LAND USE MAPPING USING LANDSAT TM DATA: A CASE STUDY IN SENTOSA ISLAND

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ABSTRACT

The project is essentially using microBRIAN Version 2.3 to process and analyse images taken of Sentosa Island by remote sensing satellites, in this case the Landsat Thematic Mapper, to build a database and subsequently to analyse the natural resources of Sentosa Island. The software proved to be a useful tool for this project. The database was also found to be quite accurate after ground truthing was done on the island.

INTRODUCTION

Our senses, generally thought to be five in number, are the basic tools by which we discover our world. Two out of five of our senses require physical contact with the subject in order to receive a stimulus. The other three,namely seeing, hearing and smelling, can sense from a distance, i.e without physical contact with the subject. This is the underlying concept of remote sensing, which is sensing from a distance.

Remote sensing has been used by geologists to study soil erosion, the existence of coral reefs and the mapping of valuable natural resources only at recent times.

Remote sensing generally relies on the ability to measure spectral, spatial and temporal variations in field strength. These variations include variations in: (1)Electromagnetic fields (2)Force fields (3)Acoustic wave fields

Remotely sensed photographic data are produced by directly recording the radiation from an object from a distancein space. The range of wavelengths which may be detected is limited by the sensitivities of the film and filter(s) being used in the camera. The spectral sensitivity of photographic film can range from ultraviolet to near infrared wavelengths.

MATERIALS AND METHOD

The Landsat Thematic Mapper or Landsat TM records its data on seven channels, each receiving data on different wavelengths. The raw image of Sentosa Island that was acquired had its data recorded in the first, second, third and fifth channels of the Landsat TM. Their respective wavelengths were 450-520 nm, 520-600 nm, 630-690 nm and 1.55-1.75 μm.The first three channels are channels for receiving data on the wavelengths of visible light while the last channel receives data on the infra-red wavelength. The image was recorded on the 24th of May 1989.

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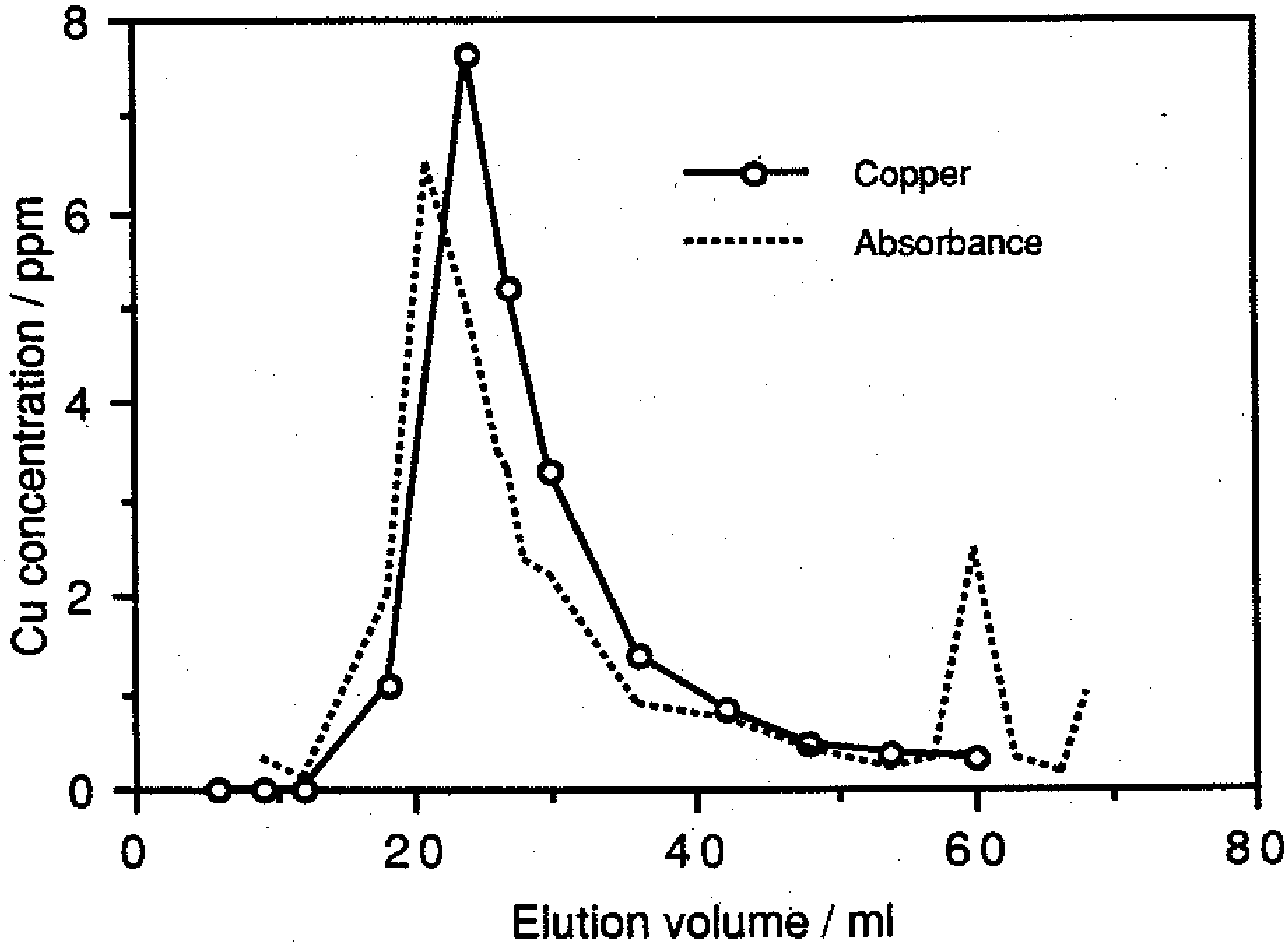

Figure 2

2. Ion exchange chromatography

Peaks I and II were subjected to ion exchange chromatography for further purification of the proteins. Fig.2 shows a typical ion exchange elution profile from DEAE-Sephacel.

CONCLUSION

In this project , the two metallothioneins MT-1 and MT-2 have been successfully isolated, though not purified by further resolution, using a combination of chromatographic techniques. The results are affirmative because metal analysis shows the presence of metal at predicted positions in the elution profiles, and established results verify this.

Ultimately, it is hoped that sufficient quantities of purified sample are collected to enable an in-depth study of the structure of the metallothioneins.

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REFERENCES

[1] Low Chok Ping. 1991. Honours Research Project:"Isolation & Purification of Metallothionein Proteins". Department of Chemistry, NUS.

The methods involved in this project is summarised below:
Step 1: Separating land from water(spectral digitizing)
Step 2: Manual digitizing of inapplicable land parts
Step 3: Enhancement of image(linear stretching of image)
Step 4: Getting training areas/sets
Step 5: Classification of training sets
Step 6: Colouring of image
Step 7: Smoothening of image
Step 8: Ground truthing
Step 9: Pasting back the digitized image

The tool used for this project is the computer software microBRIAN Version 2.3. This software was devised in Australia for coral reef mapping. The "BRIAN" stands for Barrier Reef Image ANalysis.

The case study for this project is Sentosa Island, an island south of mainland Singapore. Sentosa Island is a popular tourist attraction in Singapore. This island was chosen mainly because Sentosa is undergoing rapid developments and a database of its landuse should be built for future references.

STEP 1

The sub-programme used in microBRIAN for spectral digitizing is mSPDIG. This programme was used to segment images using spectral themes.

The satellite photograph provided contained images of the southern tip of Singapore, Sentosa Island, Buran Darat and Pulau Brani. Using mSPDIG, the raw image of Sentosa Island was spectrally digitized from the other images. This raw image of Sentosa Island was the image that was worked with throughtout the project.

STEP 2

The raw image of Sentosa Island includes its land area and the surrounding waters. As only the land area had to be analysed, it had to be isolated from the surrounding waters. The sub-programme used in this step is mDIGIT.

With this programme, the surrounding waters of Sentosa Island was manually removed. The final product only contained the land area of Sentosa Island.

STEP 3

The image after digitizing does not have well defined details of the land area. In this step, the objective is to enhance the details in the image. A total image histogram was first taken of the raw image.

The spectral reflectance values of 1entered into the maximum and minimum values of the raw image. The computer followed the data given and subsequently displayed an enhanced image of Sentosa Island. The total image histogram is obtained from the programme mJLAT.

STEP 4

To classify a remotely sensed image, sample pixels must be taken from the image for the clustering or assembly of similiar or closely linked pixels. From the enhanced image of Sentosa Island, training areas or sets are obtained. The sub-programme mTRAIN is used for this step.

For an accurate classification, depending on the size of the image, the number of training areas taken should be as many as possible. For the image of Sentosa Island, 40 training areas were taken at the first attempt. All these training areas were stored into a seeds file to be classified later.

STEP 5

The classification of an image requires several steps. The first step is to cluster the pixels in the image into manageable classes. The sub-programme used for this process is mCLASS.

The 40 training areas, previously obtained, were put through a classifier in another programme called mTAXON. The classifier will cluster the pixels that are near to the 40 seeds using a method called the Wards Incremental Sum of Squares sorting(ISS). To allow for errors, the computer is able to produce seeds for pixels that do not come under any of the 40 seeds. The final number of seeds used in classification was 74. The number of pixels classified was 4166 pixels.

Statistics of the classification are printed out and the Mahalanobis distance is calculated. The number of unclassified pixels are also stated. Following this, a dendogram showing the relationship of each seed to the others is plotted out. The dendogram is useful in the analysis of the image.

The second step in the process of classification is to further cluster the classes obtained in mCLASS into a smaller number of super-classes. The sub-programme used in this step is called mSUPER. mSUPER creates classification or super-class channels from a computer based classification of image data.It uses the mean image(s) output mCLASS and the associated seeds file and creates a super channel. A super-class channel is a nominal data channel and its order of magnitude is not of much significance.

The dendogram obtained in the previous step is analysed and the number of super-classes determined. The number of super-classes is entered into the mSUPER programme. The individual classes in each super-class is also stated.

For the image of Sentosa Island, nine super-classes were obtained.

STEP 6

The nine super-classes were each given a colour chosen from a colour table that consists of 512 colours. The sub-programmes used for this step is mPAINT or mOVRLY. In mPAINT, the maximum and minimum spectral values of each super-class is entered into the programme together with the colour value assigned to it. The programme will then colour the pixels in the image according to the colours assigned to the super-classes.

In mOVRLY, each super-class has to be individually entered into the programme with its own maximum and minimum spectral values and colour value. These data will be entered as themes in the programme. Using these themes the programme will overlay the data onto the raw Sentosa Island image.

STEP 7

The image produced after step 6 will have individually coloured pixels scattered throughtout the image. As each pixel is only 30m by 30m, these individual pixels can be "filtered" out without causing too much error. This step requires the service of sub-programme mSMOOO for the smoothening of the image.

The Sentosa Island image was put through the Mode filter to remove the scattered pixels. The resultant image had less scattered pixels.

STEP 8

As there are many different colours on the image map, there is a need to find out what each colour represents. It does not necessarily mean that green colour on the map will represent vegetation. Ground truthing is an important process to find out the accuracy of the map classified.

For the image of Sentosa Island, ground truthing was done on a field trip to Sentosa itself. The image map was first verified with a map of Sentosa. Then the image map was further verified by making trips to as many places on the island as possible. Some of the places were not verified due to unforseen circumstances like government and private property.

STEP 9

After ground truthing was done, a legend has to be formulated to show what each colour on the image map represented. To enhance the final image map, the digitized land parts and water has to be "pasted" back. The programme used for this step is mPASTE.

Using this programme, the coloured image map of Sentosa Island was recombined with the digitized land parts and surrounding waters. The final image produced contained the coloured and classified image of Sentosa Island, the unclassified images of Pulau Brani, Buran Darat and the southern tip of Singapore and the surrounding waters.

RESULTS AND DISCUSSION

Following Steps 1 to 7, a full-coloured image map was obtained. The coloured image was verified following Step 8, which is ground truthing. Using Step 9, the final image was obtained. Refer to Figure 7 for the final image of Sentosa Island. The total land area of the island is 3.73 ha.

From the ground truthing, the various colours on the classified image was verified. The yellow colour on the image map represented the natural secondary forest on the island. It covers 1.45 ha., 38.7% of the land area of the island. The green colour on the image map represented the artifical vegetation on the island. It covers 1.41 ha., 37.7% of the land area. The red colour represented the grassland and golf courses on the island. It covers 0.47 ha., 12.6% of the land area. The dark blue colour represented the sparsely distributed low trees like coconut and palm trees on the island. It covers 0.17 ha., 4.5% of the total land area. The maroon colour on the map represents the sandy beaches and concrete areas on the island. It covers0.19 ha., 5.0% of the land area. The pink colour represented the sandy areas with vegetation on the island. It covers 0.022 ha., 0.0058% of the total land area. The orange colour on the image represented the cleared flat land on the island. It covers 0.017 ha., 0.0046% of the land area. The light blue colour on the image map represented the shallow pond on the island. It covers 0.011 ha., 0.0029% of the total land area. The dark green colour represented the swamp land on the island. It covers 0.0045 ha., 0.0012% of the total land area of Sentosa Island.

As the raw image was taken in 1989, ground truthing done in 1991 will definitely contribute some errors. The lagoon is undergoing some major reconstruction now which is not reflected in the raw image. The removal of some natural vegetation for the construction of some tourist attractions is also not reflected in the raw image.

To further enhance the final image, the image was put through manual stretching to bring the details of the unclassified land parts and the surrounding waters.

CONCLUSION

From the analysis of the land area covered by each colour, only approximately one-third of Sentosa is covered by natural vegetation. As this image was taken in 1989, ground truthing has revealed that more of this natural vegetation is being cleared for developments. Much of Sentosa is covered by artificial vegetation. At least one-ninth of Sentosa Island consists of grassland and golf courses. The 1989 image of Sentosa consists mainly of vegetation, about 70% of the total land area. But from the ground truthing carried out, the 1991 Sentosa is undergoing rapid development resulting in much of natural vegetation being cleared.

This project has shown that the software microBRIAN, developed initially for reef mapping, is also a feasible and useful means for mapping land uses in Singapore. This database may be used as a reference for future developmental plans and management of Sentosa's natural resources.

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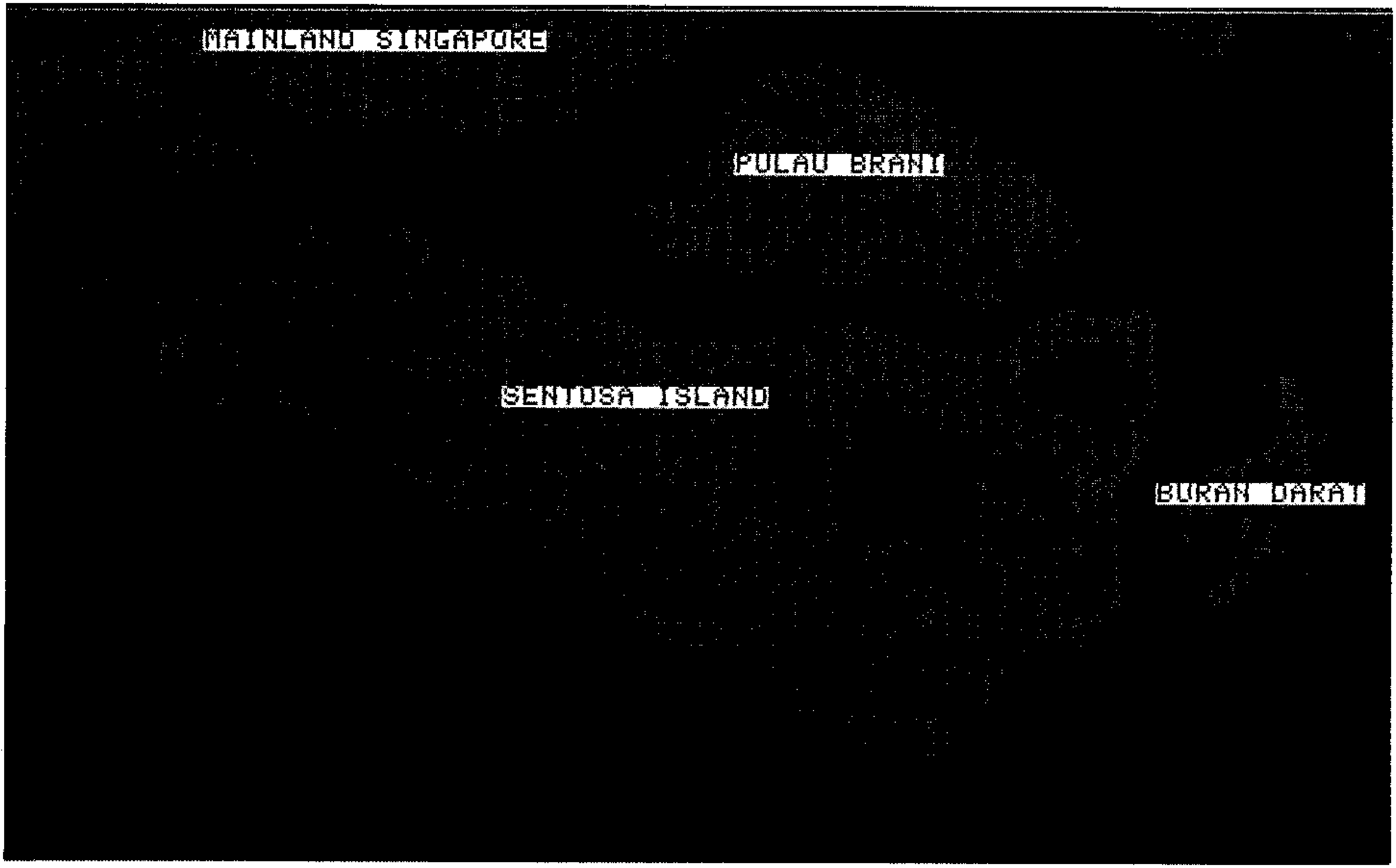

FIG. 1: RAW IMAGE FROM SATELLITE

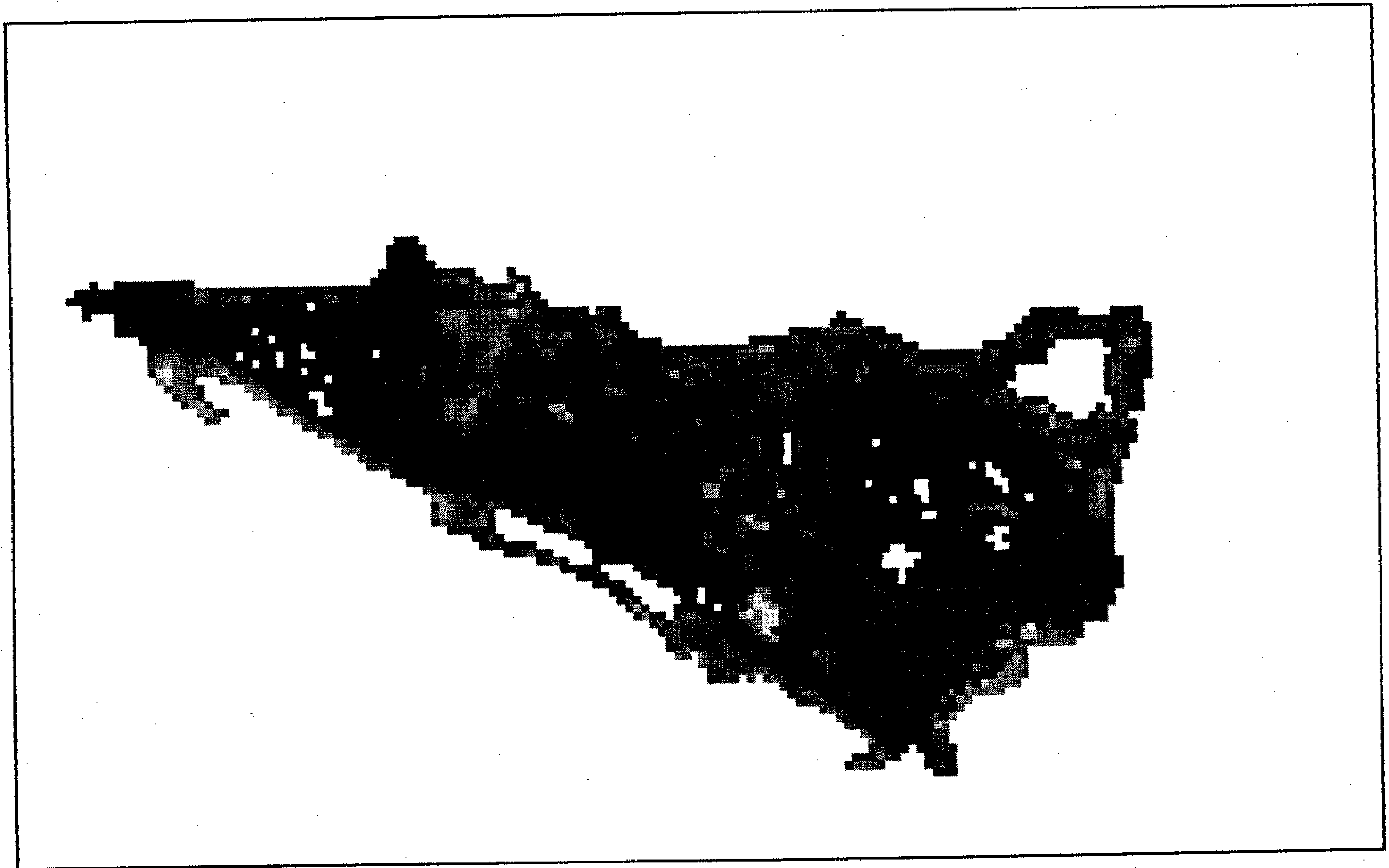

FIG. 2: ENHANCED LAND IMAGE

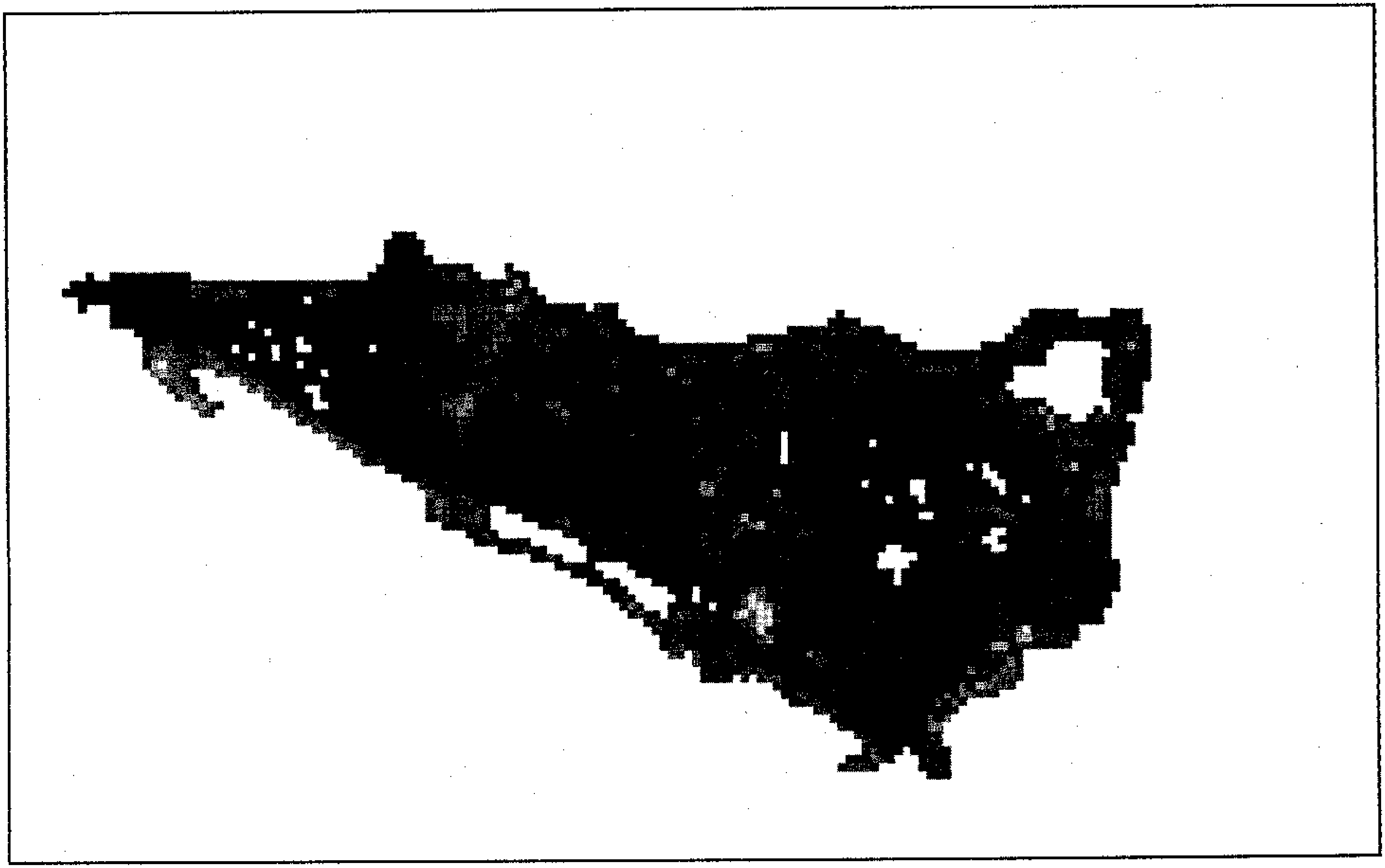

FIG. 3: GETTING TRAINING SETS/AREAS

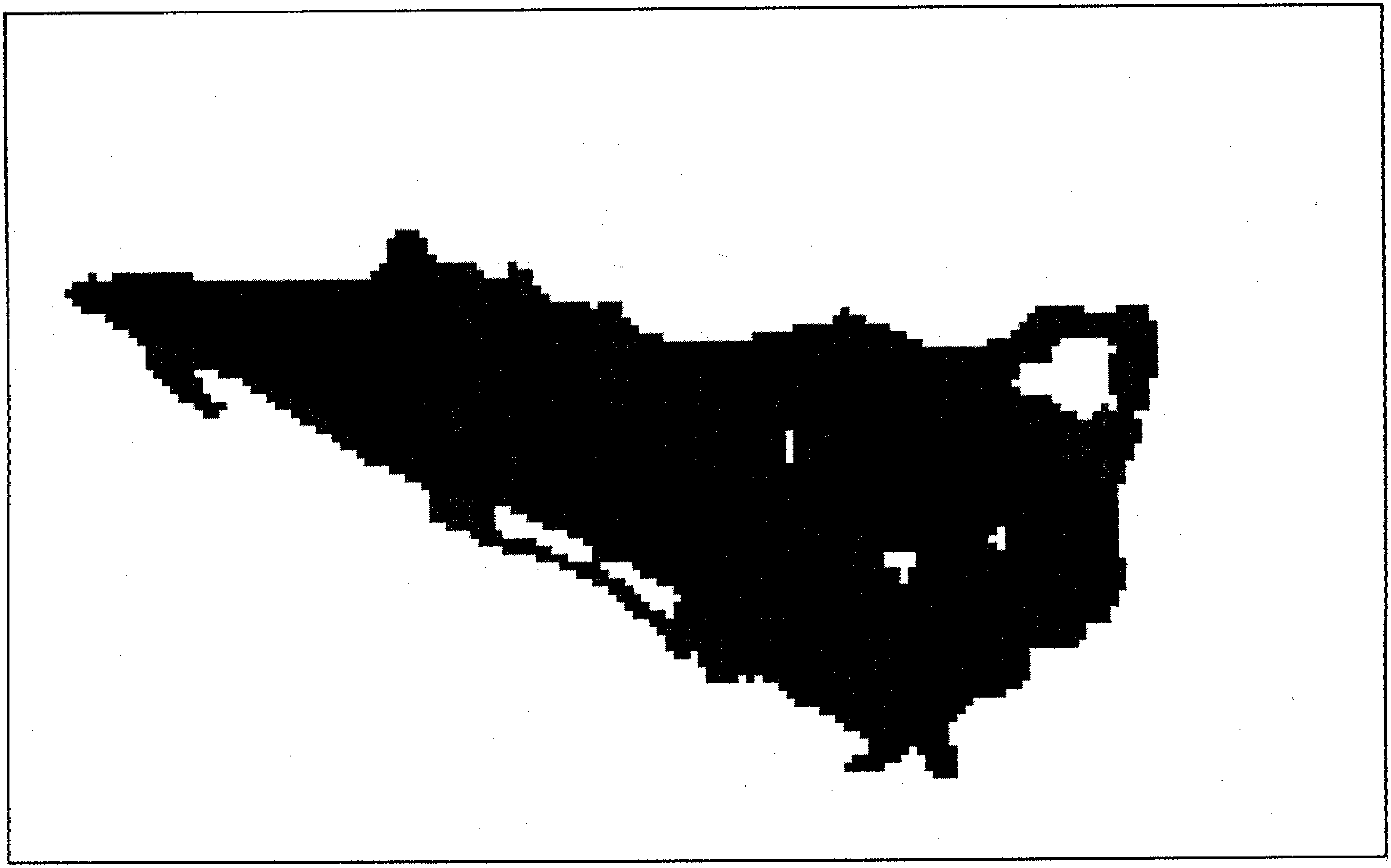

FIG. 4: IMAGE DISPLAYED USING SUPER CHANNEL

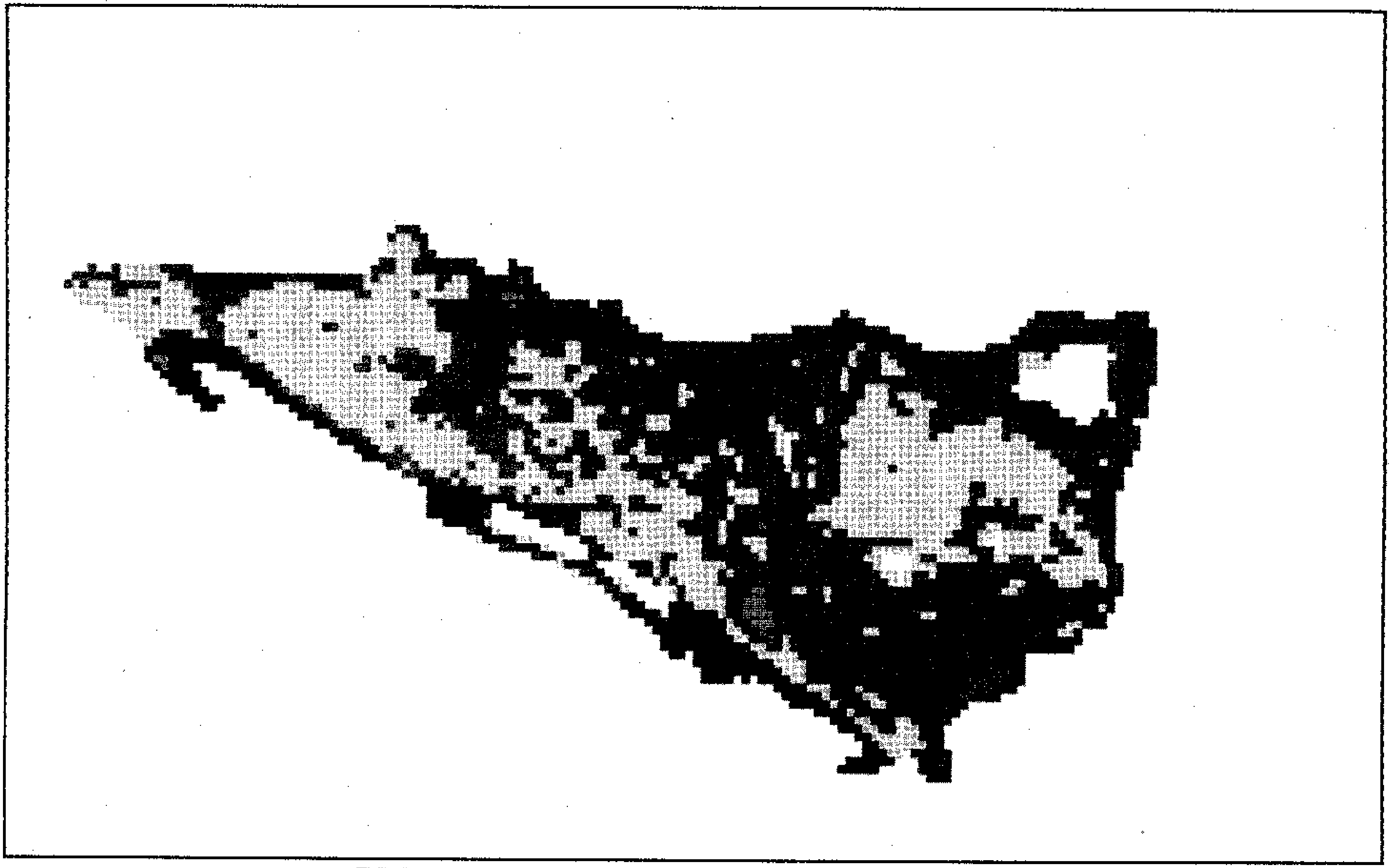

FIG. 5: COLOURED IMAGE BEFORE SMOOTHING

FIG. 6: COLOURED IMAGE AFTER SMOOTHING

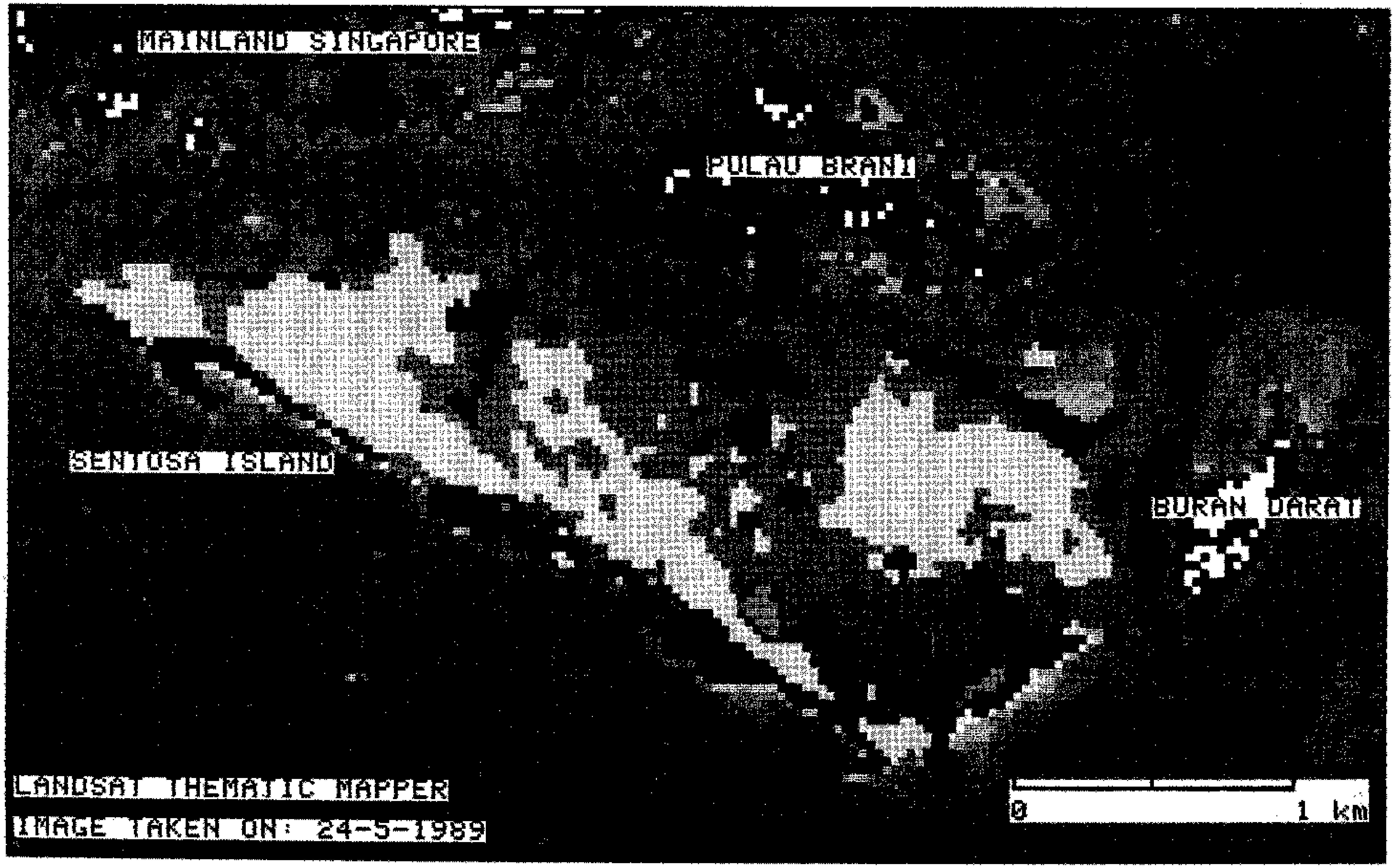

FIG. 7: CLASSIFIED IMAGE OF SENTOSA ISLAND

LEGEND:

- NATURAL SECONDARY FOREST
- ARTIFICIAL VEGETATION
- GRASSLAND AND GOLF COURSES
- SPARSELY DISTRIBUTED LOW TREES (COCONUT AND PALM TREES)
- SANDY BEACHES AND CONCRETE AREAS
- SANDY AREAS WITH VEGETATION
- CLEARED FLAT LAND
- SHALLOW POND
- SWAMP LAND