EDUCATIONAL ASPECTS OF INTRODUCING REMOTE SENSING EDUCATION IN SOUTHEAST ASIA - SOME OBSERVATIONS FROM MALAYSIA

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Ecologically sustainable development of natural resources and optimal management of the environment constitutes an essential ingredient in the economic development of Malaysia and the Southeast Asian Region.The frequent occurrence of man-induced hazards and increasing depletion of natural resources since the late 1980s further re-enforced the need for a more sustainable development and a detailed understanding of the dynamic interdependence of the natural environment. Remote sensing technology would be able to provide the technological tool needed to cut across the narrow confines of the sectoral approaches practiced in the region in order to initiate a well balanced programmed and structured development strategy, whilst ensuring ecological balance and conservation of the natural resources.

This paper discusses the problems and limitations that could seriously affect the need for a more pragmatic remote sensing education in Southeast Asia in general with examples cited from Malaysia especially with new and advance technologies like radar. The components of pragmatic education in this case, must include the imparting of sufficient knowledge , in firstly, a more holistic view of the environment, especially the relationships between man and the environment and between environmental parameters themselves, and secondly, the need for adequate technical skills especially in computer data processing and mathematical/ statistical modeling. This paper traces the general status of remote sensing education in Malaysia and the main problems that have been encountered. The case of remote sensing education at the University of Malaya (UM) acts as a background of the discussion.

INTRODUCTION

The growing demand for information to support Spatial Information System Databases (SISD) and map production of the region's natural wealth has led countries like Malaysia to undertake a very rigorous and positive approach developing her remote sensing programmes. This demand is deemed to be crucial, as natural resources exploitation and urban expansion have changes rapidly since the 1980s. Frequent updating of information thus becomes useful for natural resources inventorying and management and national development planning. In Malaysia the specific objection of The National Remote Sensing Programme

(NRSP), are - to (1) strengthened the capabilities and coordinate the activities of remote sensing technologies in the country, and (2) to promote greater utilisation of remote sensing and related technologies for resources management, environmental protection and strategic planning have thus been operationalized (MACRES 1991).

Manpower training still precedes NRSP objectives, especially to increase local expertise and skill. Since the establishment of MACRES (Malaysian Centre For Remote Sensing) under the Ministry of Science, Technology and Environment, a number of workshops cooperation programmes have been organised with countries such as China and Sweden to provide training and expertise in the use and applicaton of remote sensing techniques. These colloboration programmes covers research topics and transfer of remote sensing technologies in the field of environmental modelling and monitoring and landuse mapping.Selected personnel from the centre and other government departments are also send for short and long term courses overseas.One notable programme is the United Nations-Swedan Training Course on Remote Sensing. Advanced training courses are also being organised and planned in the country with the help of experts from foreign countries such as Australia, Canada and the USA.

DATA AQUISITION AND MANAGEMENT

MACRES has initiated the process of acquiring various types of remotely sensed data to meet the requirements of research, inventorying and updating of spatial data bases.The Remote Sensing Division of the National Research Council of Thailand(NRCT) through its ground receiving station, is the main source of data for Malaysia. Recent data acquired through NRCT covers almost the whole country. MACRES has also acquired MOS-1 data from the Remote Sensing Technology of Malaysia of Japan (RESTEC). Apart from this, the 50 m resolution MESSR data covers about 90% of the coastal region of Malaysia. VTIR data will also be purchased on a selective basis for sea surface temperature studies. Discussions have been carried out with SPOT IMAGE and Russia to purchase high resolution satellite data coverage of Malaysia.

Facilities installed at MACRES are configured specifically to integrate image processing and GIS (MACRES 1991). Accordingly the facilities consist of four major components. They are image Processing System (IPS), GIS, PC-based facilities for image processing and GIS and a remote sensing photo laboratory for high quality hardcopy outputs. Software architecture uses Meridian Software and a Geocoded Image Correction System (GICS), runs on Microvax II. Other than raw satellite data, the system also accepts scanned, and converted analog-to-digital data. Raw Radar data is also accepted by using Generalized Synthethic Aperture Radar (GSAR) software.

The GIS component consists of Image Graphics System (IGS) built around an Advance Mapping System (AMS), which accepts manually digitized thematic maps as input data and is capable of generating plotted maps and graphics as outputs. Softwares for the PC-based component, which are used mainly for training purposes are Meridian PC for image processing and Tydac-Spans for GIS.

OPERATIONAL FRAMEWORK

The operational framework of the NRSP includes the Educational, Quasi-Governmental Bodies , Utilities and the Military. Data is provided through computer data files and hardcopies that are geocoded to the locally adopted referencing system of the country. In Malaysia, all spatial data derived from remote sensing / digitized thematic/ topographic maps and imported from any GIS must be referenced to the Malaysian Rectified Skew Orthomorphic (RSO) projection. Additionally, the software should be capable of transforming digital file in the RSO system to the Universal Transverse Mercator (UTM) projection or other geographic referencing systems. The conversion of RSO to UTM and vice versa is still considered to be at a semi-operational stage. This is because most of the land information data in Malaysia is based on the Cassini Solder Projection (CSP). In Peninslar Malaysia, cadastral maps have 9 different coordinate systems based on the CSP. To incorporate all land - related information and to support a fully operational remote sensing and GIS, the software must have the following capabilities: (1) conversion of RSO to UTM and vice versa; (2) conversion of all the 9 different states of Cassini Soldner based coordinate system to RSO and vice versa, and (3) conversion of RSO to other geographical coordinate and vice versa. To facilitate the establishment of a fully operational RSO-based IPS and GIS database in Peninsular Malaysia, the parameters listed in Table 1 are required.

TRENDS IN APPLICATIONS

The application of remote sensing technology spans a wide field, but in Malaysia photogrammetry and thematic air photo interpretation, are firmly established and their importance will not diminish significantly in the near future. The strength of air photo interpretation and photogrammetry techniques have been in spite of their often cumbersome methodologies , supported by large organizational networks built at the national level. The military and strategic importance of maps has meant

Table 1. RSO parameters for Peninsular Malaysia

Spheroid	Modified Everest
Semi Major Axis	6377304.1m
Flattening	1/300.8017
Eccentricity squared	0.006637846630200
Origin	4° 00' 00" N, 102° 15' 00' E of Greenwich
Scale factor at Origin	0.99984
False Coordinate Projection	E = 804671.28 m N = 000000 m
Initial line of projection	Passes through the origin in an azimuth of 323° 01' 01' 32.8458"

Source : MACRES 1991

that the Department of National Survey and Mapping (DNSM) had played significant roles in topographic and landuse inventorying of the country. Large scale thematic maps (of scales 1:10,000 and 1 : 25,000) is being prepared by the department and also the updating of the 1966 - 1:63360 topographic maps to 1:40,000 for the whole country. The DNSM is able to do this as staffs are fully trained and geared to thematic mapping and the availability of facilities for interpretation of the varied and multifacetted data from the air photos. These maps have provided sufficient inputs as prerequisites to various development planning carried out by government departments as well as researchers from the local Institution of Higher Learning

The modern age of remote sensing in Malaysia begins with the inception of MACRES (1989), acting as a pivotal point within the overall organizational framework. It could be said here that if the use of satellite imageries are associated with this modern age, then Malaysia could be considered an infant as compared to China, for example. However, this does not mean that the full potential offered by this new technology is not realised. The main problem is 'coping up' with the ever changing supply of technology and endless availability of remotely sensed data. Significant usage of SPOT and Landsat TM data have been used in ground inventorying, change detection studies, environmental consultation studies and general undergraduate academic exercises. However, the resultant maps produced though depicting spatial distribution and temporal changes do not compare too well with the interpretation from large scale aerial photographs.

The availabilty of microwave imagery through SEASAT, SIR-A, SIR-B, SIR-C, ERS-1 and JIR-1 would greatly expand the scope of operational remote sensing further and allow insight into phenomena of wind and waves and those affected by cloud cover (Carver et.al.1987) . Furthermore , SAR system for example provides oblique ilumination and can record information at different polarization. This would greatly influence research in 'stereo-imagery' for relief mapping and extraction of thematic information (Buchroitner 1989a), Mapping of geomorphological features, for example, could infer geological processes, is highly feasible in stereoscopic mode. The utility of SAR imagery for geological maping and cartography has been well documented, and the techniques for application of SAR imagery to these disciplines are established.

The sensitivity of SAR imagery to surface roughness, slope and the presence of water makes it an ideal instrument for geomorphological studies, for delineating structural and tectonic features , for discriminating lithological boundaries, and when stereo-pairs are available, for radargrammetric mapping (Khairulmaini 1996b).

The experiences with space - borne stereo radar are still limited, because there exist worldwide only a few stereo pairs and triplets of radar imagery from SEASAT and Shuttle Image Radar A and B (SIR-A and SIR-B). Longer - wavelength SARs (eg. L band) are also capable up to several meters in very dry aeolian sheets , furthermore the use of SAR to characterise the effects of faster - paced geologic and geomorphological phenomena could become invaluable particulary where cloud cover such is commonly associated with the Equatorial Tropics limits the use of optical data. Radar sensors can operate independent of weather and illumination, which implies that neither daylight nor season of data aquisition plays a role.This makes radar especially useful for future surface observation and monitoring in countries handicapped by problems mentioned earlier.However, the use of SAR data is not without limitations. Amongst the disadvantages noted, are (1) the processing of SAR data, for example, is very complex and time consuming, although real time processing is now feasible at special installations, (2) shadows occur where ground objects obstruct the passage of a radar pulse, and so information is lost, (3) resolution is variable with distance from the ground track, although this can be corrected by resampling, and (4) in mountainous areas serious geometric distortions in the imagery are created.

It thus becomes clear that the last 5 years or so, a wide variety of remote sensing tools including radar technology have been made available to Malaysia to add to the already well-endowed arsenal of aerial photo interpretation and photogrammetry. Yet there is also a more disturbing aspect to this endowment.Although the full potential of remote sensing data are generally understood, the use of data from such *passive and active microwave sensing systems* for inventorying of ground characteristics and in academic research are severely lacking. In the latter case, it is still considered more practical to use large scale B/W panchromatic air photos (1:10,000) in *change detection studies*, for example studies relating to vegetation and urban landuse changes and those associated with surficial processes and natural resource explotations (Khairulmaini 1988; 1993).

However, 5 years is a very short period to judge the impact of this technology, for example radar technology in Malaysia. Yet ,as a gauging yardstick the numbers of research cum-usage of radar data (for that matter other forms of satellite imageries) and publications in established journals are to my opinion at a very minimum.However, the technology is here to stay in Malaysia and it all depends on what kind of future actions should be taken amidst the rapid growth of the technology so as to fully utilised its potential.

EDUCATIONAL BACKGROUND AND HUMAN RESOURCES DEVELOPMENT

Human resources development is a key issue for future development in remote sensing applications in Malaysia. Radar technology compared to other satellite imageries though considered not to be affected by weather constraints, for example, is difficult to master. Two basic scientific requirements are needed here. Firstly, the remote sensers should be able to interpret the visual images - the holistic education that the geographer has undergone fits him very well for this purpose. However, thematic interpretation could also be carried out by a geologist, soil scientist and botanist. However these disciplines lacks the holistic ability to relate man as part of the spatial distribution as well as other environmental factors. Secondly, and a bit more difficult if the interpretation is based on digital processing a firm understanding of computer processing and applied statistics becomes crucial. It thus becomes clear that two categories of basic educational skills are needed , ie. visual interpretation and technical/computer skills. The young modern scientist should posess sufficient educational background and training which is holistic in approach.

Basic Educational Background

The concept of 'phenomena in space', to be more precise 'man in his environment' becomes a central issue in understanding the relationships of the spatial distribution patterns as been depicted by the images derived by air and satellite-borne sensors (Khairulmaini 1996a). This has always remain the central focus of Geographical studies - ie. what , where and why are objects as they are shown in the images (man-made or natural) are distributed accordingly, systematically or *chaoticly* in space. The training of the geography student, beginning from standard primary level education up to the tertiary level (standard geography curriculum) provides the necessary expertise and knowledge to meaningfully interpret such distributions. Geographical education provides the basic spatial overview of phenomena in space and time , especially that relating to man and his environment and is thus seen ,in my point of view, an important prerequisite for anyone to be fully appreciative and understand the use of spatial imageries. After all, maps has always been the geographer's basic tools and *close friend*.

In Malaysia, however, geographical studies in schools have taken a back seat. Geography as compared to other arts-based disciplines such as history and economics has been down graded from a core - subject in primary and secondary schools to just being an elective. This changes occur in the late 1980s when the education policy of the country began to favour subjects such as history, making them core subjects in secondary education. Futhermore, upper secondary science students are discouraged from taking geography in their 4th and 5th year, and those students taking geography are generally arts students choosing from a range of subjects ranging from religous studies to understanding living skills.

From about 40,000 students taking geography, as one of five subjects at the MHSC (Malaysian Higher School Certificate) level - equivalent to the GCE-A levels before late 1980s, the number has been reduced to about 17,000 in 1995. This marked reduction in student numbers would greatly influenced the quantity and quality of students wanting to pursue tertiary education in the country. The best students from this pool would either proceed to do economics, law and religous studies, while the average - mediocre students would go for arts -based subjects like history, social administration, gender studies and including geography, to name but a few. These students usually, have no MHSC mathematics and generally a credit at the MCE (Malaysian Certificate Examination), equivalent to the GCE-O levels. The scenario is set at least for the three premier universities in the country, The University of Malaya (UM), The National University of Malaysia (NUM), and the Sains University of Malaysia (SUM).In these universities the subject of remote sensing is formally taught in the department of geography under the techniques module, usually with minimum resources available.

Analytical Capabilties

Analytical capability is a prerequisite to a successful data analysis of satellite imageries and to facilitate technology transfer from developed to developing countries. However there is a serious lack of rigorous technical training in the local universities and are thus constraint in their ability to impart technically based knowledge when securing jobs with government departments and private companies. Usually such students have to undergo further on-job training before familiarising themselves with the technical aspects of remote sensing. However, science -based students (usually with no formal education in geography at the secondary level) who enters the departments of geology, physics, civil and electrical engineering, are also been exposed to remote sensing, though the numbers are very small. Furthermore, the number of written project papers by undergraduates and postgraduates students on subjects relating to remote sensing are generally very few. The Technical University of Malaysia (TUM), however, offers courses in remote sensing but are rather limited in its scope of teaching. However, the university do produce undergraduate and graduate students competent in the technical aspects of remote sensing.

It is imperative that those associated with data management operations must be exposed not only to the interpretation, analysis and applications of environmental and natural resources data available from satellite imageries but sufficient technical skills made available through an intensive educational process. Only an in-depth and continuous education programme can provide such knowledge and skills. Such an approach should provide an appropriate environment for the assimilation of the basic fundamental principles of remote sensing technology which would include the basic technical know how and interpretation, which is critical to the succesful development of knowledge in the discipline.

Short termed courses which are applications-oriented are usually conducted abroad, or on the job training at home. Such individuals are taught skills that are tailor-made for specific tasks. In most instances, it is impossible to adapt such skills to other tasks without fundamental knowledge and understanding of the basic principles and methodology involved. On the other hand technical experts or technical graduates who having gone through short-term courses or tertiary education in the technical and statistical aspects of remote sensing would be at a lost as how to apply the training gained to solve real-world problems.These graduates usually lacks knowledge in basic environmental processes and man-induced changes.

It is for this simple reason too, that the research application of remote sensing technology in water resources studies, forest and crop inventories, geological and mineral exploration, environmental management, including weather forecasting, agrometeorology, cartography and mapping and their subsequent use in the development of roads, pipelines, power lines and related engineering applications, land use and urban development, oil pollution survey and monitoring, assessment and management of coastal/marine environment and ocean resources, disaster assessment and the general monitoring of environmental impact of human activities are indeed seriously lacking (Khairulmaini 1996b).

Remote Sensing Education

The use of aerial photographs in ground surface interpretation and mapping has always been associated with the departments of geography and civil engineering since mid- 1960s.The latter especially stresses more on the photogrammetric aspects of air-photo interpretation whilst the former on visual air -photo interpretation. Courses on remote sensing was taught at the department of geography in the early 1980s. However, the departments of civil engineering and physic are beginning to show interests in the importance of satellite technology , but maybe for the wrong reasons especially on Information Technology (IT). Usually these are single unit courses involving 20 to 24 hours of lectures supplementing the overall course structure of the departments.

By the end of 1995, a number of undergraduate exercises on inventorying and change detection especially on the changing land use patterns in the Klang River Basin have been carried out, mainly by students from the department of geography. The main source of data used in such exercises are usually the Landsat TM imagery either through hard copy maps or digital data. Research activities and consultation studies, mainly on preliminary environmental impact assessment have also depended on visual interpretation of Landsat TM imageries. There have been no attempt so far to use radar -based imageries in class practicals and research work.

The scope and potential for using radar imagery in classroom practicals and research are, however, limitless. The subject matter of specific fields in geography, for example, geomorphology, urban and regional planning and water resources studies are always in need of new as well as greater accuracy techniques. The capability of stereoscopic viewing from SAR data, for example, could prove very useful in geomorphological mapping and terrain analysis and thus in the environmental impact assessment of an area (Buchroitner, 1989b).

However, the running of a remote sensing course in the department of geography are not without its problems, not to mention too the type of remote senser it is to produce. Remote sensing espeacially radar remote sensing as been mentioned earlier is a highly technical and scientific field. It would involve some understanding about the basics of optical physics especially that relating to the electro-spectra of the solar and terrestrial radiation. These fundamental principles would then influence, for example, one's understanding of spectral signatures and absorptivity of objects on the ground surface and the images formed (Barret and Curtis 1992). In relation to this is the skills and knowledge in image analysis. Again here there is a need for a certain standard of computing ability and analysis. As the technology advances the complicatedness of underlying principles and computing requirements would also increase. However, on a non-technical aspect the holistic ability to thematically interpret ground features would also form an important prerequisite.

From my point of view, basic MCE qualification in mathematics, physics and geography would form the necessary basic qualifications needed to undergo any remote sensing courses. However, sadly to say here, this criteria has never been the case with students associated with the departments attributed to remote sensing teaching in Malaysia. There are a number of reasons that can explain for these limitations. Firstly, the Ministry of Education's policy to make geography an elective arts subject at the secondary education level, secondly, geography does not come under the science stream in secondary level education. Thirdly, a more fundamental question is that affecting students choice of courses whether in science or arts based-departments. The better arts students with good geography grades (at the MHSC) need to be interested in pursuing a carreer in law or economics, while science students pursue carreers in mathematics, chemistry or physics. All these factors then influences the pool of qualified students who pursue courses and undertake research in remote sensing.

For example, in the Department of geography UM, there exists two full courses in remote sensing, ie.(1) fundamentals of remote sensing , and (2) remote sensing applications, and in to addition to these two courses there is a non-compulsoray graduation exercise where students could apply remote sensing skills (not necessarily so) in studying geographical processes. The academic background of the students are basically arts- based with some science students (the department of geography offers a BA and BSc in Geography). The science-based students are small in numbers, with minimum science subject qualifications and does not do geography at the MCE/MHSC level. Usually the science students fared fairly better than the arts based students and have found work with MACRES for example. However, the number of science - based students would become less in the future as a result of Government Policies and the main pool of geography students would come from the arts-based students who are generally very weak in mathematics and statistics and finds difficulty in understanding the fundamental principles of remote sensing.

The quality of students alone would not determine whether a balance remote sensing education could be achieve by any departments. Other factors should also be considered. Among the other important requirements which are generally lacking, is the availability of qualified teachers and supporting personnel, the number of remote sensing courses (theory as well as practical) that are offered , basic infrastructural facilities and finally the accessibility to computer hardware and software. In most cases these facilities are shared with other courses which could disrupts the teaching schedule of the remote sensing courses.

The problems discussed above are not easily solve as it involves government policies, students' perception and preference , priority in allocation of funds for human resources development cum training and not of least importance is the availability of funds for setting up basic infrastructure and computing facilities. These limitations would remain the basic major problems that needs to be overcome in the immediate future if a more balance education in remote sensing is to be realised.

It is for these basic reasons that I fully support the United Nations Committee On The Peacful Uses of Outer Space, 1993 as far as education is concern pertaining to development of skills and knowledge of university educators and formulating a long term curriculum structure for in-depth remote sensing education at both the primary and secondary levels.

CONCLUSION

The enormous importance of remote sensing in acquisition, transmission, processing, analysis and utilization of environmental information in natural resources development , environmental monitoring , implementation of social and economic programmes are very well understood in Malaysia. However, the utilization of the technology itself in research and *pure* applications are at a minimum. Many reasons could account for this but the most immediate problem is getting the right quality student to undergo a *tailor made* remote sensing programme at the undergraduate level supported by able teachers and physical infrastructures (hypothethically these students would form the *core thinkers and users* of the technology). These problems need to be solve if ever Malaysia is to move as fast as the technology itself It seems that from the very small number of published works and research conducted by the universities in Malaysia the utilization of remote sensing technology will generally lag far behind that the advancements made by the technology itself.

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