman and Boro rice cultivation, but poorly suited for dryland crops.

7.6.8 PAGLA SERIES

Noncalcareous Grey Floodplain Soils - Older Meander Floodplain

62 Kajla - Pagla Association

Pagla Series - Aeric Fluvaquentic, order - Entisols, sub-order - Aquents, great group - Fluvaquents, sub-group - Aeric Fluvaquents, family - Silty clay.

Pagla soil series developed on low floodplain ridges on the old meander floodplain. They are mineral wet soils. The top soil consists of about 15 cm of gray to very dark gray silty clay. The subsoil occurs gray to olive green mottled brown or reddish brown, silty clay or clay which cracks in block on drying. Pagla soils are almost level to gently sloping. Poorly drained, seasonally flooded and poorly retentive of moisture in the dry season. These soils are well suited for paddy cultivation throughout the year. With irrigation, good yields of dryland crops including Boro paddy could be grown.

Soil taxonomy description of the study area both in Bangladesh system and United States Department of Agriculture (USDA) system are given in Table 5 and 6.

8. VEGETATION

There is no evidence of natural vegetation remains in the study area except some planted forest trees along both sides of the road. The soils of the study area are developed mainly from alluvial deposits. Mostly floodplain soils. Therefore, this area is generally agriculture land. Main agricultural practice is Aman and Aus plantation during summer monsoon period and the Boro rice plantation during the dry season provided the irrigation is available. The major crops are rice paddy, jute, wheat, pulses, spices and vegetables. But in general, the vegetation of this area are broadcast Aus, both broadcast and transplanted Aman paddy, Boro rice, wheat, jute, sugarcane, maize, potato, sweet potato, mustard, groundnut, and other oil-seeds, pulses and other green legumes, chille and other spices, tobacco and vegetables.

In all floodplain areas, houses are built on earthen platforms for flood protection. These platform homestead lands are commonly used to grow small amounts of vegetables, especially gourds and beans, spices, tobacco, fruit trees including coconut and betelnut trees and bamboos and also used for Aman and Boro paddy nurseries.

But this study was done taking the MSS data (CCT) of 3rd January 1977. So, in the month of January following vegetation may remain in the fields which are wheat, winter rice (Boro), potato, sweet potato, mustard, groundnut, and other oil-seeds, pulses and other green legumes, chille and other spices tobacco, bringle and other vegetables (Figure 13).

9. MATERIALS AND METHOD

In the present study of Dhamrai Upazila of Bangladesh, the following base materials were used.

1) Thana map of Dhamrai (scale = 1:63, 360) prepared by the Department of Land Records and Survey, Bangladesh.

2) Ground Truth data of Dhamrai Upazila areas.

3) Soil Association maps of Dhaka District, Department of Soil Survey, Bangladesh.

SOIL TAXONOMY (BANGLADESH SYSTEM)

SOIL TYPE	SERIES
Noncalcareous Grey Floodplain Soils	Pagla Dhamrai Sonatala Sabhar Bazar
Noncalcareous Dark Grey Floodplain Soils	Kajla
Acid Basic Clay	Khilgaon
Deep Red-Brown Terrace Soils	Tejgaon
Shallow Red-Brown Terrace Soils	Gerua

TABLE 6a. SOIL TAXONOMY DESCRIPTION OF DHAMRAI UPAZILA

SOIL TAXONOMY (USDA SYSTEM)

ORDER	SUBORDER	GREAT GROUP	SUBGROUP	FAMILY	SERIES
Ultisols	Ustults	Paleustults	Typic Paleustults	Clay loam	Gerua
	Udults	Paleudults	Typic Paleudults	Loam	Tejgaon
Entisols	Aquents	Fluvaquents	Typic Fluvaquents	Silt loam	Dhamrai
		Haplaquents	Aeric Fluvaquents	Silty clay loam	Khilgaon
		Fluvaquents	Aeric Fluvaquents	Silty clay	Pagla
			Aeric Fluvaquents	Silty clay loam	Sabhar Bazar
			Aeric Fluvaquents	Clay	Kajla
			Typic Fluvaquents	Silty clay loam	Sonatala

TABLE 6b. SOIL TAXONOMY DESCRIPTION OF DHAMRA UPAZILA

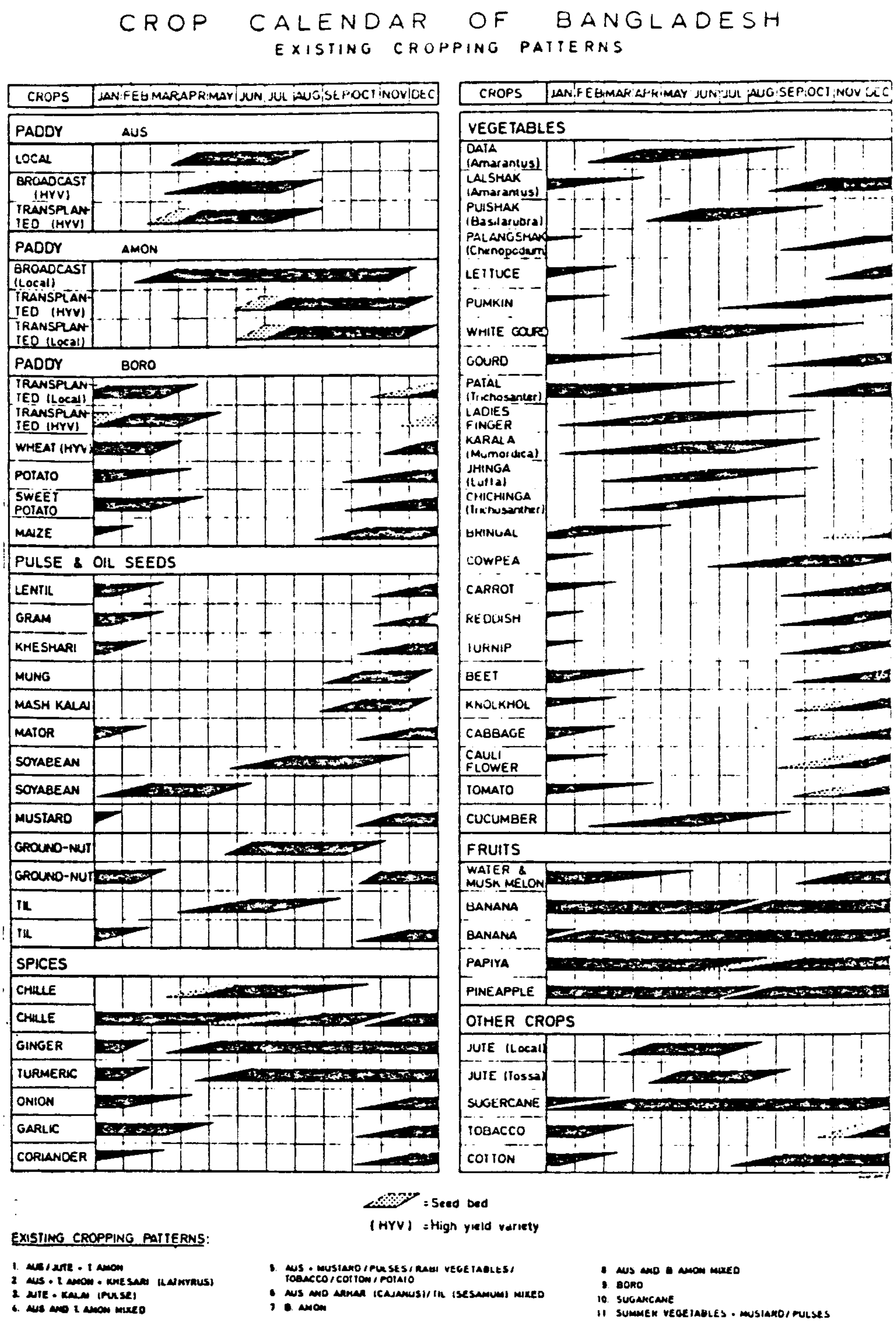


Figure 13: Crop calendar of Bangladesh.

4) Computer Compatible Tape (CCT) of January 3, 1977 of the study area.

The main data utilized in this study only from one frame from LANDSAT 3 and the MSS digital data collected on January 3, 1977. These data are stored in a computer compatible tape (CCT) in LARSYS format.

Run Number 77006902, Tape 121, File 4

By using the LARS software system and the IBM 370/158 computer, the author has analyzed the study area. Before displaying pictureprint of the study area, the author first displayed the output varian of Gdata by electronic printer using all the four channels in order to enable the selection of the study area for further analysis. These output varian of Gdata were used to obtain detailed information about the surface features. After examining all the four channels of the Gdata prints (Figure 14, 15, 16 and 17) the author found that channel 2 and 4 were good for detail surface feature information but channel 4 printout was more suitable for attaining all the details surface feature information of the study area.

After this pictureprint processor execution was done and its data quality was checked, besides from this pictureprint the boundary delineation of the study area was completed. However, it was later found that the study area was not geometrically correct. Then the CCT was corrected in LARS. Then through this corrected data the pictureprint was again displayed both in visible and infrared channels. This enabled to get statistics of output data values from the multispectral image storage tape. These data can be used for further functions, usually statistics and classifypoints.

The entire study area with some surrounding areas (42773·0 hectares) was used to be clustered. Three areas were selected within the study area in the pictureprint, 1 (3605·5 hectares), 2 (3395·75 hectares), 3 (3807·0 hectares), and plotted one in the northwest corner, one in the middle and one in the eastern side of the study area (Figure 18). These cluster areas were taken in such a way as to keep maximum surface features. These three selected areas were taken for unsupervised classification and executed cluster processor. Each cluster contained 16 classes. The cluster algorithm, with 16 classes in four wavelengths, was used for all three areas. Then the cluster classes were merged together by using mergestatistics processor to combine cluster statistics files into one file. After clustering, the MERGESTATISTICS and SEPARABILITY processing functions were used to merge all the cluster clases and to determine which cluster classes are similar and what was the probability of correct classification. Transformed divergence of 1550 as the threshold print was used, cluster classes with transformed divergence of less than 1550 were combined because of the high probability of their being the same cover type due to their spectral similarity. Those

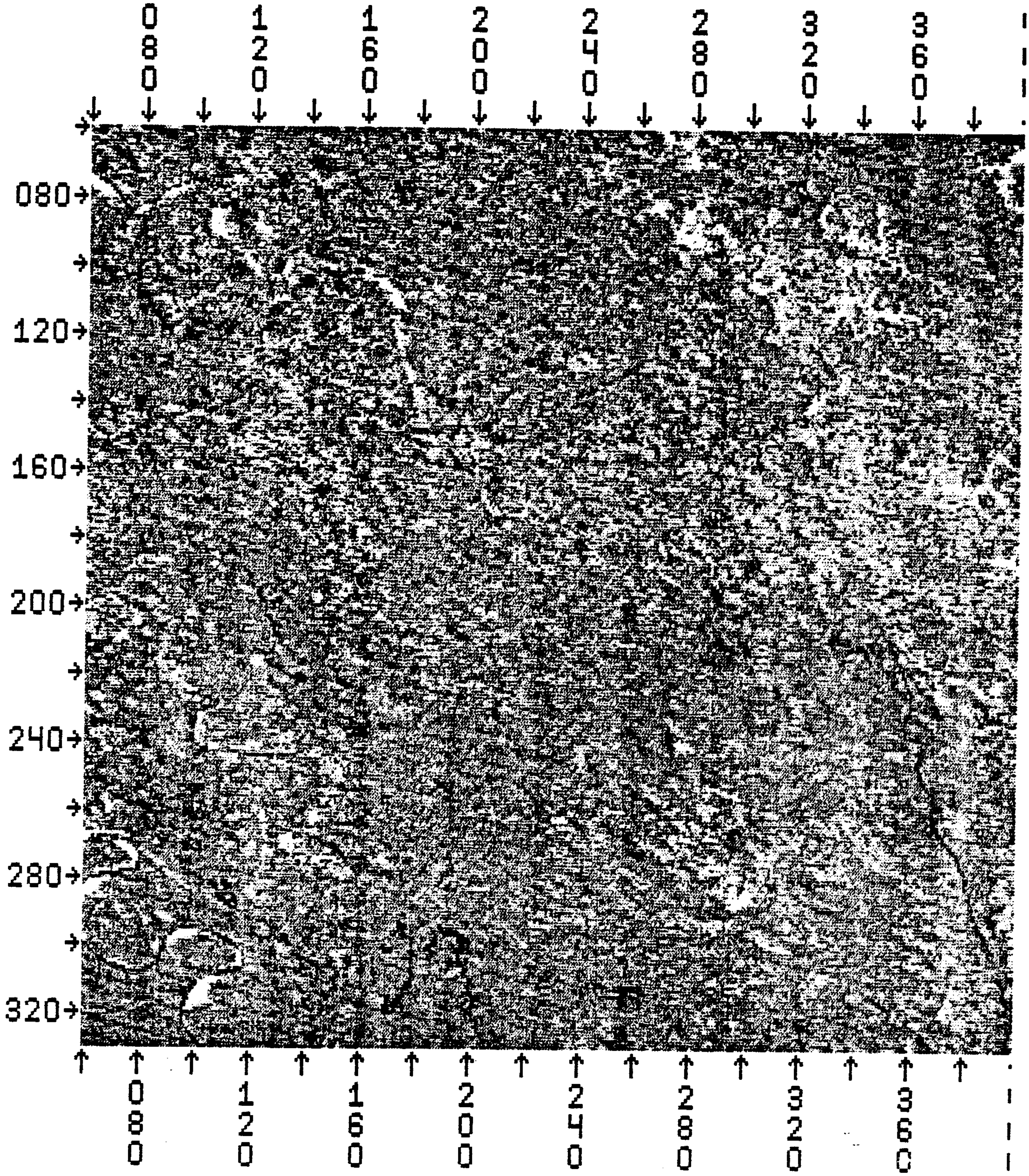


FIGURE 14 CHANNEL 1 SPECTRAL BAND 0'50 To 0'60 MICROMETERS

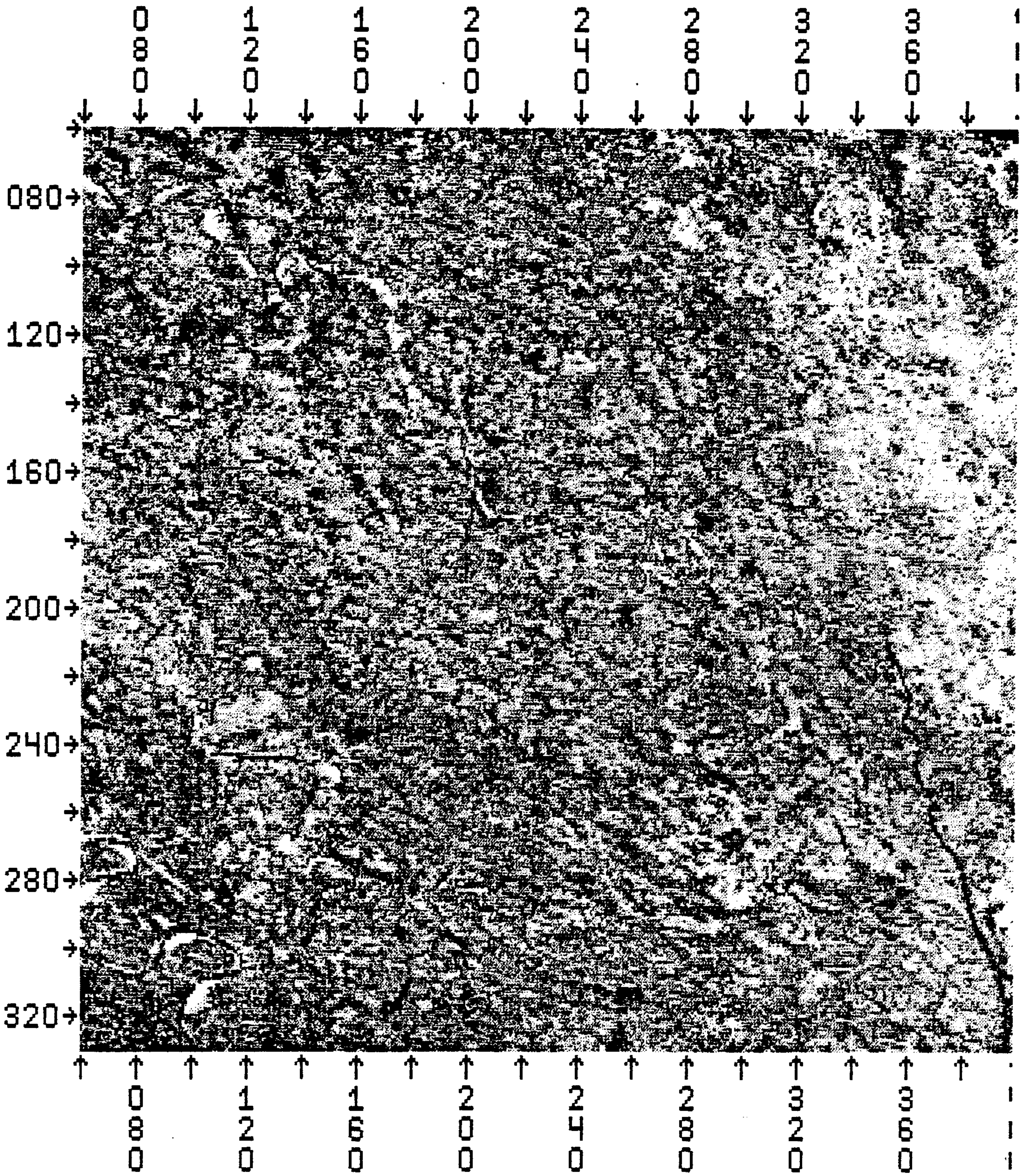


FIGURE 15 CHANNEL 2 SPECTRAL BAND 0'60 TO 0'70 MICROMETERS

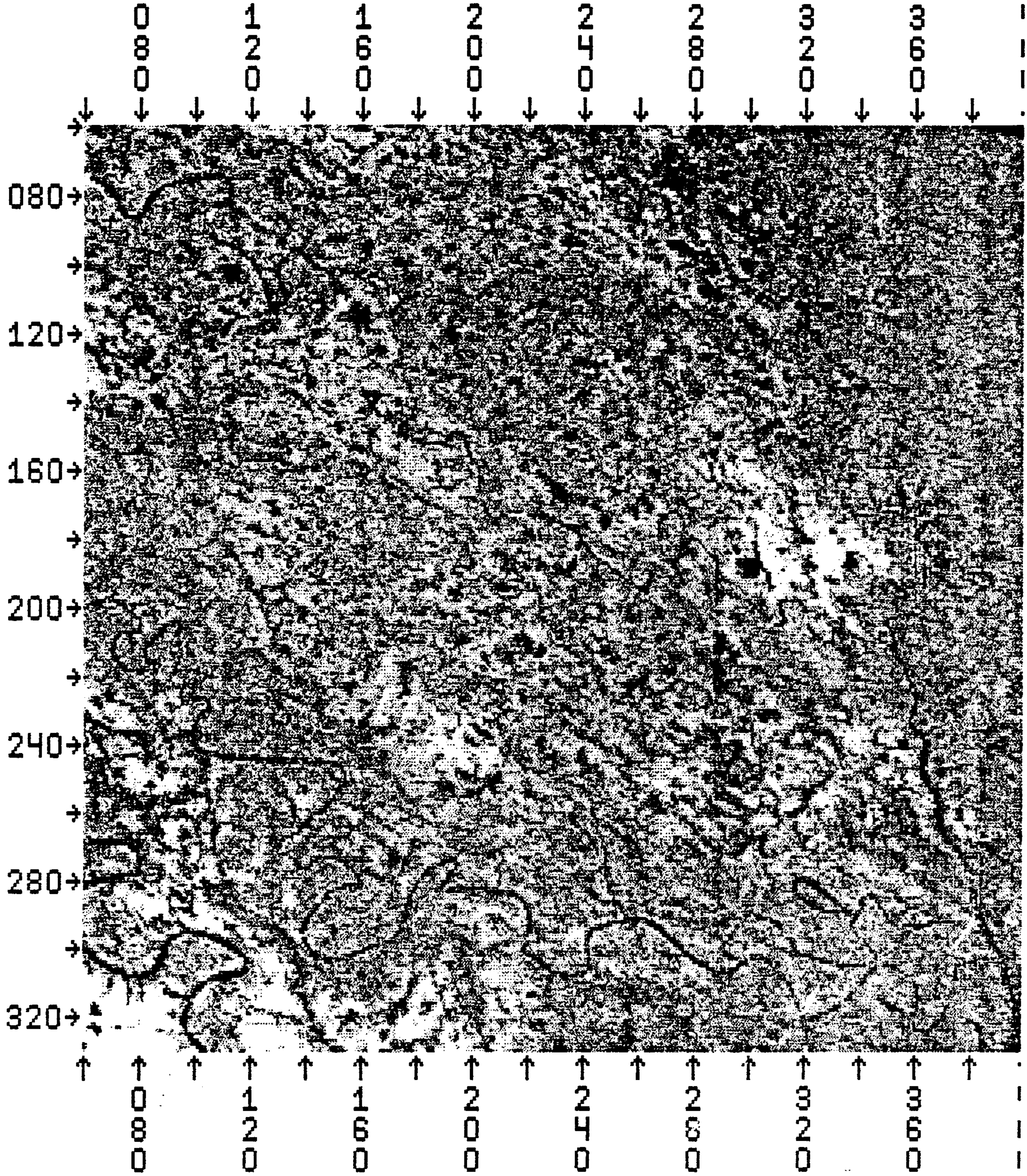


FIGURE 16: CHANNEL 3 SPECTRAL BAND 0'70 TO 0'80 MICROMETERS

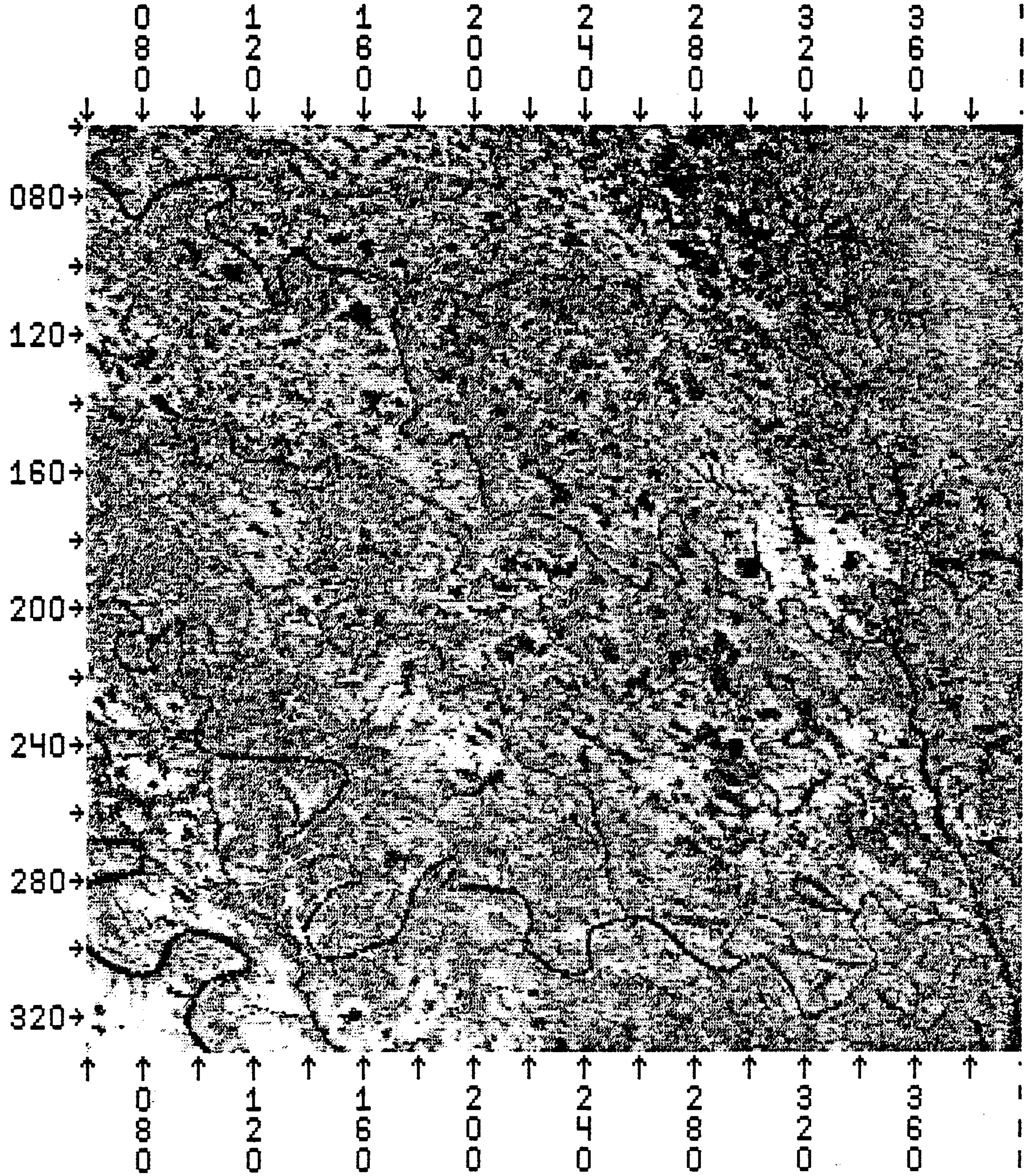


FIGURE 17: CHANNEL 4 SPECTRAL BAND 0'80 TO 1'10 MICROMETERS

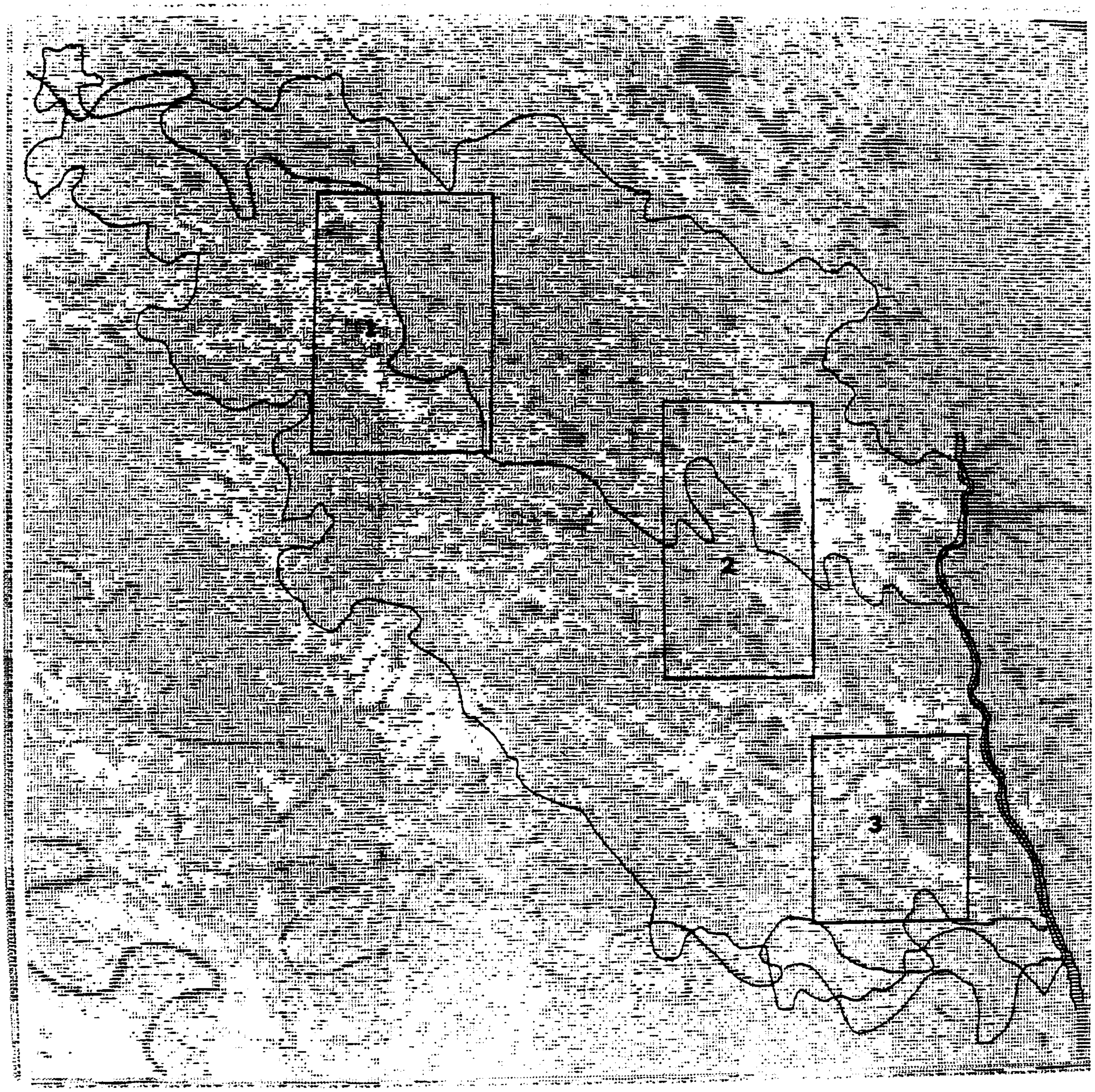


FIGURE 18: COMPUTER LAND RESOURCES MAP OF DHAMRAI UPAZILA, BANGLADESH. SHOWING DIFFERENT CLUSTER LOCATIONS. MSS DATA COLLECTED ON JANUARY 3, 1977.

greater than 1550 were kept separate. Again MERGESTATISTICS processor is used to perform which cluster class will be delected or be pooled or which will keep separate, so that the procedure finally completed with 15 spectrally separable classes of 48 classes.

The output of the classification results is a land cover classification map. The printresults function provided a variety of printed outputs describing the classifiction results produced by classifypoints function. Identifying and refining training classes are very important steps toward an accurate classification. Reference data were used for the final identification of the classes and the final classification of the classes were mainly based on the magnitude and ratioing information.

10. RESULTS AND DISCUSSION

In Landsat CCT, which coordinates the study area, was defined by lines 60 to 330 and columns 60 to 398 covering an area of 427730 hectares. The basic steps and the different processors used in the numerical analysis of Dhamrai area were illustrated in flowchart of Figure 19. Finally the analysis produced 15 spectral classes, and it represents the most important types of soils, vegetation and water that existed in the study area at the time when the data were acquired (January 3, 1977).

Soil color and moisture are important factors influencing reflectance both in the visible and infrared region. The reflectance ratio and greenness transformation are useful for predicting land covered by vegetation. Based on the statistics of the spectral classes the author found that most of the study areas were covered by crops. The rest was divided into agricultural land, having some vegetation in a complex of soil, generally bare, and often wet. The water classes consisted of comparatively clear water in the river and turbid water in the bils (lakes and ponds). Two computer land resources maps (one alphanumeric representation of 15 multispectral classes and one graphic symbols representation of 15 multispectral classes) were made and 15 classes were projected for representation (Figures 20 and 21).

Class 1 represents urban areas. It has medium spectral reflectance in the infrared wavelengths because almost all the villages of the study area were surrounded by green trees (Figure 22).

Classes 2 and 3 (MHLVEG1 and MHLVEG2) represent vegetation that vary in their spectral responses because of little differences in density of vegetative cover and chlorophyl content (Figure 23).

Class 4 represents bil (lakes, ponds, etc.). It has very low spectral reflectance in the water absorbed bands (Figure 24).

Class 5 represents char (sandy soils). It has high spectral reflectance in the near infrared portion (Figure 25).

Class 6 represents clear water and river water with very low spectral responses in the water absorbed bands (Figure 26).

Classes 7 and 8 (BAREL1 and BAREL2) represent bare land with low spectral responses in the infrared portion of a wavelength that vary spėctral responses because of little differences of soil moisture content (Figure 27).

Class 9 (MHLDVEG) represents dense vegetation. It has high spectral responses in the infrared portion of the wavelength (Figure 26).

Classes 10 and 11 (MARSHYL2 ans MARSHYL1) represent marshy land with very little vegetation and have low spectral responses (Figure 23).

Classes 12 to 15 (MFLVEG1, MFLVEG2, MFLVEG3, and MFLVEG4) represent vegetation with medium spectral responses in the infrared portion. Their spectral responses vary because of difference in soil color, different level of soil moisture content or differences of soil elevation (Figures 28 and 29). Table 7 shows the final 15 classes with their respective acreage percentages.

Two more computer land resources maps (one alphanumberic representation of 4 general classes and one graphic symbols representation of general classes) were made and 4 classes were projected for representation (Figures 30 and 31).

Class 1 represents urban areas. Class 2 (all lands covered by vegetation were merged together and made into one class) represents vegetation. Class 3 (bare land, marshy land and char were merged together and made into one class) represents bare land and Class 4 (turbid water and clear water merged together and made into one class) represents water. Table 8 shows the four general classes with their respective areas percentages. Finally the author classified the soils, of the study area into four different spectral classes, based on the physiographic position and relief characteristics, soil texture, different level of moisture content, physical and chemical properties. These four classes were:

1) Khilgaon - Tejgaon - Gerua complex (30)
2) Sonatala - Dhamrai Complex (55)
3) Dhamrai - Sabhar Bazar Association (56)
4) Kajla - Pagla Association (62)

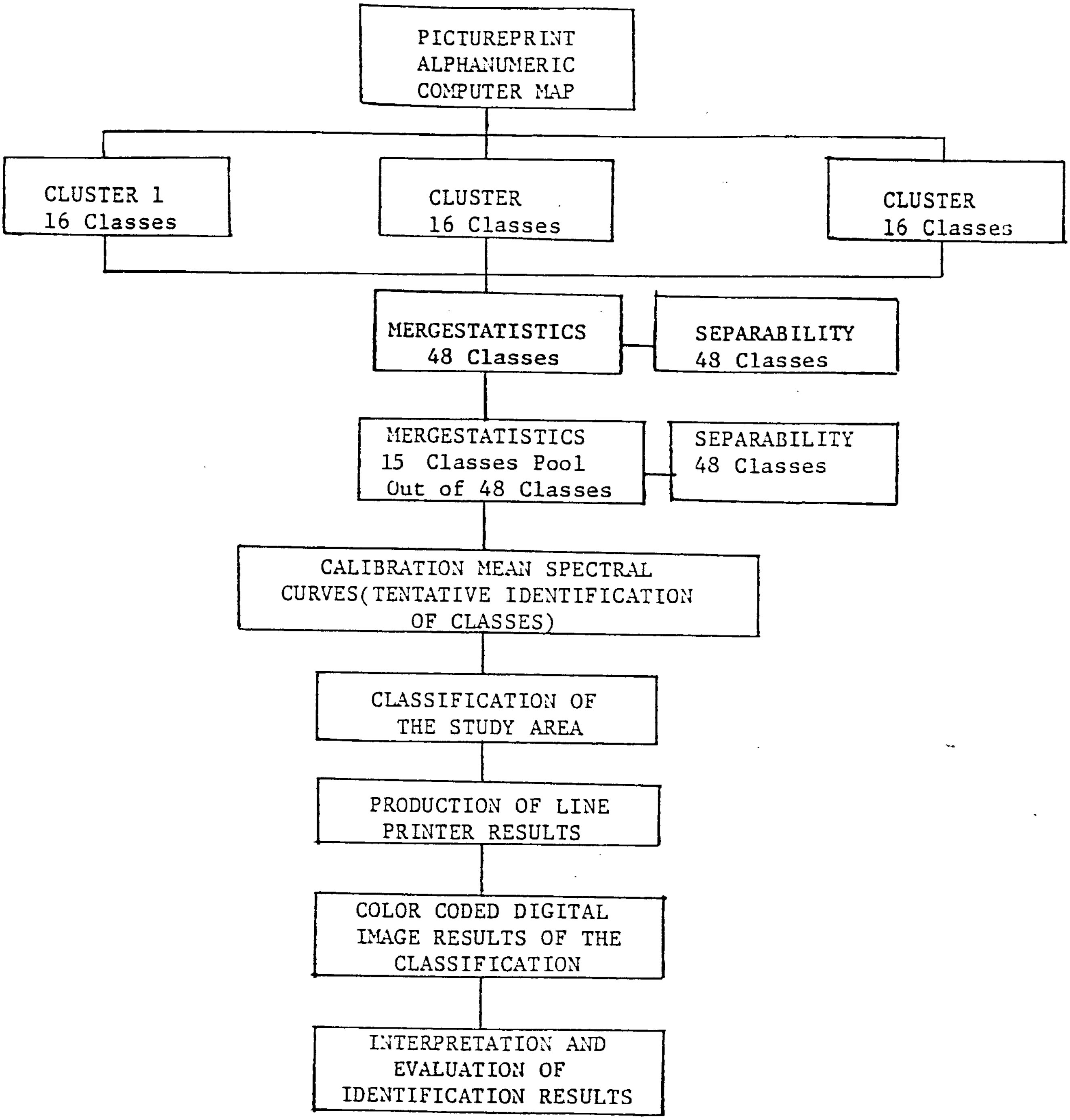
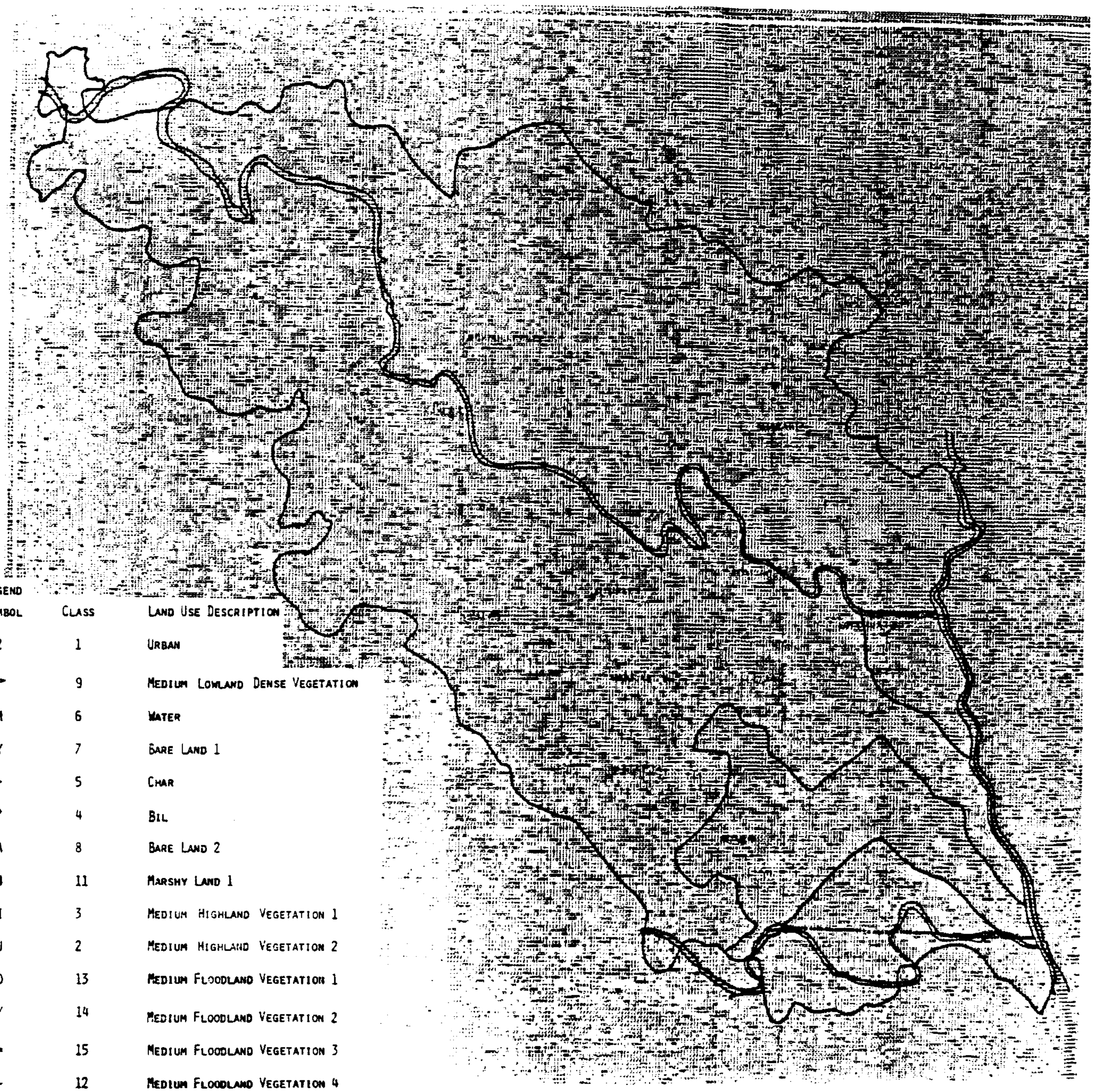


FIGURE 19: Showing Numerical Analysis Procedure of LANDSAT MSS Data Of Rupganj Thana, Dhaka, Bangladesh, 3 January 1977.



Legend Symbol	Class	Land Use Description
2	1	Urban
>	9	Medium Lowland Dense Vegetation
M	6	Water
Y	7	Bare Land 1
+	5	Char
•	4	Bil
A	8	Bare Land 2
8	11	Marshy Land 1
I	3	Medium Highland Vegetation 1
J	2	Medium Highland Vegetation 2
0	13	Medium Floodland Vegetation 1
/	14	Medium Floodland Vegetation 2
=	15	Medium Floodland Vegetation 3
-	12	Medium Floodland Vegetation 4
Z	10	Marshy Land 2

FIGURE 20: COMPUTER LAND RESOURCES MAP OF DHAMRAI UPAZILA, BANGLADESH.
MSS DATA COLLECTED ON JANUARY 3, 1977.

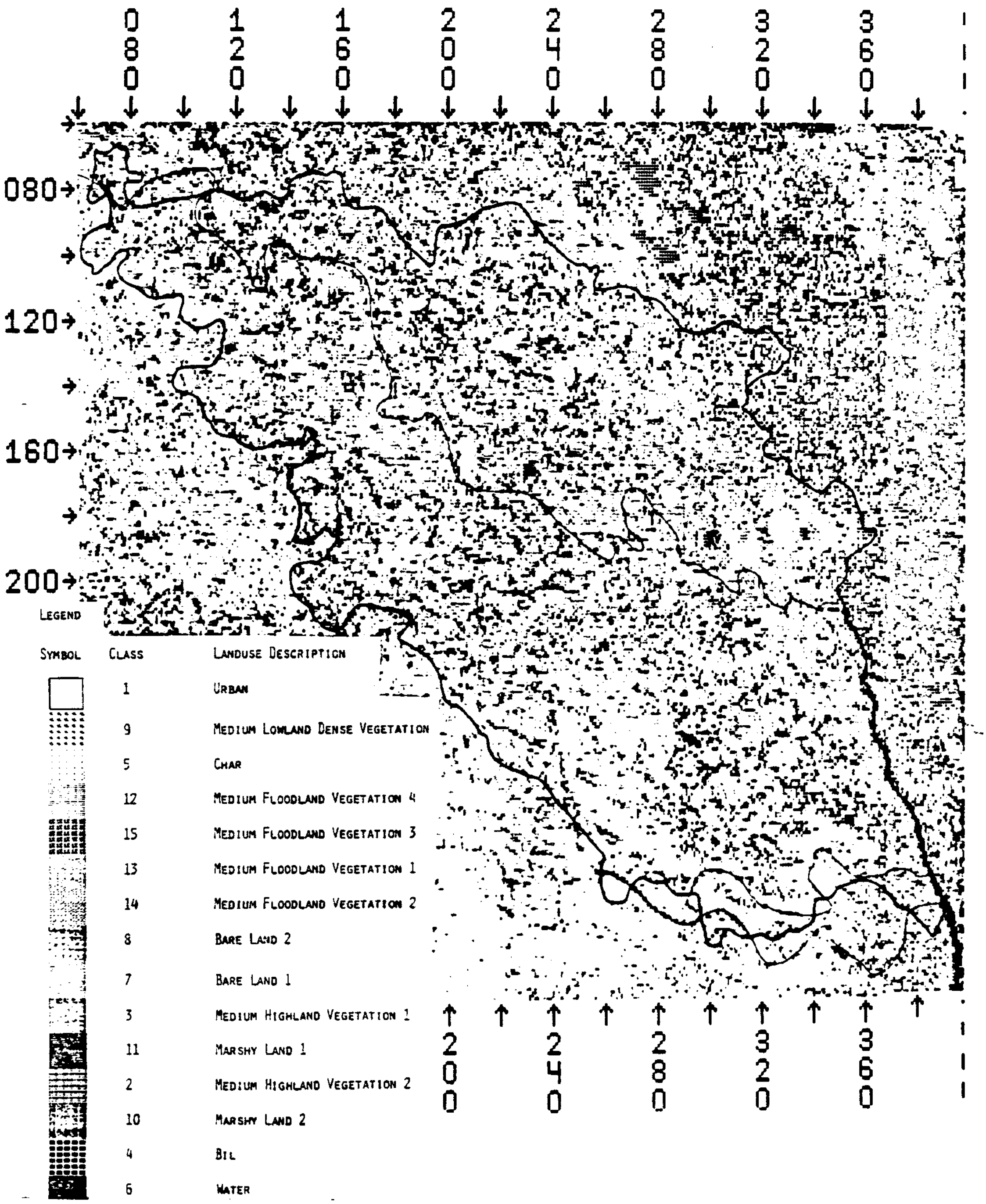


FIGURE 21: COMPUTER LAND RESOURCES MAP OF DHAMRAI UPAZILA AREA.
PRODUCED ON ELECTRONIC PRINTER/PLOTTER FROM
LANDSAT MSS BANDS 0·5 - 1·1 μM
DATA COLLECTED ON JANUARY 3, 1977

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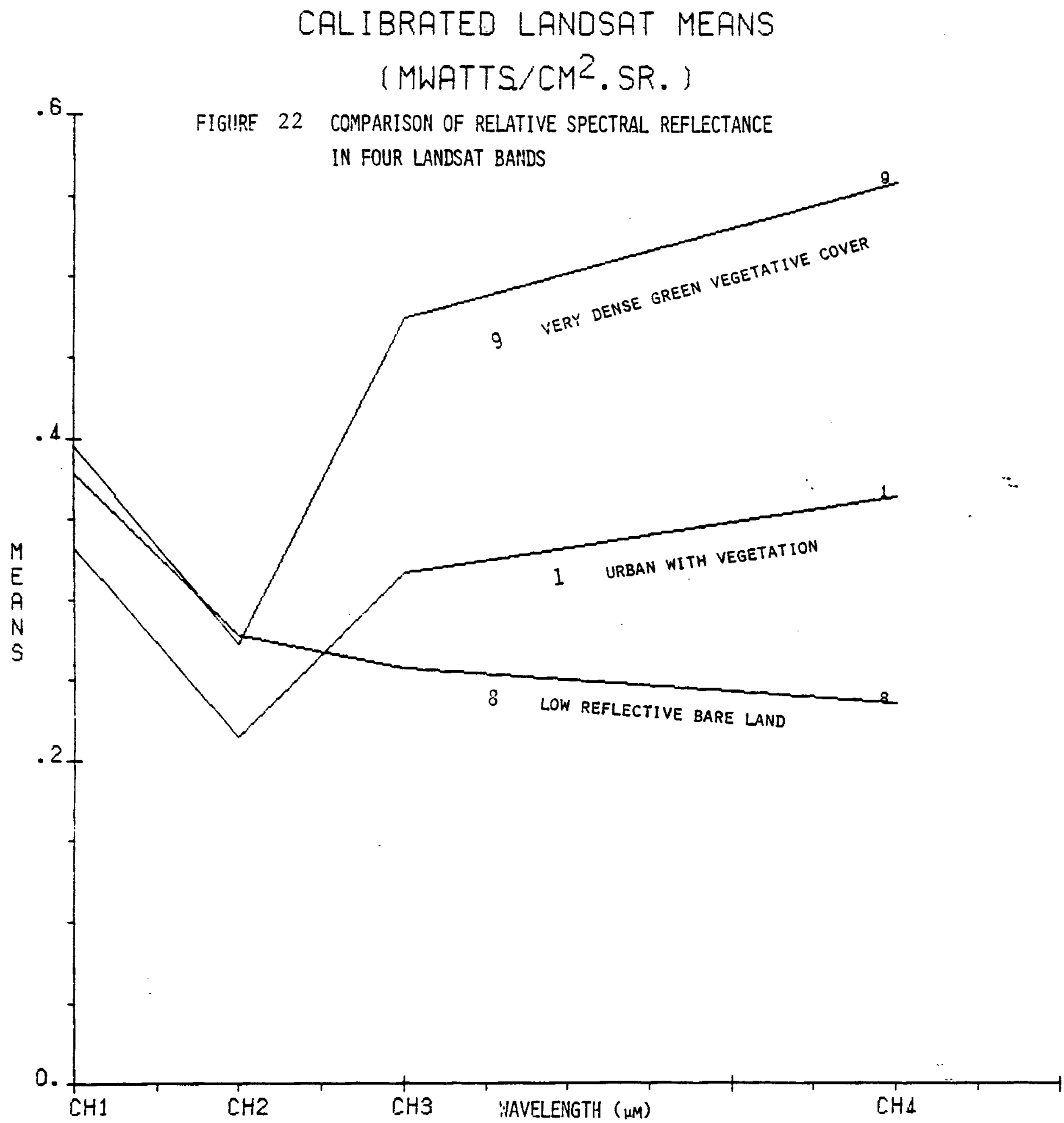

FIGURE 22 COMPARISON OF RELATIVE SPECTRAL REFLECTANCE IN FOUR LANDSAT BANDS

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CALIBRATED LANDSAT MEANS
(MWATTS/CM^2.SR.)

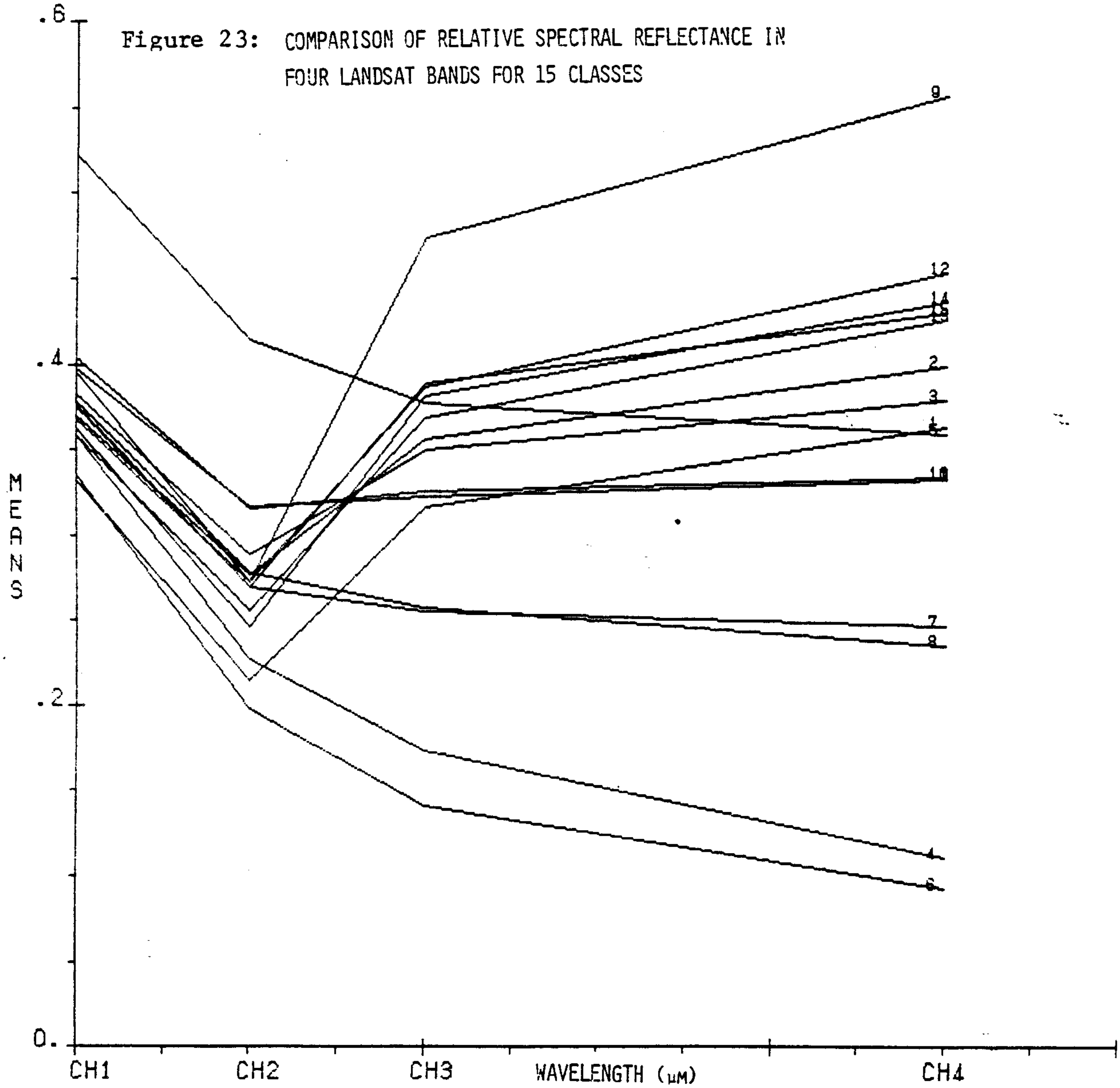

Figure 23: COMPARISON OF RELATIVE SPECTRAL REFLECTANCE IN FOUR LANDSAT BANDS FOR 15 CLASSES

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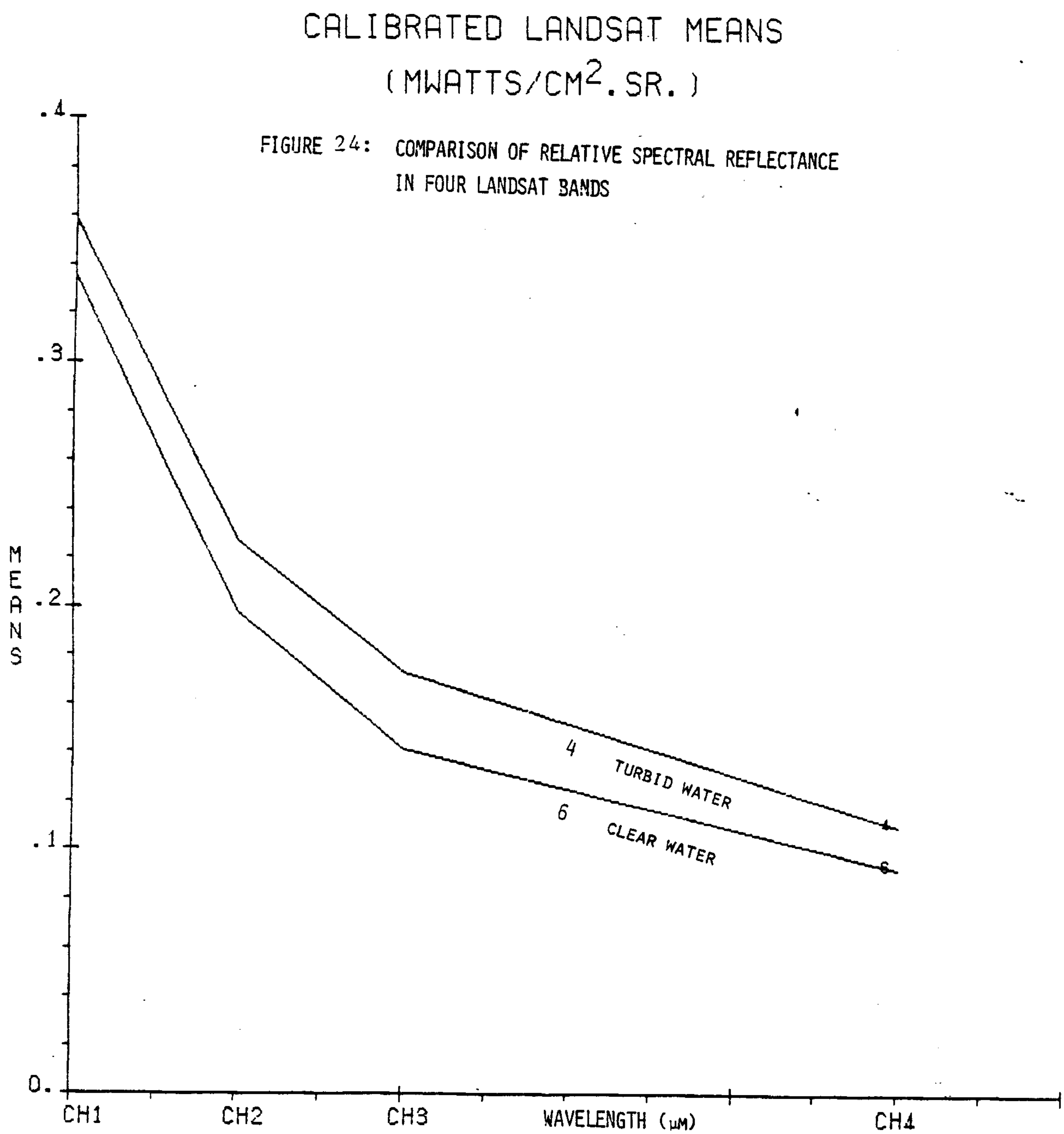

FIGURE 24: COMPARISON OF RELATIVE SPECTRAL REFLECTANCE IN FOUR LANDSAT BANDS

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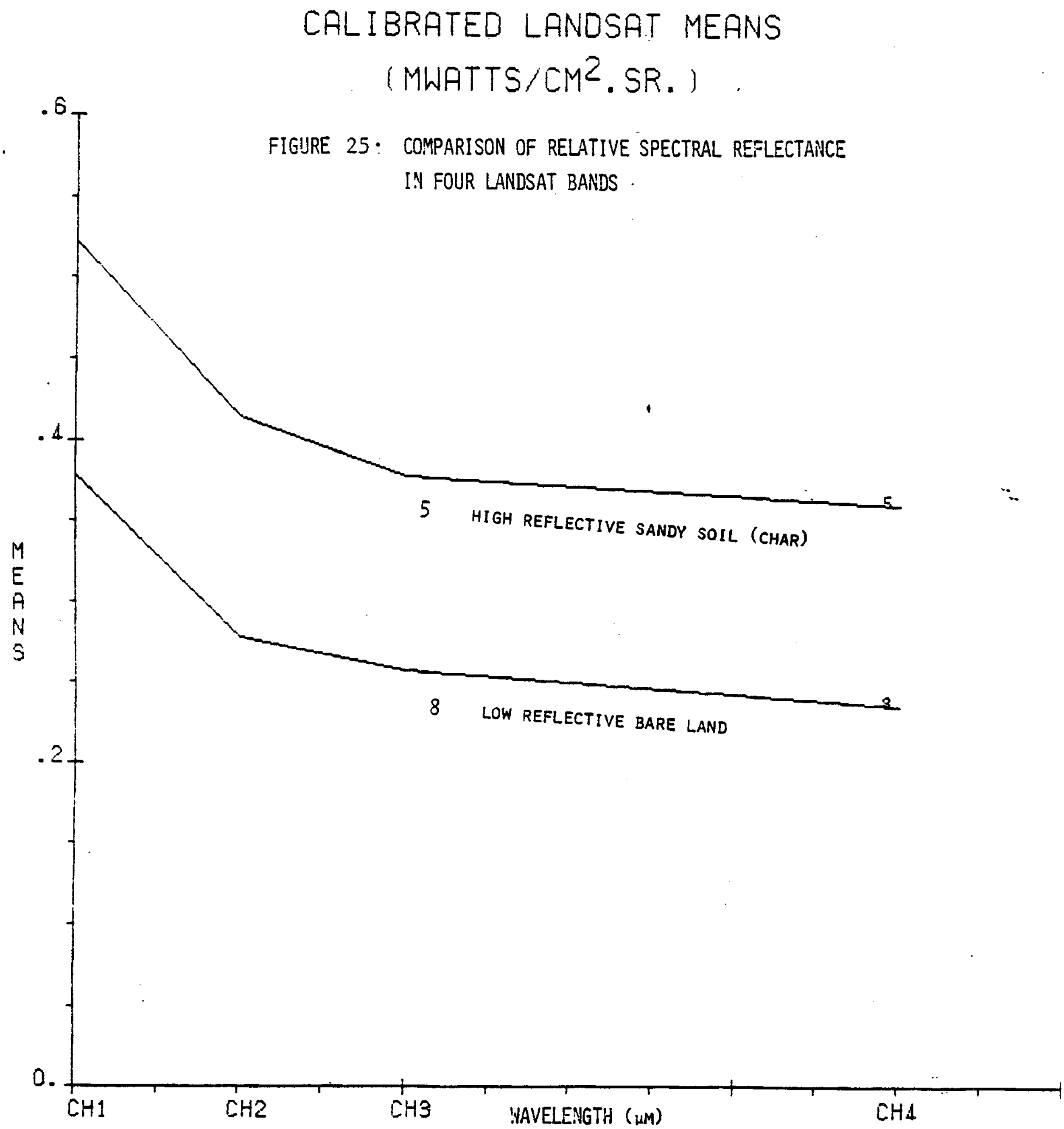

FIGURE 25: COMPARISON OF RELATIVE SPECTRAL REFLECTANCE IN FOUR LANDSAT BANDS

77006902

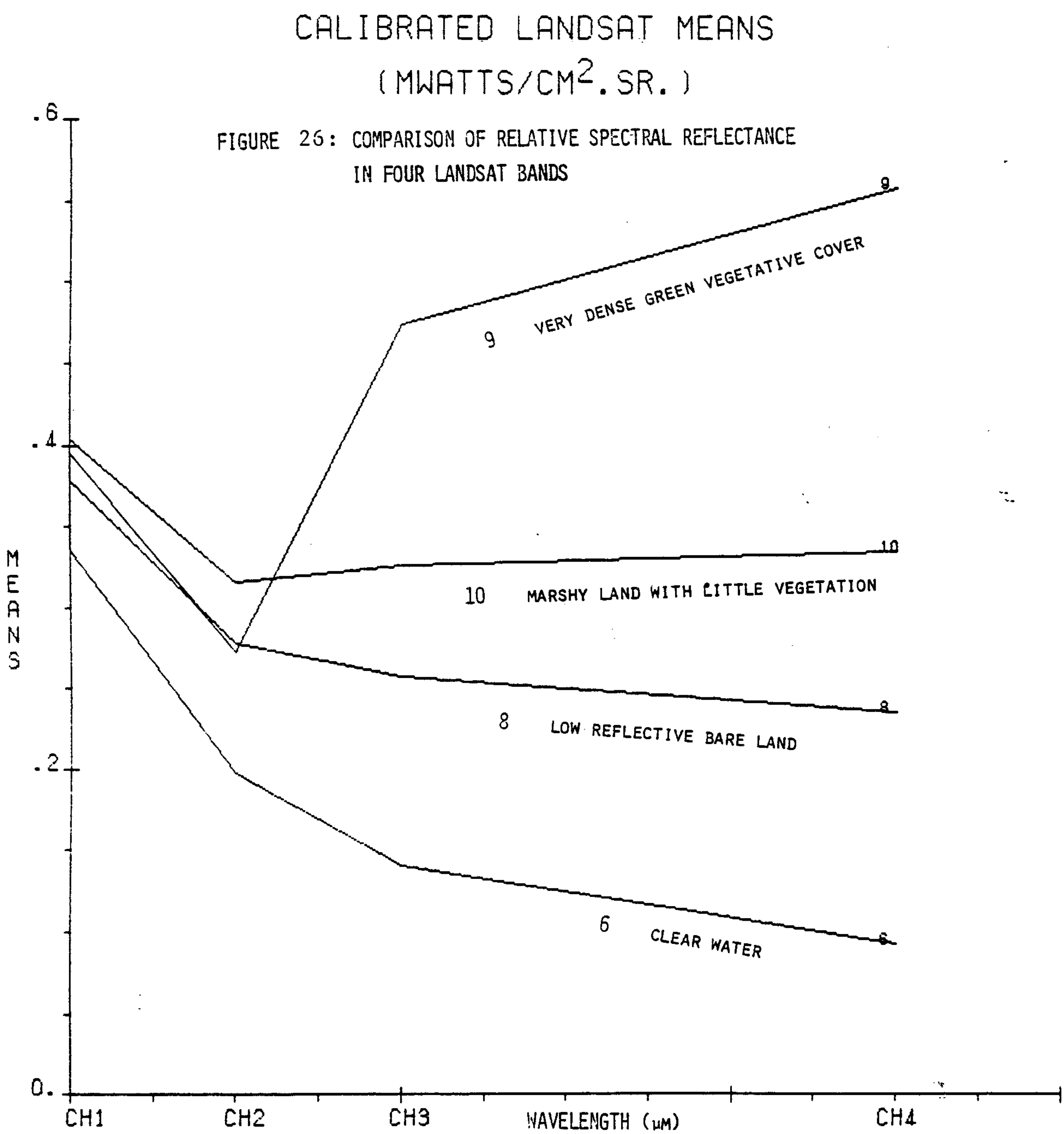

FIGURE 26: COMPARISON OF RELATIVE SPECTRAL REFLECTANCE IN FOUR LANDSAT BANDS

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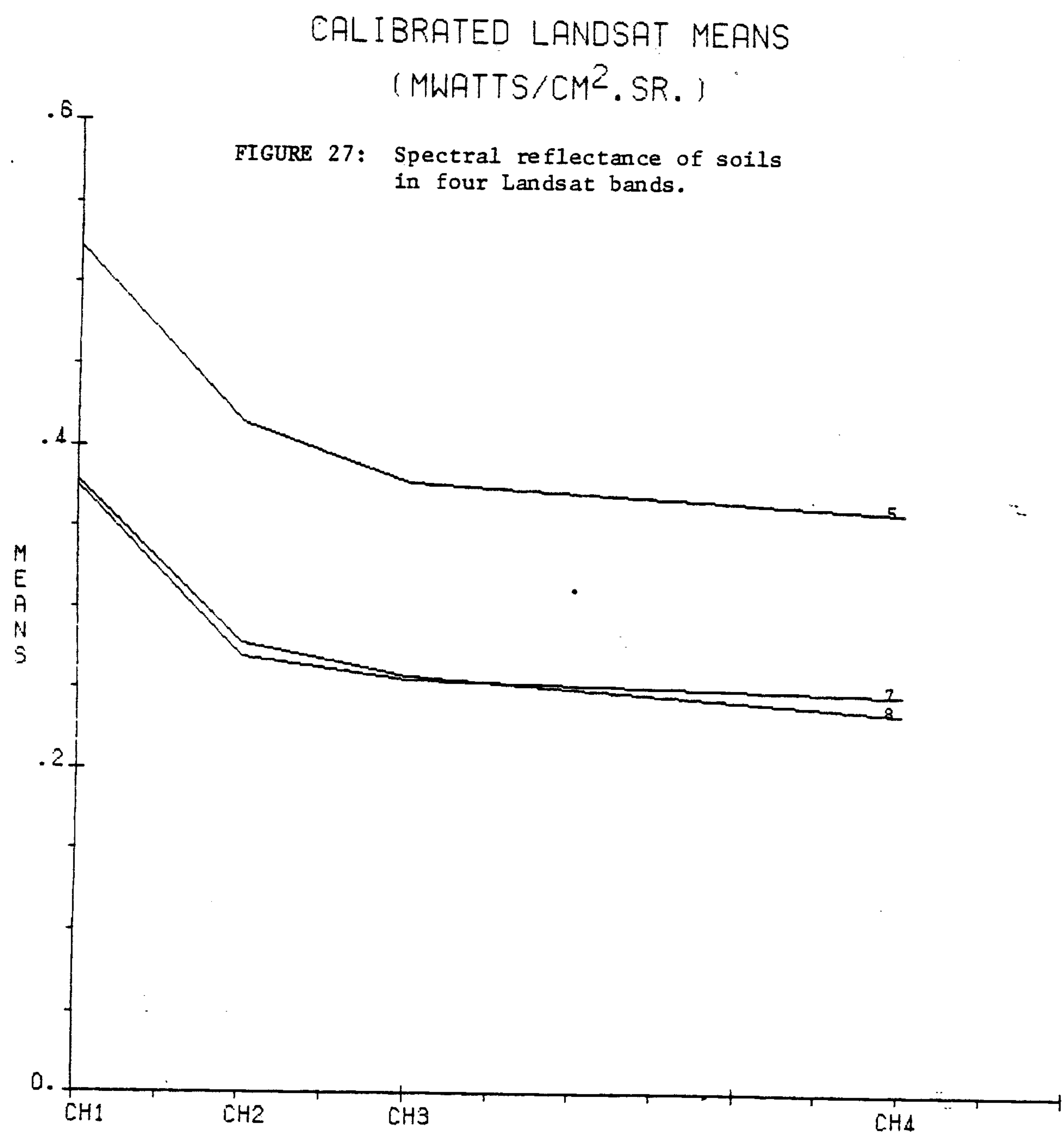

FIGURE 27: Spectral reflectance of soils in four Landsat bands.

77006902

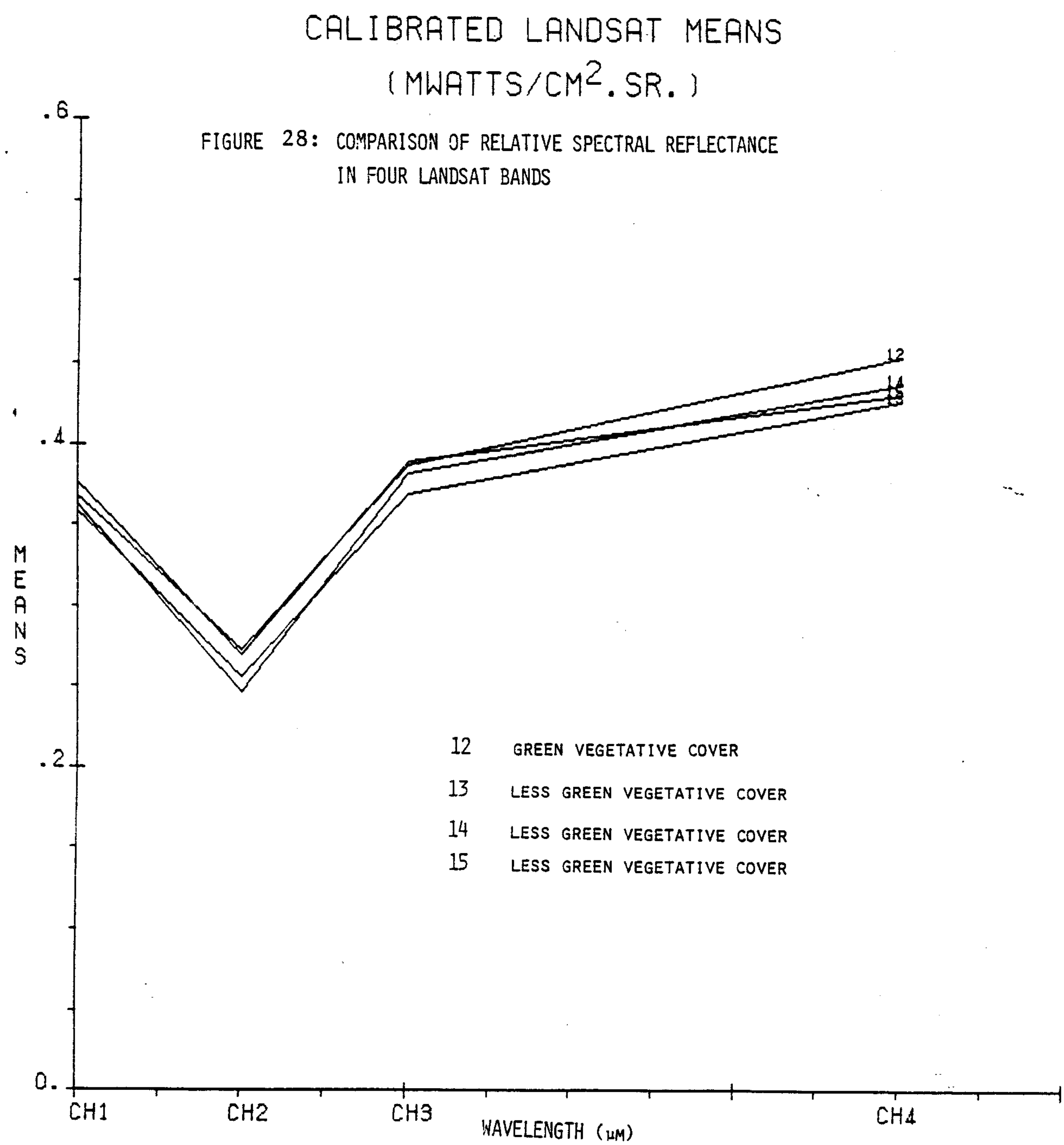

FIGURE 28: COMPARISON OF RELATIVE SPECTRAL REFLECTANCE IN FOUR LANDSAT BANDS

77006902

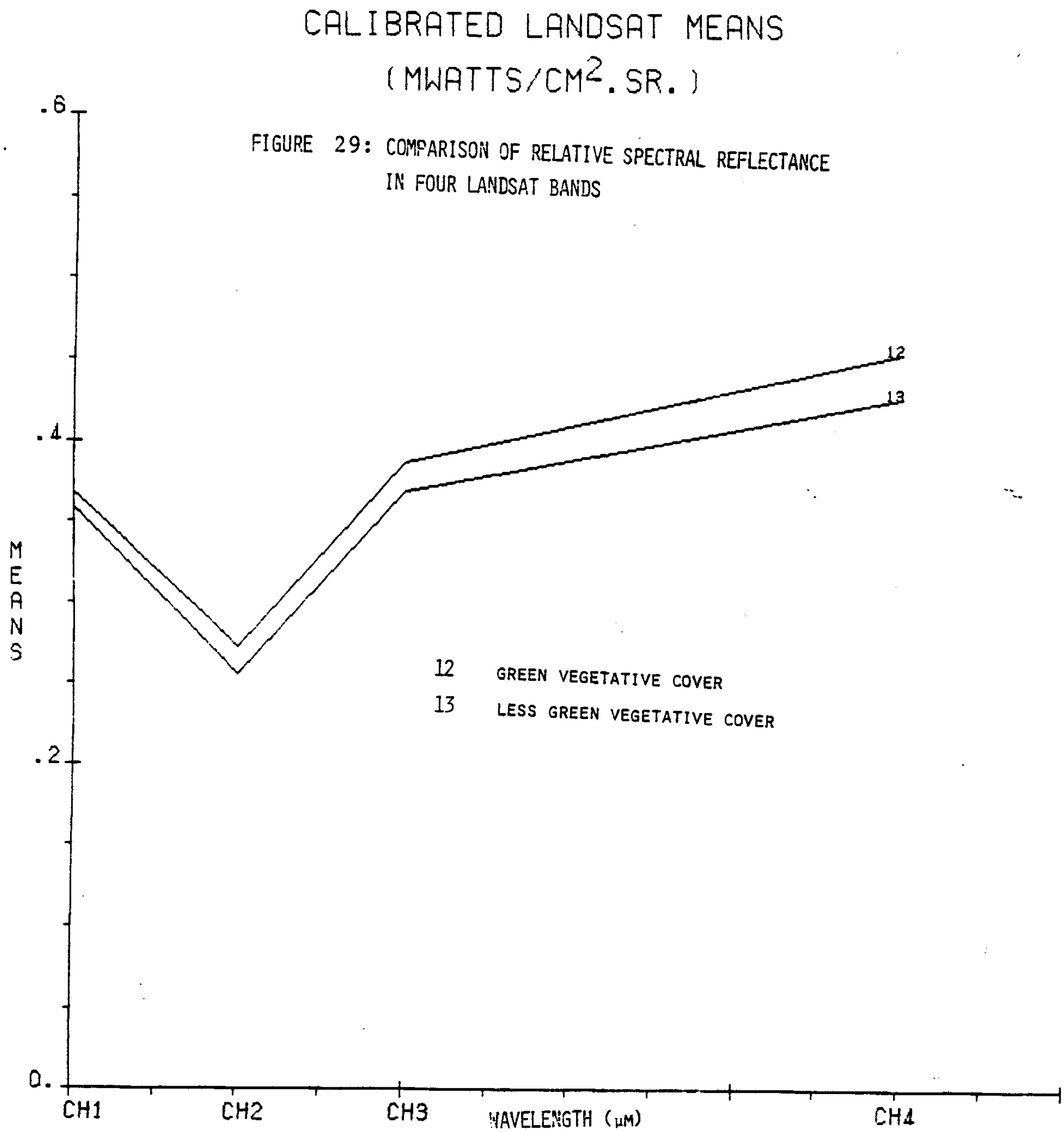

FIGURE 29: COMPARISON OF RELATIVE SPECTRAL REFLECTANCE IN FOUR LANDSAT BANDS

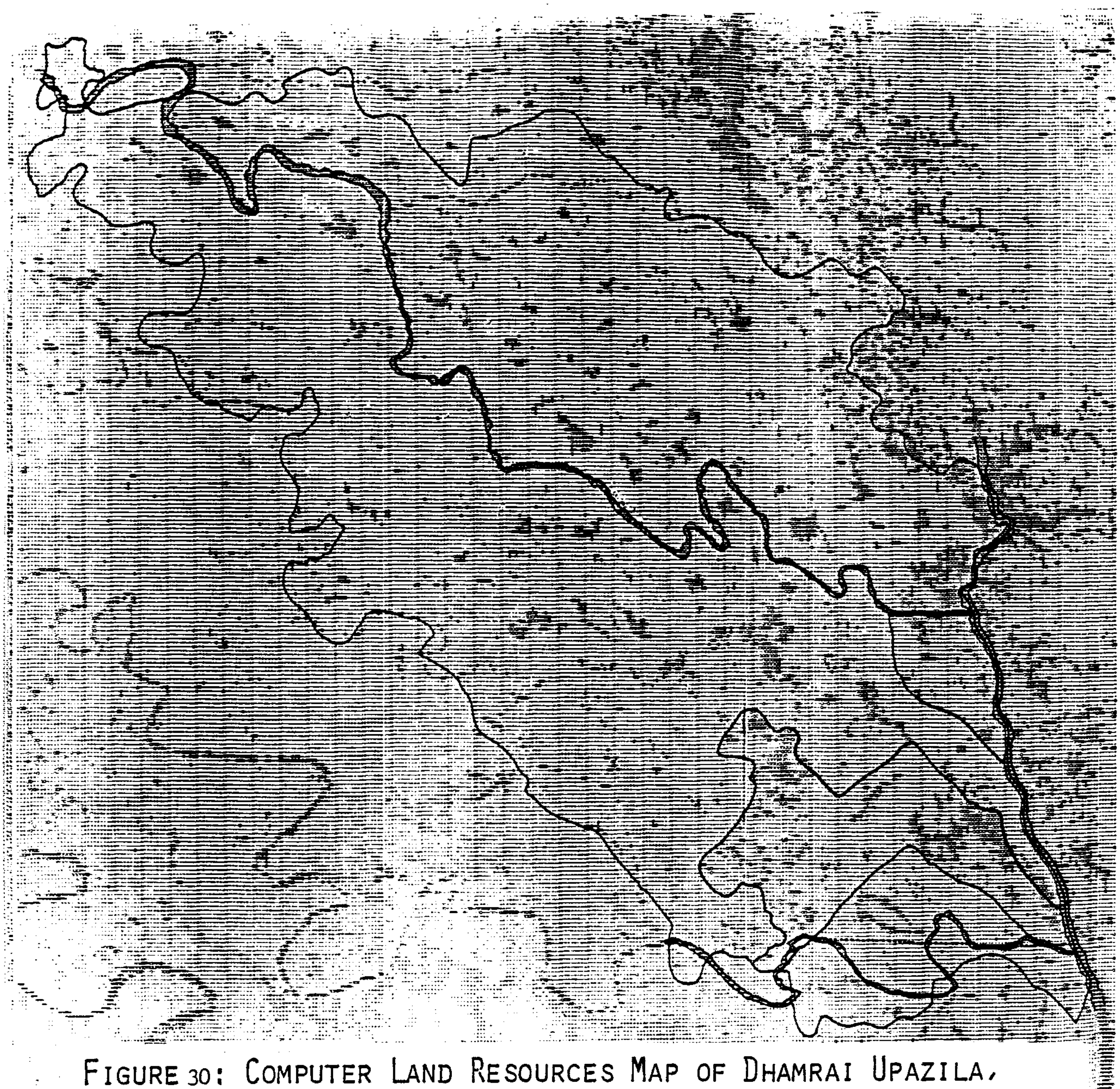

FIGURE 30: COMPUTER LAND RESOURCES MAP OF DHAMRAI UPAZILA, BANGLADESH.
MSS DATA COLLECTED ON JANUARY 3, 1977.

LEGEND

SYMBOL	CLASS	DESCRIPTION
====	1	76·5% OF LAND COVERED BY VEGETATION
+ + +	2	12·0% OF LAND USE BY URBAN
0000	3	9·1% OF BARE LAND
MMM	4	2·4% WATER AREA

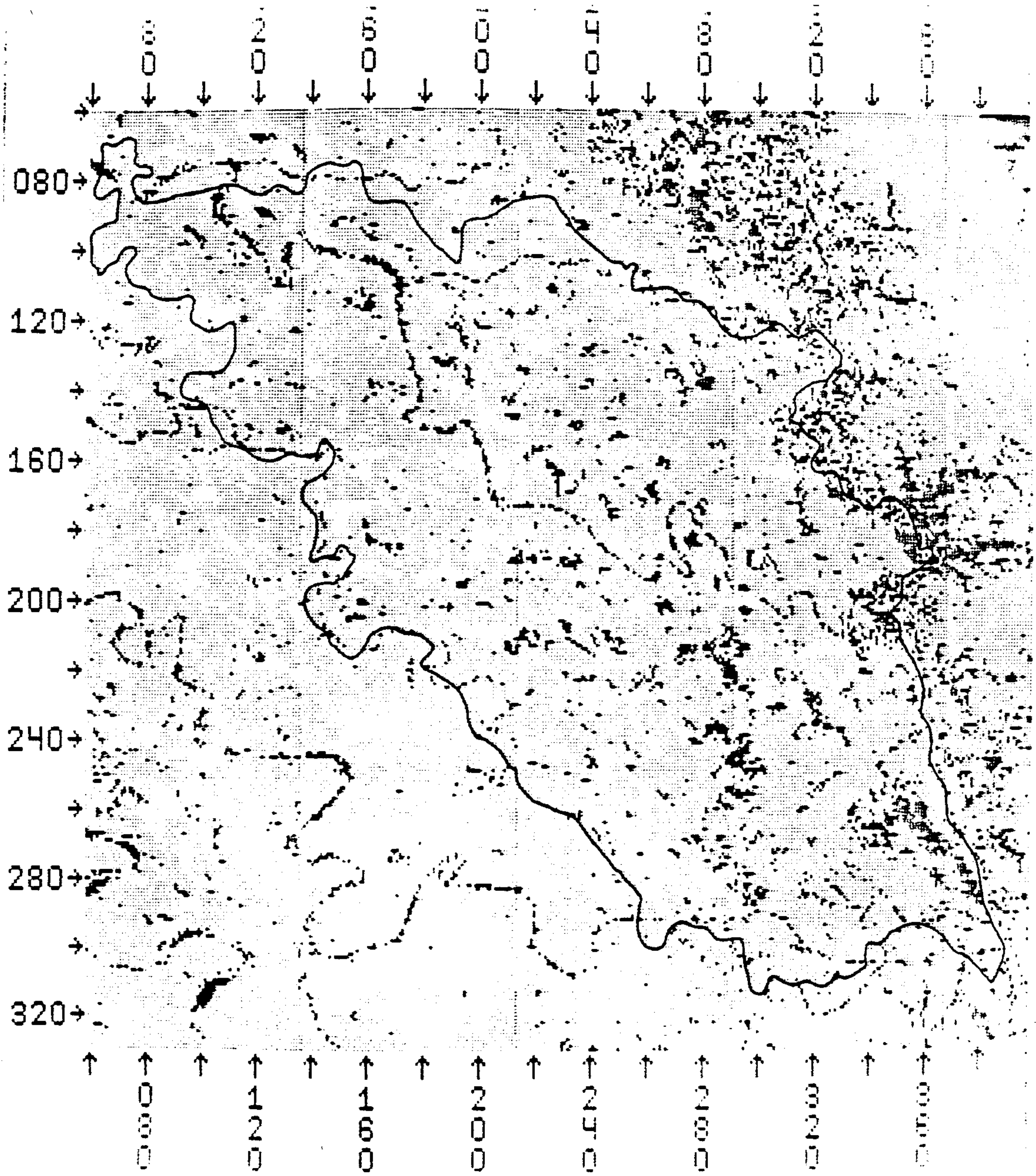

FIGURE 31: COMPUTER LAND RESOURCES MAP OF DAHMRAI UPAZILA AREA.
PRODUCED ON ELECTRONIC PRINTER/PLOTTER FROM THE
LANDSAT MSS BANDS 0·5 - 1·1 μM
DATA COLLECTED ON JANUARY 3, 1977.

LEGEND

SYMBOL	CLASS	DESCRIPTION
	1	76·5% OF LAND COVERED BY VEGETATION.
	2	12·0% OF LANDUSE BY URBAN
	3	9·1% OF BARE LAND
	4	2·4% WATER AREA

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LABORATORY FOR APPLICATIONS OF REMOTE SENSING
PURDUE UNIVERSITY

JAN 18, 1985
04 10 40 PM
LARSYS VERSION 3

GROUP CLASSIFICATION OF DHAMRAI AREA JAN 3 1977

CLASSIFICATION STUDY 501442114
RUN NUMBER............ 77006902
FLIGHT LINE... 2712033100BNGLDSH
DATA TAPE/FILE NUMBER.. 121/ 4
REFORMATTING DATE. DEC 3, 1984

CLASSIFIED JAN 14, 1985
DATE DATA TAKEN... JAN 3, 1977
TIME DATA TAKEN..... 1031 HOURS
PLATFORM ALTITUDE..3062000 FEET
GROUND HEADING..... 180 DEGREES

CLASSIFICATION TAPE/FILE NUMBER ... 247/ 20

TEST FIELD ACREAGE TABLE FOR GROUP URBAN

GROUP	POINTS	ACRES	HECTARES	PERCENT
URBAN	11027	12681.0	5134.0	12.0
MLVEGL	5440	6256.0	2532.8	5.9
MHLVEGL	17184	19761.6	8000.6	18.7
BIL	1480	1702.0	689.1	1.6
CHAR	1702	1957.3	792.4	1.9
WATER	727	836.0	338.5	0.8
BAREL1	3167	3642.0	1474.5	3.4
BAREL2	3527	4056.0	1642.1	3.8
MLDVEG	4184	4811.6	1948.0	4.6
MARSHYL1	7226	8309.9	3364.3	7.9
MARSHYL2	7169	8244.3	3337.8	7.8
MFLVEG1	4451	5118.6	2072.3	4.8
MFLVEG2	10706	12311.9	4984.6	11.7
MFLVEG3	9738	11198.7	4533.9	10.6
MFLVEG4	4141	4762.1	1928.0	4.5
TOTAL	91869	105649.2	42773.0	100.0

EACH DATA POINT REPRESENTS 1.15 ACRES
0.47 HECTARES

TOTAL POINTS IN CLASSIFICATION = 91869

Table 7. Acreage percentage of 15 classes of Dhamrai Upazila.

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DHAMRAI AREA JAN 3 1977

LABORATORY FOR APPLICATIONS OF REMOTE SENSING
PURDUE UNIVERSITY

JAN 18, 1985
03 43 14 PM
LARSYS VERSION 3

CLASSIFICATION STUDY 501442114	CLASSIFIED JAN 14, 1985
RUN NUMBER............ 77006902	DATE DATA TAKEN... JAN 3, 1977
FLIGHT LINE... 2712033108NGLDSH	TIME DATA TAKEN..... 1031 HOURS
DATA TAPE/FILE NUMBER.. 121/ 4	PLATFORM ALTITUDE..3062000 FEET
REFORMATTING DATE. DEC 3, 1984	GROUND HEADING..... 180 DEGREES

CLASSIFICATION TAPE/FILE NUMBER ... 247/ 20

TEST FIELD ACREAGE TABLE FOR GROUP BARELAND

GROUP	POINTS	ACRES	HECTARES	PERCENT
BARELAND	8396	9655.4	3909.1	9.1
URBAN	11027	12681.0	5134.0	12.0
VEGET	70239	80774.8	32702.3	76.5
WATER	2207	2538.0	1027.6	2.4
TOTAL	91869	105649.2	42773.0	100.0

EACH DATA POINT REPRESENTS 1.15 ACRES
0.47 HECTARES

TOTAL POINTS IN CLASSIFICATION = 91869

Table 8. Acreage percentage of 4 broad classes of Dhamrai Upazila.

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LABORATORY FOR APPLICATIONS OF REMOTE SENSING
PURDUE UNIVERSITY

JAN 23, 1985
03 48 37 PM
LARSYS VERSION 3

STATS OF FIFTEEN CLASSES OF DHAMRAI AREA

****************************** ORDERED BY CLASS ******************************

NO.	SYMBOLS	CLASS	CHAN 1	CHAN 2	CHAN 3	CHAN 4	MAGNITUDE	VIS/IR	PCT. VIS	PCT. IR
1	2	(/)	16.00	15.45	26.40	11.80	69.65	0.8232	45.15	54.85
2	J	(+)	17.84	19.89	29.71	12.95	80.39	0.8845	46.94	53.06
3	I	(-)	18.45	20.77	29.23	12.30	80.75	0.9443	48.57	51.43
4	*	(MM)	17.29	16.35	14.45	3.55	51.64	1.8689	65.14	34.86
5	+	(4)	25.22	29.86	31.52	11.65	98.24	1.2757	56.06	43.94
6	M	(M)	16.17	14.22	11.79	2.98	45.15	2.0577	67.30	32.70
7	Y	(Y)	18.08	19.39	21.29	7.99	66.75	1.2793	56.13	43.87
8	A	(YY)	18.27	20.00	21.50	7.62	67.38	1.3140	56.79	43.21
9	>	(I)	19.04	19.66	39.62	18.09	96.41	0.6706	40.14	59.86
10	Z	(FF)	19.46	22.71	27.24	10.85	80.25	1.1073	52.55	47.45
11	8	(F)	19.16	22.82	26.90	10.80	79.68	1.1134	52.68	47.32
12	-	62(O)	17.75	19.65	32.30	14.71	84.40	0.7954	44.30	55.70
13	O	30(O)	17.31	18.41	30.81	13.84	80.37	0.8001	44.45	55.55
14	/	55(O)	17.49	17.72	31.82	14.19	81.21	0.7652	43.35	56.65
15	=	56(O)	18.14	19.37	32.43	13.98	83.93	0.8082	44.70	55.30

****************************** ORDERED BY MAGNITUDE ******************************

NO.	SYMBOLS	CLASS	CHAN 1	CHAN 2	CHAN 3	CHAN 4	MAGNITUDE	VIS/IR	PCT. VIS	PCT. IR
6	M	(M)	16.17	14.22	11.79	2.98	45.15	2.0577	67.30	32.70
4	*	(MM)	17.29	16.35	14.45	3.55	51.64	1.8689	65.14	34.86
7	Y	(Y)	18.08	19.39	21.29	7.99	66.75	1.2793	56.13	43.87
8	A	(YY)	18.27	20.00	21.50	7.62	67.38	1.3140	56.79	43.21
1	2	(/)	16.00	15.45	26.40	11.80	69.65	0.8232	45.15	54.85
11	8	(F)	19.16	22.82	26.90	10.80	79.68	1.1134	52.68	47.32
10	Z	(FF)	19.46	22.71	27.24	10.85	80.25	1.1073	52.55	47.45
13	O	30(O)	17.31	18.41	30.81	13.84	80.37	0.8001	44.45	55.55
2	J	(+)	17.84	19.89	29.71	12.95	80.39	0.8845	46.94	53.06
3	I	(-)	18.45	20.77	29.23	12.30	80.75	0.9443	48.57	51.43
14	/	55(O)	17.49	17.72	31.82	14.19	81.21	0.7652	43.35	56.65
15	=	56(O)	18.14	19.37	32.43	13.98	83.93	0.8082	44.70	55.30
12	-	62(O)	17.75	19.65	32.30	14.71	84.40	0.7954	44.30	55.70
9	>	(I)	19.04	19.66	39.62	18.09	96.41	0.6706	40.14	59.86
5	+	(4)	25.22	29.86	31.52	11.65	98.24	1.2757	56.06	43.94

****************************** ORDERED BY RATIO ******************************

NO.	SYMBOLS	CLASS	CHAN 1	CHAN 2	CHAN 3	CHAN 4	MAGNITUDE	VIS/IR	PCT. VIS	PCT. IR
9	>	(I)	19.04	19.66	39.62	18.09	96.41	0.6706	40.14	59.86
14	/	55(O)	17.49	17.72	31.82	14.19	81.21	0.7652	43.35	56.65
12	-	62(O)	17.75	19.65	32.30	14.71	84.40	0.7954	44.30	55.70
13	O	30(O)	17.31	18.41	30.81	13.84	80.37	0.8001	44.45	55.55
15	=	56(O)	18.14	19.37	32.43	13.98	83.93	0.8082	44.70	55.30
1	2	(/)	16.00	15.45	26.40	11.80	69.65	0.8232	45.15	54.85
2	J	(+)	17.84	19.89	29.71	12.95	80.39	0.8845	46.94	53.06
3	I	(-)	18.45	20.77	29.23	12.30	80.75	0.9443	48.57	51.43
10	Z	(FF)	19.46	22.71	27.24	10.85	80.25	1.1073	52.55	47.45
11	8	(F)	19.16	22.82	26.90	10.80	79.68	1.1134	52.68	47.32
5	+	(4)	25.22	29.86	31.52	11.65	98.24	1.2757	56.06	43.94
7	Y	(Y)	18.08	19.39	21.29	7.99	66.75	1.2793	56.13	43.87
8	A	(YY)	18.27	20.00	21.50	7.62	67.38	1.3140	56.79	43.21
4	*	(MM)	17.29	16.35	14.45	3.55	51.64	1.8689	65.14	34.86
6	M	(M)	16.17	14.22	11.79	2.98	45.15	2.0577	67.30	32.70

******************** VARIANCES ********************

NO.	SYMBOLS	CLASS	CHAN 1	CHAN 2	CHAN 3	CHAN 4	NO. POINTS
1	2	(/)	1.46	2.41	3.67	0.72	261
2	J	(+)	2.03	8.59	17.51	6.31	406
3	I	(-)	0.91	0.55	2.05	0.94	128
4	*	(MM)	3.72	5.66	6.79	2.39	100
5	+	(4)	7.82	14.68	13.18	2.01	74
6	M	(M)	1.43	2.84	11.07	2.96	77
7	Y	(Y)	1.71	5.65	3.90	1.25	43
8	A	(YY)	1.24	2.54	2.73	1.27	80
9	>	(I)	3.09	6.59	11.01	1.90	104
10	Z	(FF)	1.52	4.72	2.94	0.75	34
11	8	(F)	1.33	3.06	2.68	1.01	49
12	-	62(O)	0.85	2.43	3.40	1.43	75
13	O	30(O)	0.35	1.38	7.72	1.05	48
14	/	55(O)	0.54	1.69	3.46	1.16	123
15	=	56(O)	0.97	2.38	3.84	0.87	86

I0103 CPU TIME USED WAS 5.433 SECONDS. (LARSMN)

TABLE 9: STATISTICS OBTAINED FROM CLUSTER SPECTRAL CLASSES USING FOUR WAVELENGTHS

The author then prepared a soil map of the 4 different soils of the study area by delineating the different soil boundary (Figure 12).

11. HACIENDA DISPLAY

Classification results of the study area in color coded digital format was displayed on the HACIENDA. Different colors were assigned to each class. A total of 15 classes from the data of January 3, 1977 were displayed. Grouping of the same type of classes was accomplished to avoid color discrimination difficulties (Figures 32 and 33).

CLASS NAME	COLOR
Urban Areas	White
Medium land with vegetation (MHLVEG1 and MHLVEG2)	Orange
Bil (lakes, ponds)	Dark Grey
Char (Sandy land)	Yellow
Clear water	Blue
Bare land (BAREL1 and BAREL2)	Brown
Medium high land dense Vegetation (MHLDEVG)	Red
Marshy Land (MARSHY1 and MARSHYL2)	Grey
Medium floodland vegetation (MFLVEG1, MFLVEG2, MFLVEG3, MFLVEG4)	Green

12. HACIENDA DISPLAY

Classification results of the study area in color coded digital format was displayed on the HACIENDA. Different colors were assigned to each class. A total of 4 classes from the data of January 3, 1977 were displayed. Grouping of the same type of classes was accomplished to avoid color discrimination difficulties (Figures 34 and 35).

Class Name	Color
Urban areas	Grey
Bare land 1 and 2 and Char	Yellow
All land covered with vegetation	Green
Turbid and clear water	White

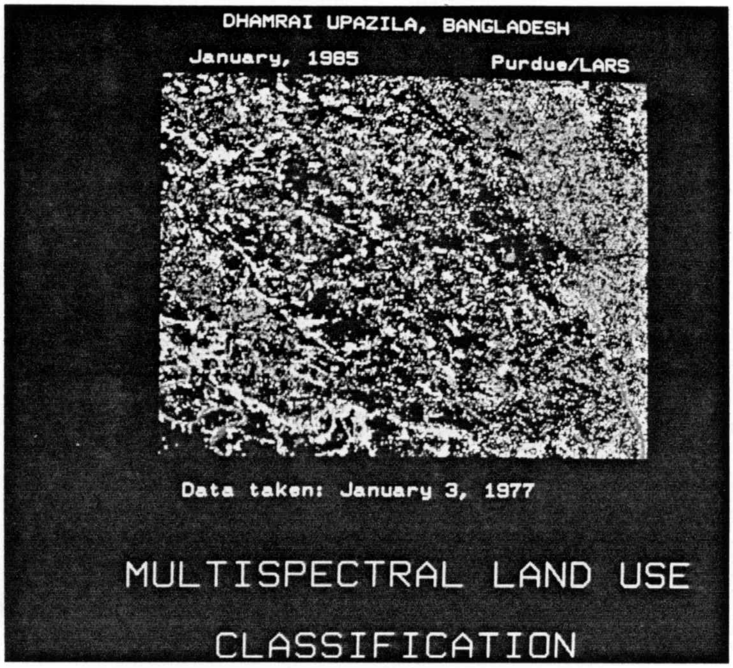

Figure 32: Classification results (15 classes) in color format of Dhamrai Upazila area.

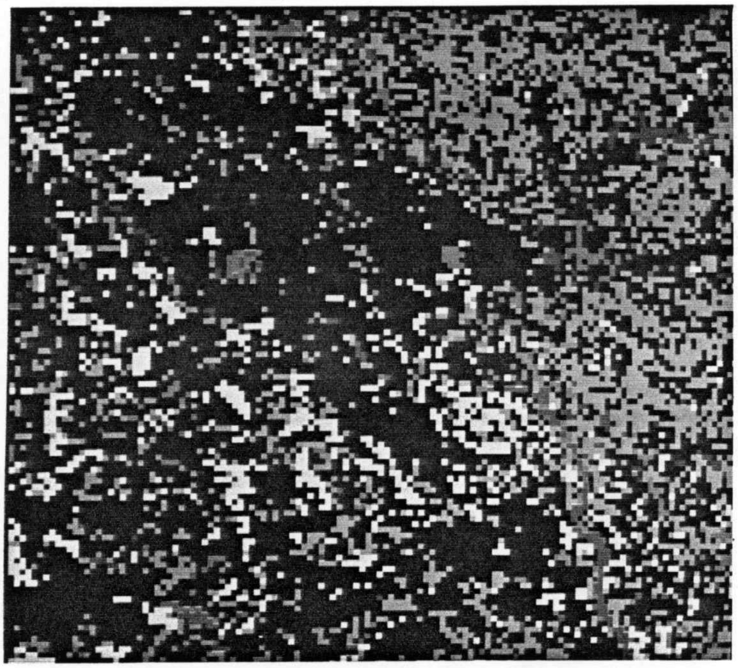

Figure 33: Classification results (15 classes) in color format of Dhamrai Upazila area (2 x enlarged).

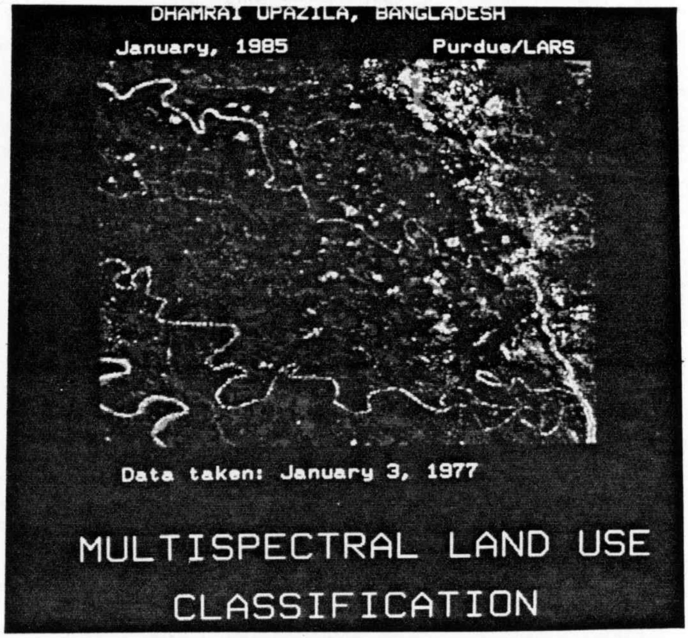

Figure 34: Classification results (4 classes) in color format of Dhamrai Upazila area.

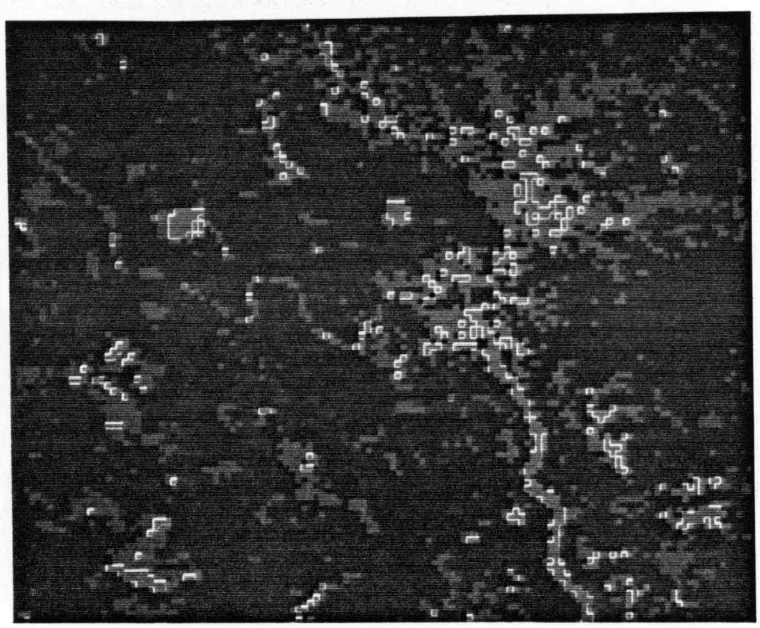

Figure 35: Classification results (4 classes) in color format of Dhamrai Upazila area (2 x enlarged)

13. CONCLUSIONS

Computer-aided LARSYS analysis techniques using Landsat MSS data showed the potential for obtaining more accurate and timely information about ground cover types. In my six months project training at LARS, at first I classified the whole land cover of the study area by using this technique especially based on different spectral values. As the results of classification, five vegetation, one dense vegetation, one urban, one bil (pond, lake), one char (bare sandy soils), two marshy land, two bare land and two types of water were identified successfully. Then I also classified the area into four general land used percentage classifications. As a result, i) 76.5% land cover by vegetation; ii) 12.0% land used for urban; iii) 10.0% bare land and iv) 2.4% water were classified successfully. At last I also identified the four different soils of the study area from the picture prints based on magnitude and ratio of spectral values. The results of soils boundary delineation was very fruitful but more physical and chemical data are essential for accurate soils classification

However, the data that I used for this work were not timely data. For instance, the computer compatible tape (CCT) of this area was January 3, 1977, while the ground truth data based on aerial photography was 1984. There was no resemblance between the CCT and the ground truth data. However, if the MSS data and the ground truth data were of the same time, then the results of this project would be very accurate. Even though Bangladesh is a major agricultural country, its individual crop field size is generally less than one pixel (0.5 hect) of MSS data. In spite of that even if it is not possible for the measurement of individual crop, it is possible for the measurement of crops. And so it is feasible for different soil association delineation. If it is possible for the timely availability of MSS data and ground truth data, individual winter crops measurements will be attainable. Because in Bangladesh the size of individual crop field is smaller than one pixel, the accuracy of individual crop measurement will not be that fruitful, however, the higher resolution data from the new TM system will allow a higher classification accuracy to be achieved.

Landsat 5 was successfully launched on March 1984 carrying the Thematic Mapper scanner with improved image resolution (30 meters) on the ground. France will launch the SPOT satellite which is designed to give 20 meters resolution in three spectral channels and 10 meters in a single wide band channel. These data will be available in Computer Compatible Tape (CCT) format.

SPARRSO has a computer facility and also has a Ground Receiving Station by which SPOT and Landsat MSS data very soon will begin receiving and hence we will be able to get timely high resolution data. Besides this, SPARRSO has already installed 11 DCP (Data Collecting Platform) throughout the country. From these DCPs hydrological and meteorological data will be available. When these high resolution data will be available, then individual crops classifications will be facilitated. Then this study for computer-aided land cover classification together with ground observation data can be extremely useful not only for inventories and environmental monitoring, but also individual crops measurements and estimates of crop production will be possible. These data will be very essential for all those research organizations which are working for the upliftment of agriculture. Also these data will be extremely useful not only for National Agricultural Developmental Planning, but also for countrywide Agricultural Census. Even though in 1980, in consultation with the United States Agency for International Development (USAID) and the World Bank, the Government of Bangladesh Organized the Food Planning and Monitoring Unit (FPMU) under the Economic Division of the Planning Commission. Its purpose was to develop an Early Warning System for providing the Bangladesh Government with an early and accurate estimate of food grains production. For the full development of this project, these data based on latest modern technology, for example Remote Sensing and computer-aided landuse data, will be extremely productive and beneficial.

Moreover, the use of these sorts of satellite data will greatly reduce the cost and time in comparison to any conventional survey method. Therefore, this six months training course at LARS, Purdue University has been very valuable and instructive. The overall experience that I gathered from this training program has undoubtedly added a value of a greater personal proficiency for me. And this will enable me to work more efficiently in the field of remote sensing data processing analysis and interpretation techniques. Both from a theoretical and practical perspective the ultimate benefit of this training can be hardly over exaggerated.

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