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NOTA TEKNIKAL/*TECHNICAL NOTE*

LANDSAT MSS IMAGERY AND ITS APPLICATION IN SELECTED AREAS OF SOCIAL SCIENCES WITH SPECIAL REFERENCE TO MALAYSIAN EXAMPLES

INTRODUCTION

Remote sensing is the acquisition of information about an object without physical contact. The term remote sensing usually refers to the gathering and processing of information about the earth's environment, particularly its natural and cultural resources, through the use of photographs and related data acquired from an aircraft or satellite.

Remote sensing is a modern technique and became very advanced after 1960, when National Aeronautics and Space Administration (NASA) placed remote sensors to satellites for the purpose of making earth observation. The rapid expansion of remote sensing is witnessed when many countries of the world began to get involved in space technology. This includes some of the Asean countries especially Indonesia and Thailand. Malaysia is lagging far behind in space remote sensing technology. Our ASEAN neighbours, Thailand, Indonesia and the Philippines have already set up their own National Remote Sensing Centre, but Malaysia, to date has only a National Remote Sensing Committee. The objective of the Committee is to promote the application of remote sensing technology in Malaysia, but till now nothing much is heard about the activity of the Committee.

Research using Remote Sensing in Malaysia can be undertaken at Terra Control Technologies Sdn. Bhd. in Kuala Lumpur. The Company is incorporated in Malaysia forming part of a global network involved in acquiring, processing, interpreting and sharing data. The Company's services included data acquisition and processing by utilising sensors such as SPOT satellite, SAR & SLAR Sensor (Radar), Thematic Mapper, Multi-spectral photography, Infrared Scanning, NOAA/TIROS and GOES, Geophysical Sensors and Gamma-rays Spectrometer. For its interactive Image processing system the Company has acquired Canadian DIPIX Aries III.

However for research purposes, Malaysia does have access to the landsat Computer Compatible Tapes which are readily available for purchase at the Earth Observation Satellite, National Earth Satellite Service, EROS Data Centre, Sioux Fall, SD 57198.

For SPOT data the sole distributor in Malaysia is the Terra Control Technologies Sdn. Bhd., Godown 3, Nupro Building, Jalan Tun Sambanthan 50470, Kuala Lumpur.

A pioneering remote sensing research in Malaysia was conducted by Malaysian Agriculture Research and Development Institute (MARDI). The Institute carried out a pilot study on the use of satellite remote sensing data for agro-ecological mapping of Peninsular Malaysia. This study was intended to assess the advantages of using satellite remote sensing in preparing inventories of the country's potential agricultural resources that could help planners in their development strategies. The factors considered were land cover types, terrains, soil types and agro-alimate. Two landsat frames that have contrasting qualities in terms of percentage cloud cover and ground conditions were selected for the purpose. An intergrated approach was adopted using digital analysis, analogue analysis and selective incorporation of non-remote sensing data. The results of the study showed that the methodology developed allows characterisation and delineation of zones of different agricultural potential for the two areas (Mahmood et al. 1983). Maps indicating these zones were produced by MARDI at the scale of 1: 250,000. According to Mahmood et al., the major limiting factors in using remote sensing in this country are excessive cloud cover and limited availability of data. As such he proposes that efforts be made to secure better quality and more timely satellite remote sensing data. Mahmood conducted his research at the Centre of Tropical Geography and National Institute of Geography, France. Aside from this major research, there is probably no other research published using sattelite remote sensing data in Malaysia.

POTENTIAL SPACE TECHNOLOGY RESEARCH FOR SOCIAL SCIENCES

This paper attempts to provide more information on the possibilities of expanding satellite remote sensing research into some areas of social sciences. Some references to Malaysian examples are cited. As a tool of research, Landsat Multispectral Scanning System (MSS) imagery provides the following advantages:

1/ Landsat MSS data gives a synoptic view of a large area. It is commonly used with the aid of aerial photographs interpretation. Social scientist could use landsat imagery for mapping purposes, to generate hyphotheses, for research design and sampling.

2/ With increased availability of digital image processors, digital landsat MSS data could be analysed in great detail. Thus it is used for classifying land cover, estimating characteristics of the earth's surface and for monitoring change, geological investigation, geomorphological mapping, hydrological studies, soil surveys, urban land cover, cultural and ecological studies.

3/ The landsat MSS data give more sources of information because they comprise 4 types of waveband: Band 4 (widthband 0.5 – 0.6 μm), band 5 (widthband 0.6 – 0.7 μm), band 6 (widthband 0.7 – 0.8 μm) and band 7 (widthband 0.8 – 1.0 μm). Band 4, 5, 6 and 7 are also called green, red, near infrared and near infrared respectively.

4/ The repetetative coverage of landsat over an area enables researchers to monitor environment especially those that are seasonal in nature, such as flood monitoring.

5/ With an introduction of Thematic Mapper (TM) on Landsat 4 and 5, the imageries should become more useful to the researchers in the future. The TM have an enormous output of data with 7 wavebands and spatial resolution of around 30 meter.

There are various stages in this technique that researchers have got to be familiar with before interpretation is feasible. These stages include the theoretical background of remote sensing, the information on Landsat MSS imagery and methods of Landsat analysis. (For details, refer Sharifah Mastura 1986). However in this paper some of these informations are given briefly in the following two sections.

THE LANDSAT MULTISPECTRAL IMAGERY

The first unmanned satellite series carried two types of sensor, a four waveband multispectral scanning system (MSS) and three return beam vidicon (RBV) television cameras. When launched in July 1972 it was called the Earth Resources Technology Satellite – 1 (ERTS-1) a name that it held until January 1975 when it was renamed Landsat 1.

Landsat 1 was a small satellite. The satellite orbits at an altitude of 919 km with a speed of 6.5 km sec^{-1}. The orbit was circular, flying within 9° of the North and South Poles and sun synchronous (that is synchronised with the Earth's motion in relation to the sun) so that its orbit could keep pace with the sun's westwards progress as the Earth rotated. To obtain repeat coverage of an area, the satellite's orbits were moved westwards each day to enable an image to be taken of each area on the Earth surface once every 18 days (NASA 1976). These orbits proved to be successful and were adopted virtually unchanged by Landsat 2 and 3.

Landsat 1 lasted for almost 6 years until January 1978 and for parts of its life, it shared the space area with Landsat 2 which was launched in 1975. Landsat 3 was launched in March 1978 while Landsat 4 in July, 1982 and Landsat 5 in March, 1984. Minor changes were made to Landsat 4 and 5. The body of both satellites was changed to improve stability and pay-load capability. Their orbital altitude was also lowered to 705 km, thus giving a faster repeat cycle of 16 days and a changed orbit spacing (NASA 1982c).

LANDSAT SENSORS

All Landsat satellites carry or have carried two sensors, a multispectral scanning system (MSS) and either a thematic mapper (TM) scanner or a return beam vidicon (RBV) television camera.

The MSS records four images of a scene, each covering a ground area of 185 km by 185 km at a nominal ground resolution of 79 m. These four images cover green, red, near infrared and near infrared wavebands and are identified by the channels they occupy in the satellite's telesystem which are 4, 5, 6 and 7 respectively.

The MSS carried by Landsat 1, 2 and 3, produce images by reflecting the radiance, recorded from 79 m wide scan lines on the Earth's surface, to detectors on board the satellite. To measure radiance for a particular area, the scan line is divided into units by the instantaneous field of view (IFOV) of the sensor. As the satellite moves forward so quickly, it is necessary to record 6 scanlines at once thus necessitating the use of 24 detectors, 6 inches each of the 4 wavebands. Each one of these detectors converts the recorded radiance into a continuous electrical signal, which is then sampled at fixed time intervals and converted to a 6 bit number (0-64) and either recorded onto magnetic tape or transmitted down to earth where it is rescaled to a 7 bit number (0.128) for band 4, 5 and 6 (Lansing and Cline 1975; Slater 1980).

A complex channel of Landsat MSS imagery comprises 2,340 scanlines and 3,240 pixels per line, a total of around 7.5 million pixels per channel and 30 million pixals per scene of 4 channels.

The MSS sensor has undergone minor changes since the launching of Landsat 1. The three changes worthy of note are firstly, the addition of an extra waveband, known as band 8 to the MSS of Landsat 3. This waveband is intended to record thermal infrared (10.4 – 12.6 μm) images but since it failed to function shortly after launching, the few images it has recorded have been used for purposes of environmental applications (NASA 1982b). Secondly, to compensate for the lower orbit altitude of

Landsat 4 and 5 the spatial resolution (IFOV) of the MSS images was decreased by 3 m to 82 m and Field of View (FOV) was increased by 3.41° to 14.93°. Thirdly, the numbering of the MSS wavebands was changed to band 1, 2, 3 and 4 for Landsat 4 and 5.

LANDSAT WORLDWIDE REFERENCE SYSTEM

The repeatability of the Landsat orbit has led to the development of the framed world concept. This concept is implemented in the worldwide reference system (WRS). Each orbit within a cycle is designated as a path along which the individual nominal sensor frame centres designate the rows of the WRS. The centre point for the reference row is taken as the equator (0° latitude). Since Landsat sensors are daylight oriented, the descending note becomes the reference point. There are about 119 potential day light scenes per orbit. The scene whose centre is on the equator has been designated row 60. The frame immediately to the north of this, in the same path is designated row 59. This scene will have its centre at a distance equivalent to 25 seconds of spacecraft nadir ground trace time. This number continues northwards to frame 1.

The WRS has 251 paths corresponding to the number of Landsat orbits required to cover the earth in one 18-day cycle. Path 1 is that orbit whose frame first includes some of the mainland of eastern North America. As the earth is rotating from west to east under the satellite, these paths are numbered progressively westwards until path 251 is reached. Path 252 will correspond to path 1 and the cycle will start over again. The paths and rows of MSS images from Landsat 1, 2 and 3 for Peninsular Malaysia are given in Figure 1. However different reference system is required for Landsat 4 and 5. Figures 2, 3 and 4 give examples of Landsat imageries for areas north-west of Peninsular Malaysia and Terengganu in the east coast.

METHOD OF IMAGE ANALYSIS

The remotely sensed images are kept in a digital format and require a computer and special display facilities to process the images and display the output. There are various centres in Britain that offer these services, notably the National Remote Sensing Centre (NRSC) of the Department of Space in Farnborough. At NRSC, the main facilities used are the image processing and display devices called GEMS. It uses the interactive image analysis softwares known as GEMSTONE, developed by the staff of the Centre. Hard copy output of research results is done via offscreen photography using a Honeywell matrix camera system. Among the techniques used in the image processing operation on the MSS imagery are destriping, edge enhancement, smoothing, contrast stretching and density slicing (Sharifah Mastura 1986).

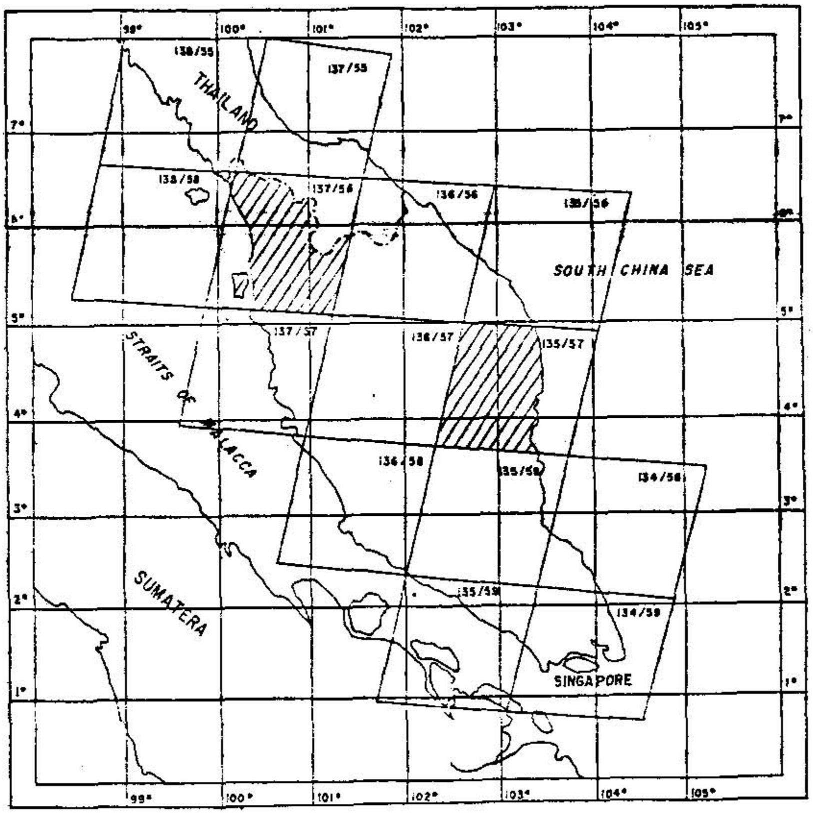

FIGURE 1: Landsat (1, 2 and 3) Index Peninsular Malaysia.

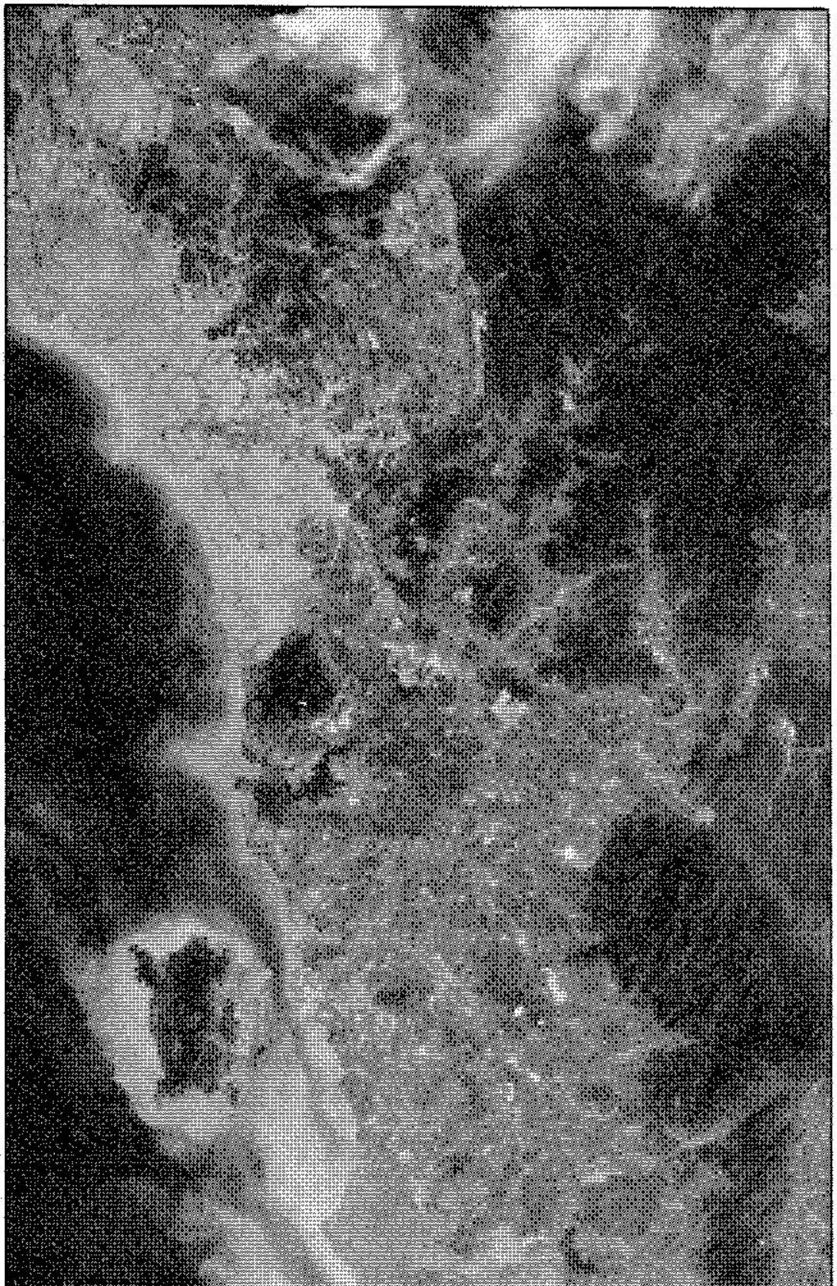

FIGURE 2: Landsat MSS imagery of north-west Peninsular Malaysia in band 4 (green band 0.5 – 0.6 μm).

FIGURE 3: Landsat MSS imagery of north-west Peninsular Malaysia in band 7 (near infrared 0.8 – 1.0 μm).

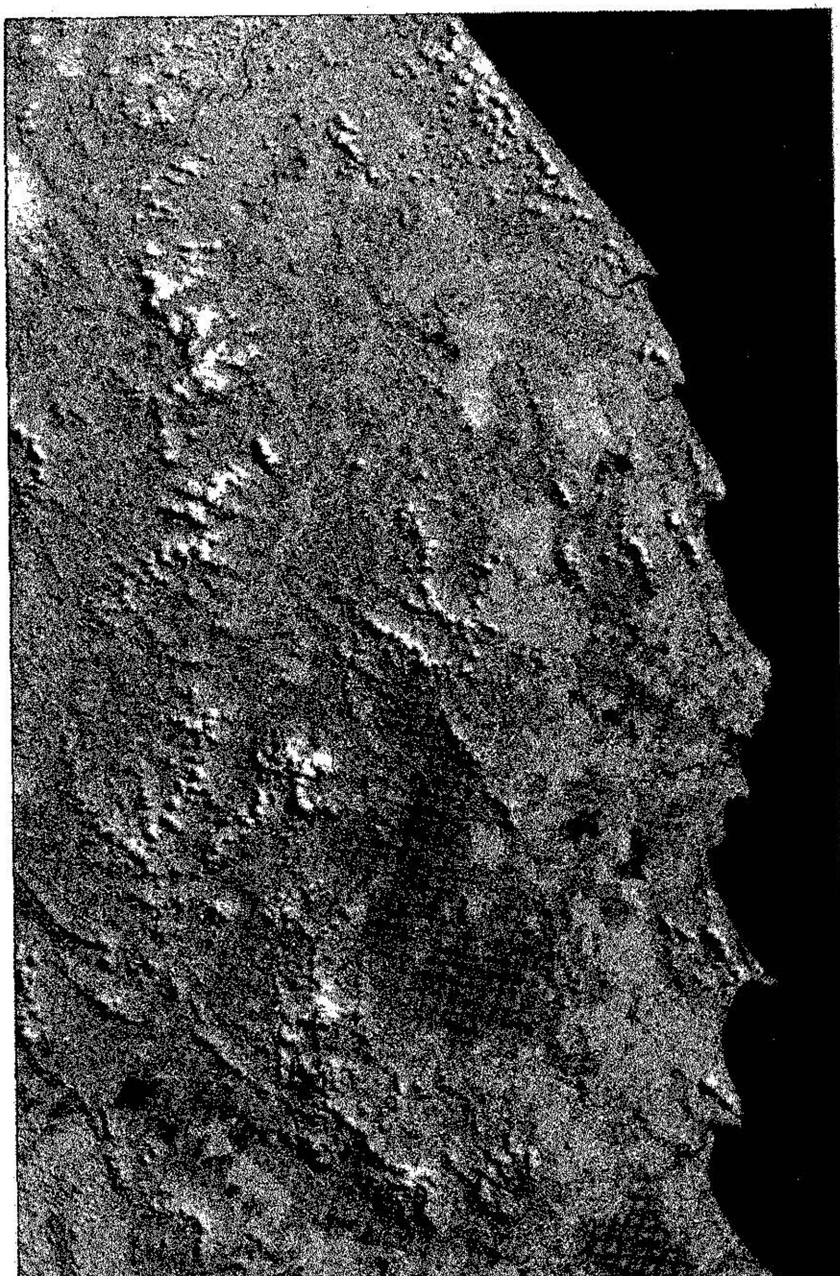

FIGURE 4: Landsat MSS imagery of Terengganu in band 5 (red band 0.6 – 0.7 μm).

Besides NRSC, there are a few British universities that offer, on application, a range of services to users such as the University of Southampton, the University of London and the University of Sheffield. In Southeast Asia, the Thailand Remote Sensing Division of the National Research Council in Bangkok provides similar facilities. In Malaysia, Terra Control Technologies is the first to provide such services. Its user services offer a wide range of activities, such as film writing, digitising, interactive digital image processing, archive and browse facilities, digital mapping and application and interpretation consultancy. Basic remote sensing courses are also offered throughout the year.

APPLICATION OF LANDSAT MSS IMAGERY IN SELECTED AREAS OF THE SOCIAL SCIENCES

Landsat MSS imagery is a highly effective method of conducting resource survey, monitoring and mapping the natural and cultural environment. In fact both general and detail investigations can be made quickly, accurately and at a fraction of the cost of conventional surveys. So far, in the social sciences, disciplines such as Anthropology, Urban Studies and Geography have found landsat MSS imagery useful.

In Anthropology, Lyons, Inglis and Hitchcock (1972) have shown that space imagery can provide two kinds of data viz, environmental and cultural, for ethnographers. Such informations as the physiography, drainage, erosion of a place that landsat imagery provides are useful for ecological analysis. The kind of cultural information provided by landsat MSS includes patterns of landuse, settlement and population. Writers also mention the use of imagery for mapping, formulating hypotheses, research design and sampling. According to them, data derived from space have great potential for temporal and regional studies because of their quantitative synoptic and repetitive nature.

Two conferences on satellite potentials for anthropological studies of subsistence activities and population change, have been held in 1975 and 1978. The conferences bring together ethnographers and members of the other disciplines including remote sensing specialists, to discuss the relevance and use of Landsat data in ethnography, specifically in the studies of human ecology in tropical and sub-tropical areas of Africa, Asia and the Middle East. The findings and recommendations of the two conferences are reported in Conant, Reining and Lowers (1975) and Conant (1978).

In 1975 a workshop (on interpretation of East African Swiddening via computer assisted analysis of Landsat 3 tapes) was organised by Conant and this served as an introduction to the Landsat system for a group of ethnographers. The discussion revolved around the utilization of Landsat and other aerospace data especially the Thematic Mapper on Landsat 4 and 5, the need for fieldwork to be part of a multistage design, the need to study the entire ecological or cultural areas, and the need to develop special signatures for shifting cultivation, settlement types, and other imprints that are discernible on Landsat imagery. More information of the uses of Landsat imagery in Anthropology can be found in the works of Conant (1978), Houseman (1975), Kruckman (1978), Riddell (1978), Fanale (1974a; 1974b) and Reining (1973, 1974a, 1974b).

In urban studies, Landsat MSS imagery has been proved useful for various urban applications (Carter & Gardner 1977). Colvocoresses (1977) gives two advantages of Landsat MSS bands. MSS band 5 is a fundamental band for indicating boundries between natural and cultural features. MSS bands 6 and 7 have demonstrated the operational value in the near-infrared for vegetation, open water (especially shorelines) and cultural delineation. Colour composite of Seattle and Austin demonstrates the contrast between the urban and suburban signatures. It is obvious that the urbanized area can be differentiated from other general level 1 land cover classes. Here the Landsat can only identify three classes of information: residential, industrial/commercial and water bodies (General Electric 1978). For a more specific land cover the use of Landsat data may give rise to separation problem of area of interest. Tood et al. (1978) are able to make adequate separation of residential, commercial/industrial, open space, water, forested and agricultural land. However, additional research is required on how the following variables affect urban and suburban signatures, lot size, type of construction materials, spacing and orientation of structures, latitude and atmosphere. Such research will provide a better theoretical understanding of how urban land cover spectral signatures vary geographically.

The application of Landsat MSS imagery is most advanced in geography especially in the field of physical geography (Lulla 1983). A few Malaysian examples using Landsat MSS Imagery in geography are presented here.

Figures 5 and 6 show the false colour composite of band 4, 5 and 7 of Kuala Merbok and surrounding areas. The bathymetric analysis via Landsat shows that there are distinct depth differences at the offshore of Merbok River. These depth differences coincide with the depth of 2m, 5m, 10m, and 20m of the hydrographic chart. The pattern of the depth differences shows pronounced

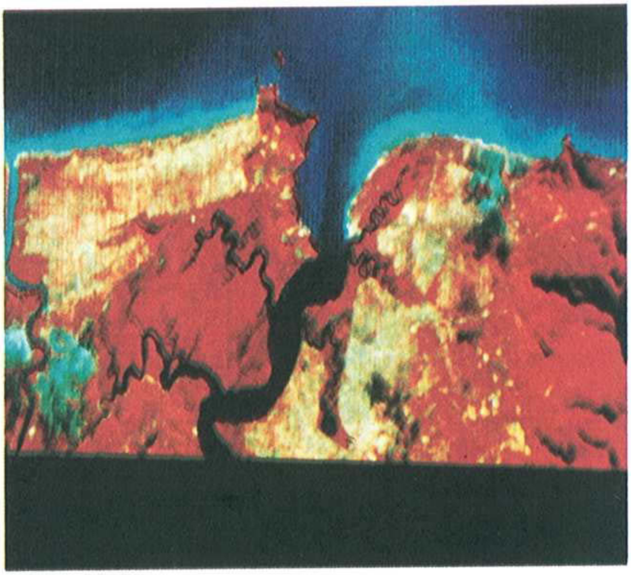

FIGURE 5: False colour composites of Kuala Merbok and offshore area. The different colours dipict different depths (2m, 5m, 10m, 20m).

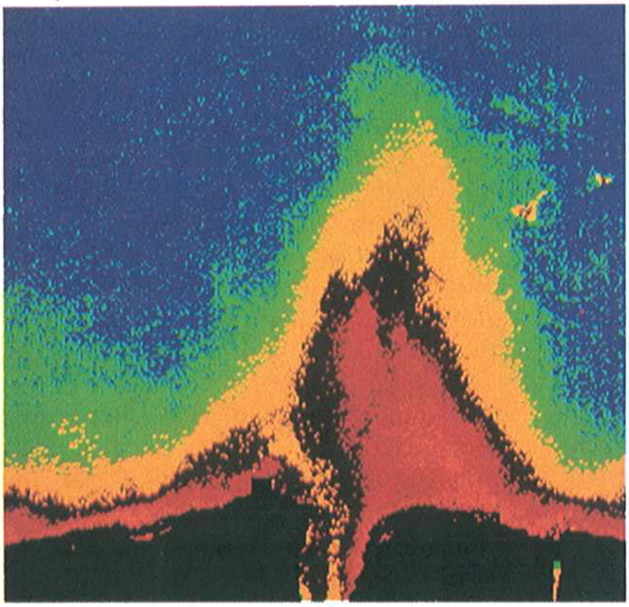

FIGURE 6: False colour composites of band 4, 5 and 7 of Kuala Merbok. The photograph shows sediment brought down by the Merbok river have obviously caused the shallowing towards offshore.

direction towards offshore. The sediment brought down by the Merbok River has obviously caused the shallowing towards offshore from the river mouth. The Landsat image was taken in January 1979. At this time of the year, surface current speed at the Central Melaka Strait was about 11 km per day in the north – westwards direction. The Landsat image also shows the tendency of shallowing in this direction.

The bathymetric study using Landsat MSS imagery is made possible because in the green band (0.5 – 0.6 μm) the sun light penetrates the water and features which are a few meters below the surface become apparent. It can be shown that in the visible part of the spectrum the intensity of the reflected radiation is proportional to the depth of the water. In band 7, the near infrared has very little reflected radiation from the sea causing it to appear almost uniformly black. Such images are ideal for defining the land-sea boundary.

Lineament studies using Landsat was proven to be very useful (American Society of Photogrammetry 1983). Permatang lineament, which have been regarded as Quaternary sea level indicators a few meters above mean sea-level offshore Terengganu coast, is shown in Figure 7. Mapping Permatang via Landsat offers synoptic viewing which is an advantage over aerial photograph methods.

Linear features are well expressed in Landsat MSS imagery and this is examplified in the imagery for North-West Peninsular Malaysia as shown in Figure 8. In this Landsat pictures linear features can easily be mapped. Other mappable features are the rice cultivation fields. Detailed analysis of the above mentioned examples are given in Sharifah Mastura (1986).

CONCLUSION

This paper attempts to put forward a modern tool of research in social sciences which has been successfully applied in other parts of the world. At present the MSS imagery is becoming more increasingly significant in investigating the environment. This is evident from the steady increase in the use of traditional techniques combined with remote sensing system (American Society of Photogrammetry 1983).

The continuing development of new remote sensing measurement techniques, complementary to as well as parallel with the development of micro-computer technology and sensors with improved spatial and temporal measurement capability, offers a new dimension for research in the field of social sciences. Expand-

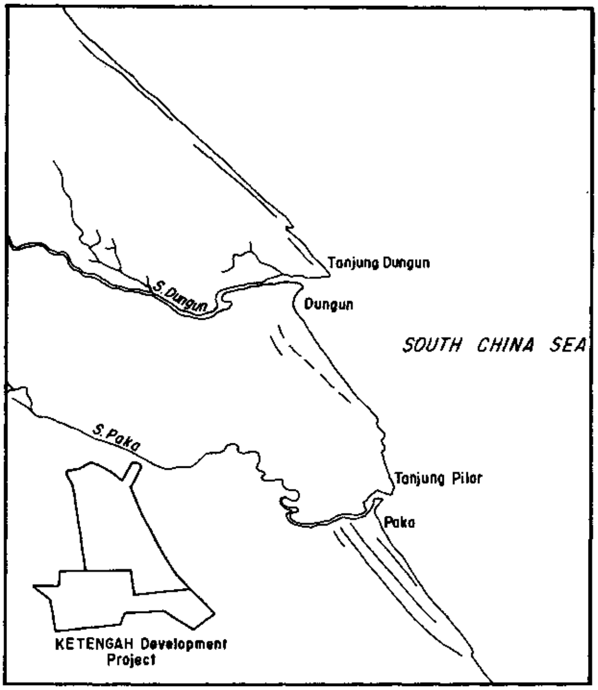

FIGURE 7: Permatang redrawn from false colour composites of band 4, 5 and 7 of Trengganu.

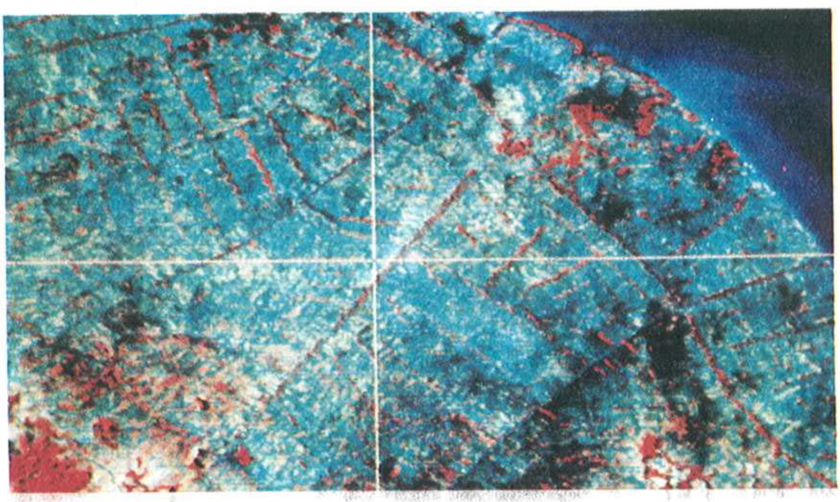

FIGURE 8: False colour composites of Air Hitam (Kedah) and surrounding areas. The linear features seen here are a few or all of the folowing; roads, canals, padifield boundries and linear settlements.

ing capabilities in microwave spectral region, particularly from satellites and serial platforms, offer opportunities for synoptic and repetitive regional and global scale measurements that have not been previously possible. Another significant factor is the availability of instruments that measure, directly or indirectly, the same or interlocking features by one or more techniques in different parts of the spectrum. This avoids some past environmental constraints such as cloud cover and other atmospheric effects. Other advancements in remote sensing include French satellite called SPOT 1, launched on the 22nd of February 1986. SPOT 1 carried a High Resolution Visible Scanner which has two operational modes: the panchromatic and the multispectral. In the future, NASA Landsat 6 will replace MSS with new and more powerful scanner capable of giving a spatial resolution of around 10 m.

Universiti Kebangsaan Malaysia at present is making a concerted effort in planning the setting up of Remote Sensing Research facilities so that researchers can utilise them without resorting to Terra Control Technologies or overseas sources. The availability and accessibility of these facilities will certainly serve as an impetus in this field of research. Consequently, Malaysian researchers will not lag behind in the acquisition and advancement of knowledge through space technology.

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