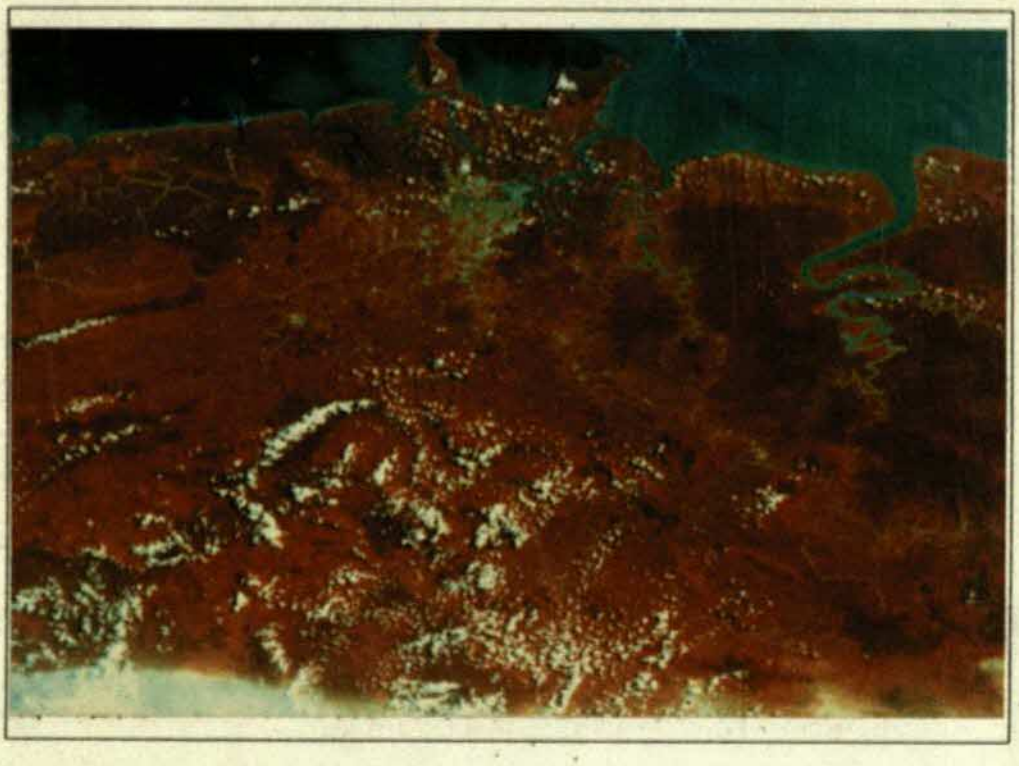
THE APPLICATION OF GIS IN SARAWAK - AN OVERVIEW AND PROPOSED STRATEGIES FOR PROPER IMPLEMENTATION OF GIS IN THE STATE

Dr. Karl Peter Kucera



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ACKNOWLEDGEMENT

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Front Page Picture: Satellite Imagery (Landsat) of Kuching - Samarahan Region

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THE APPLICATION OF GIS IN SARAWAK - AN OVERVIEW AND PROPOSED STRATEGIES FOR PROPER IMPLEMENTATION OF GIS IN THE STATE [2]

Dr. Karl Peter Kucera[1]

"In war the best weapon is often a good map. Yet in the modern office, maps are used only for decoration"

The Economist 1992

SUMMARY

Since mid eighties GIS technology has become one of the fastest growing sectors world wide. Pressure on resources and ever increasing demand on integration of sectoral planning requires application of spatial planning. The size, population distribution, physiography and associated need for infrastructure development make spatial planning highly significant topic in Sarawak. Implementation of GIS technology in Sarawak is a strategic, not a tactical issue needed to be addressed in an integrated, multi- level and multi - sectoral manner, within a specific time framework.

INTRODUCTION

.Definition

The Geographic Information System (GIS) is a system based on rather sophisticated software that consists of subsystems for input, storage, retrieval, manipulation, display, analysis and reporting of spatial data (Ardnoff 1989).

GIS covers systems that use computer hardware and software to manipulate and analyze a variety of data organised geographically (Asker at. al. 1992).

The most commonly recognised operation performed by a GIS is associated with combining a number of thematical overlays for the purpose of identification of specific spatial planning tasks.

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2 Paper Presented at the Sarawak GIS Conference, Kuching, 14-16 January 1993

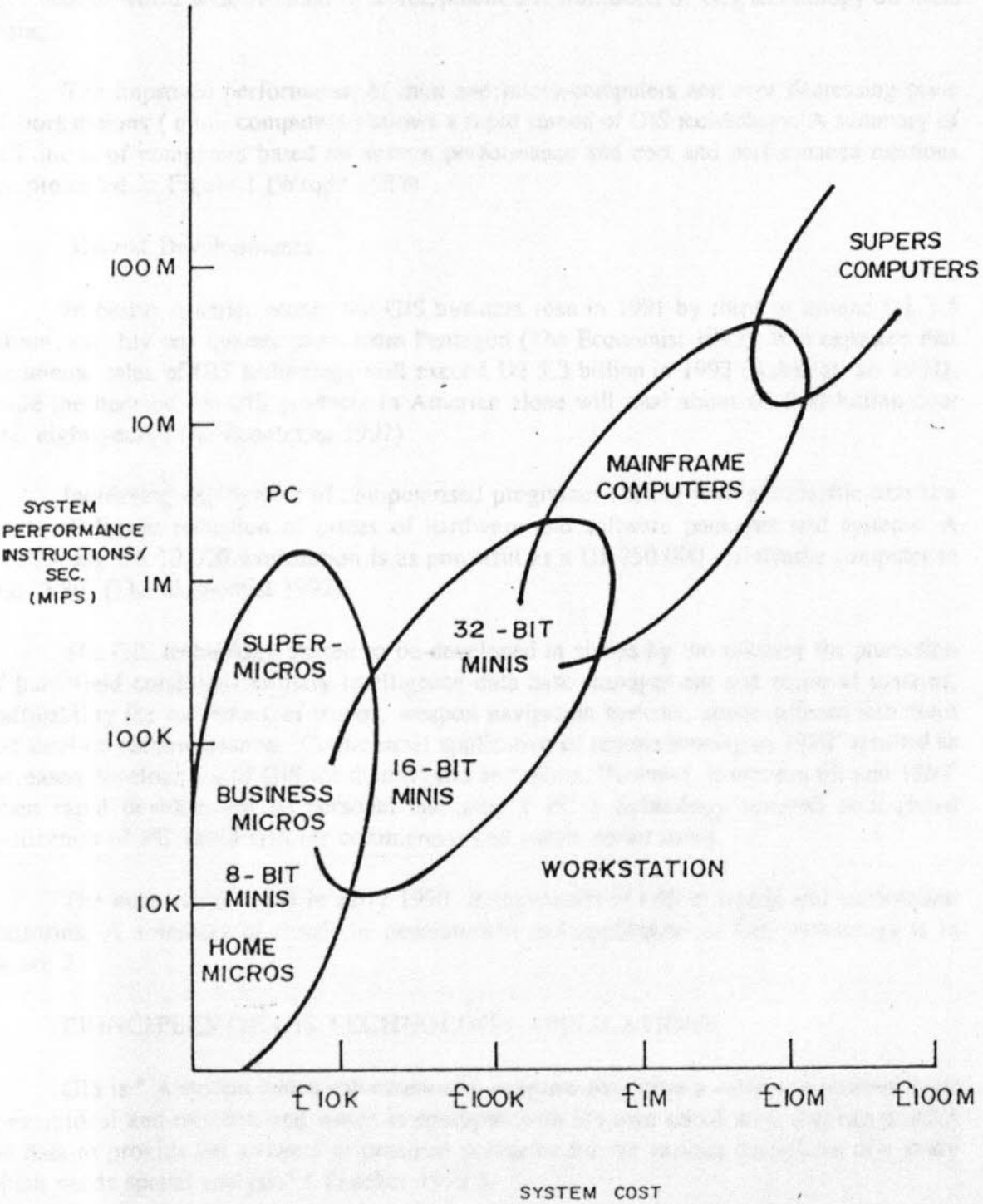


FIG 1 : COST AND PERFORMANCE OF DIFFERENT TYPES OF COMPUTER

MODIFIED FROM WRIGHT 1988.

Rapid development of computer technology and demand on utilisation of spatial information world wide resulted in development and utilisation of GIS technology on mass scale.

The improved performance of mini and micro-computers and ever decreasing price of workstations (mini- computers) allows a rapid spread of GIS technology. A summary of definitions of computers based on system performance and cost and performance relations are presented in Figure 1 (Wright 1988).

.Recent Developments

In North America alone, the GIS business rose in 1991 by third to around U$ 3.5 billion, roughly one quarter came from Pentagon (The Economist 1992). It is expected that the annual sales of GIS technology will exceed U$ 5.3 billion in 1992 (Asker at. al. 1992), while the demand for GIS products in America alone will total about U$ 100 billion over next eight years (The Economist 1992).

Increasing deployment of computerised programes dealing with geographic data is a result of drastic reduction of prices of hardware and software packages and systems. A present day U$ 10 000 workstation is as powerful as a U$ 250 000 mainframe computer in mid 1980' (The Economist 1992).

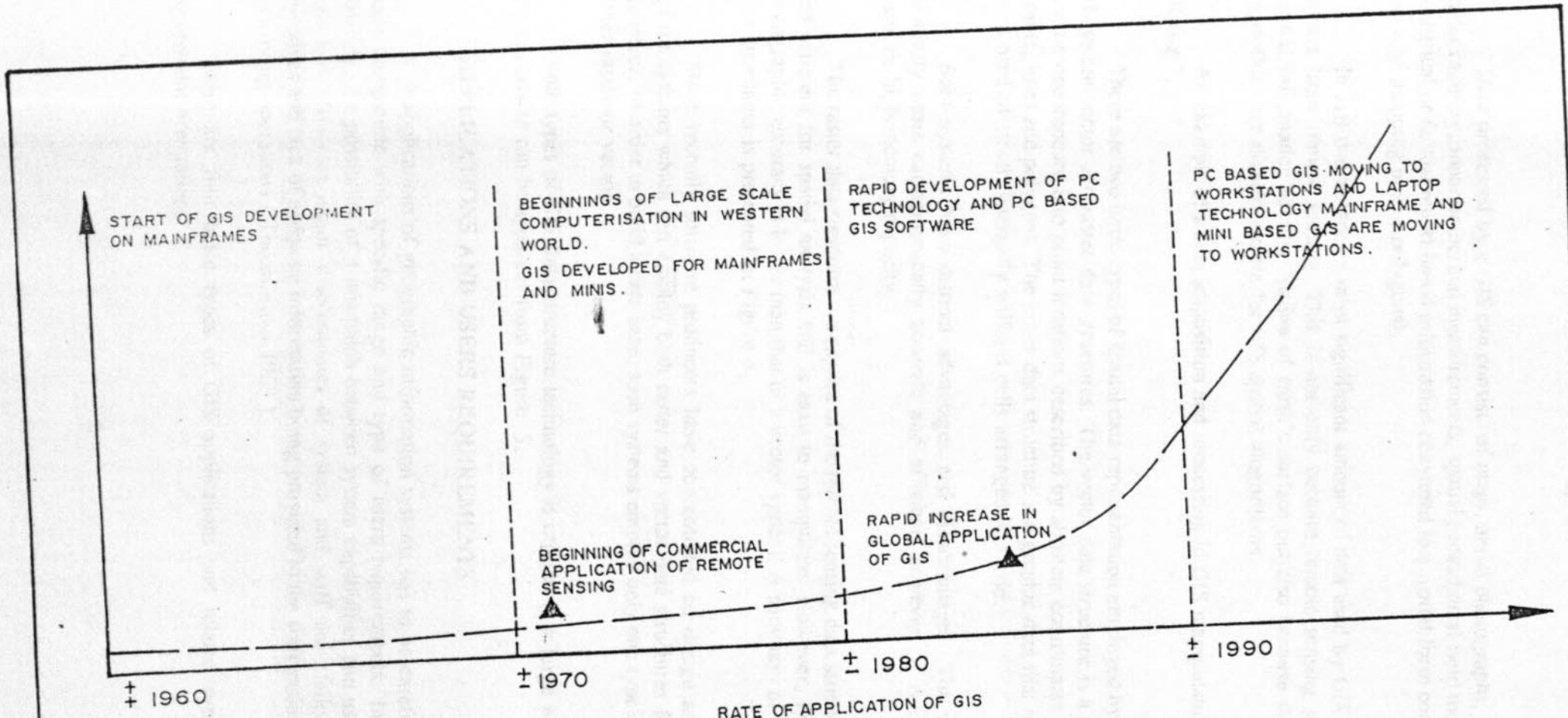
The GIS technology started to be developed in sixties by the military for prediction of battlefield conditions,military intelligence data base management and retrieval systems, trafficability for movement of troops, weapon navigation systems, space defence initiatives and satellite reconnaissance. Commercial application of remote sensing in 1970' resulted in increased development of GIS for mainframes and minis. However, it was not till mid 1980' when rapid development of personal computer (PC) technology resulted in a global application of PC based GIS for commercial and public sector users.

The most recent trend in early 1990' is movement of GIS to laptop and workstation platforms. A summary of trends in development and application of GIS technology is in Figure 2.

PRINCIPLES OF GIS TECHNOLOGY APPLICATIONS

GIS is " A system which can essentially integrate data from a variety of sources, both conventional and modern, and which is equipped with it's own set of tools that can process the data to provide the answers to practical problems for the various disciplines of a study which needs spatial analysis" (Peucker 1979).

In principle the GIS allows manipulation of spatial data that is geographically referenced and is located on an identifiable part of the earth surface. The location of such data is represented by geographic coordinates and nature of the data is expressed usually by a thematical map with a legend describing, qualifying and often quantifying data through a hierarchy and classification.



Source: Modified from Dr. Kam 1990

Fig 2 GIS AND TRENDS IN HARDWARE DEVELOPMENT

Data processed by a GIS can consist of maps, aerial photographs, satellite imagery, radar imagery, sonar or thermal measurements, spatial geotechnical field records or any other statistical or factual report based information converted to a spatial form consisting of points, lines or mapping units (polygons).

In last two decades a most significant amount of data used by GIS for manipulation comes from remote sensing. This is not only because remote sensing provides required spatial information about a section of earth's surface but also because the image analysis algorithms are directly usable for GIS spatial alogorithms.

An example of a data acquisition and processing in GIS manipulation is presented in Figure 3.

There are two basic types of spatial data representation employed by GIS technology. These are vector and raster data structures. The vector data structure is a graphic data that can be decomposed into point locations described by absolute coordinates x,y and includes points, lines and polygons. The raster data structure is a graphic data that represents images composed of small, internally uniform cells arranged in a grid.

Both systems have distinct advantages and disadvantages. The vector system is generally more cartographically accurate and efficient, however, it is too complex and requires high memory capacity.

The raster data structure is a replica of the remote sensing data structure and is simple and efficient for spatial analysis and is easy to manipulate. However, the positional and cartographic accuracy is lower than that of a vector system. A summary of vector and raster data structures is presented in Figure 4.

More recently software producers have concentrated on design and production of hybrid systems which can employ both raster and vector data structures for data analysis. However, in order to build a data base, such systems employ only one type of data structure, either raster or vector.

Both types of GIS data structure technology is utilised in a large number of spatial applications as can be apparent from Figure 5.

APPLICATIONS AND USERS REQUIREMENTS

The applications of geographic information systems has to be carefully planned and made compatible with specific range and type of users requirements. In the absence of planning, the possibility of a mismatch between system capabilities and user needs is very high and results in major diseconomies of system and staff use, failed data handling objectives and lack of adequate information being provided to the staff making decisions and controlling operations (Thomlinsom 1989).

There are four basic types of GIS applications and related system design and requirement orientations:

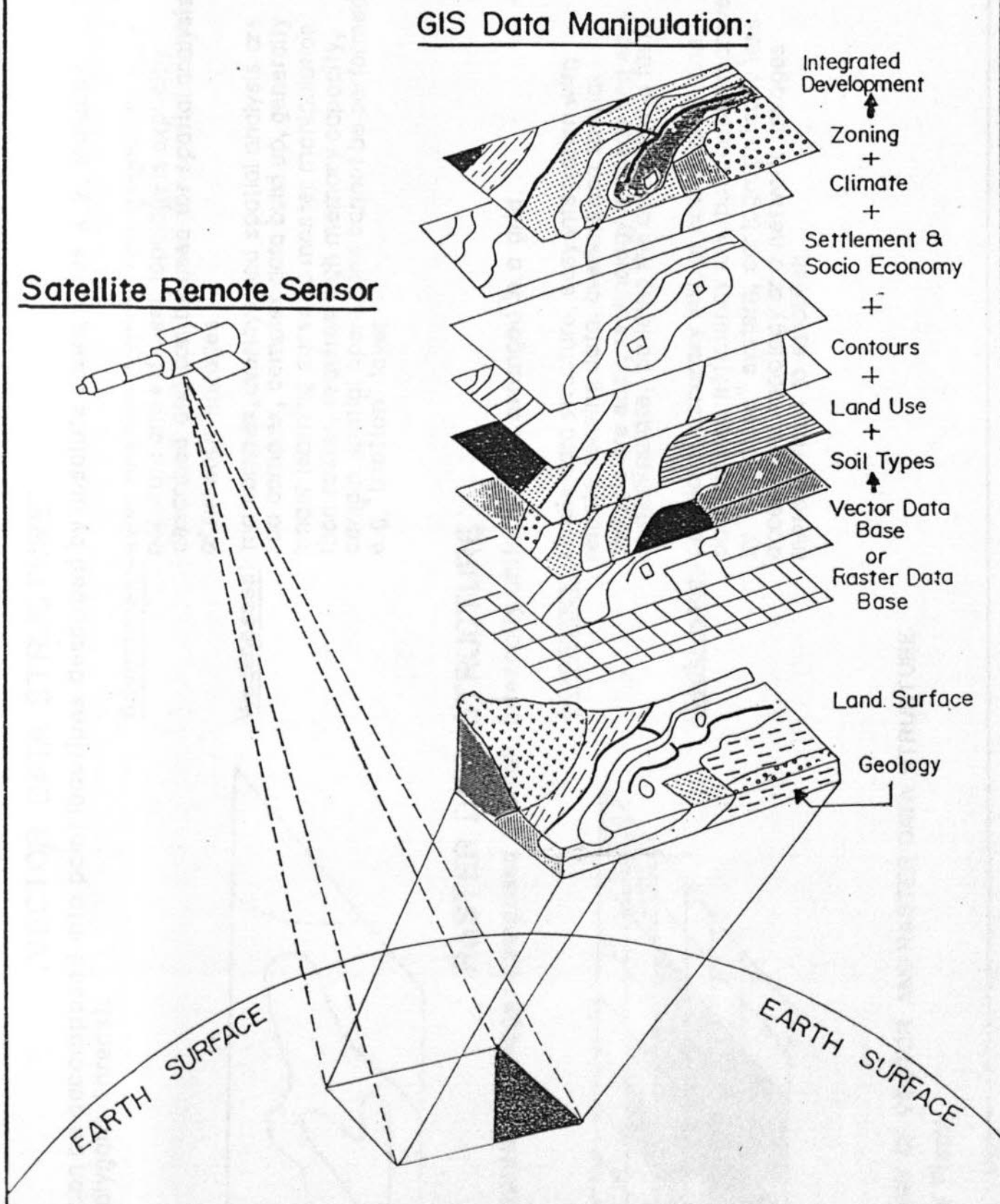
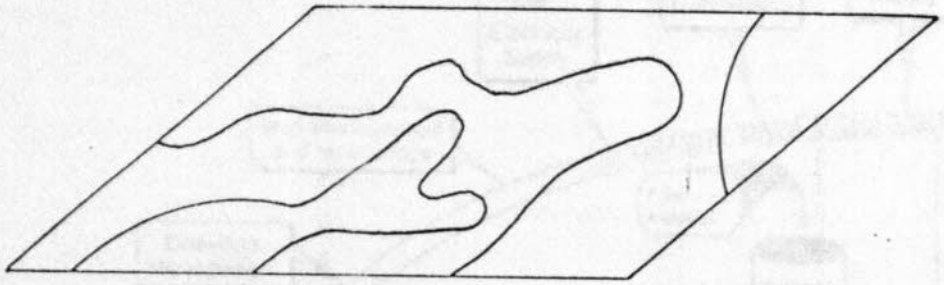


Fig. 3 AN EXAMPLE OF DATA ACQUISITION AND PROCESSING IN GIS APPLICATIONS

VECTOR DATA STRUCTURE:

Graphic data that can be decomposed into point locations described by absolute coordinates x, y, includes points, lines and polygons (areas).

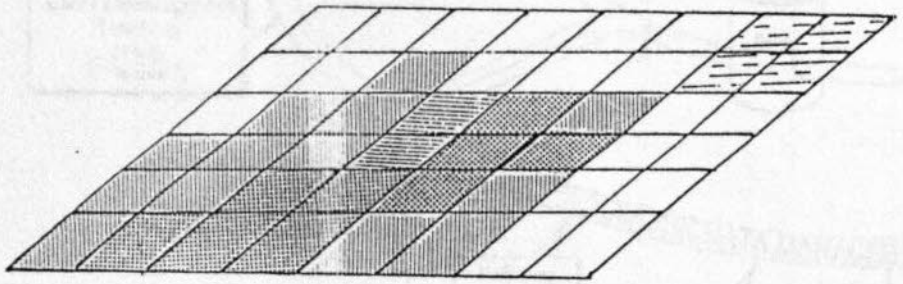


Advantages:- exact position location, cartographically more accurate and efficient, topology is explicitly described and can be used for spatial analysis of network linkages.

Weaknesses:- too complex, overlays and spatial analysis are too complex, complex data build up, generally longer learning curve to master manipulation than raster, requires high memory capacity, certain spatial operations cannot be performed e.g. "friction" layer.

RASTER DATA STRUCTURE:

Graphic data that represents images composed of small, internally uniform cells arranged in a grid.



Advantages:- simple data structure, easy integration with remote sensing data, overlays and spatial analysis are easy, technology is cheap and easy to manipulate, building the data base is fast.

Weaknesses:- positional accuracy low, at coarse resolution, data storage efficiency low, but can be improved by "quadtree" system, cartographically less acceptable, topology and network linkages more difficult to establish.

Fig. 4 SUMMARY OF VECTOR AND RASTER DATA STRUCTURE

Modified From:

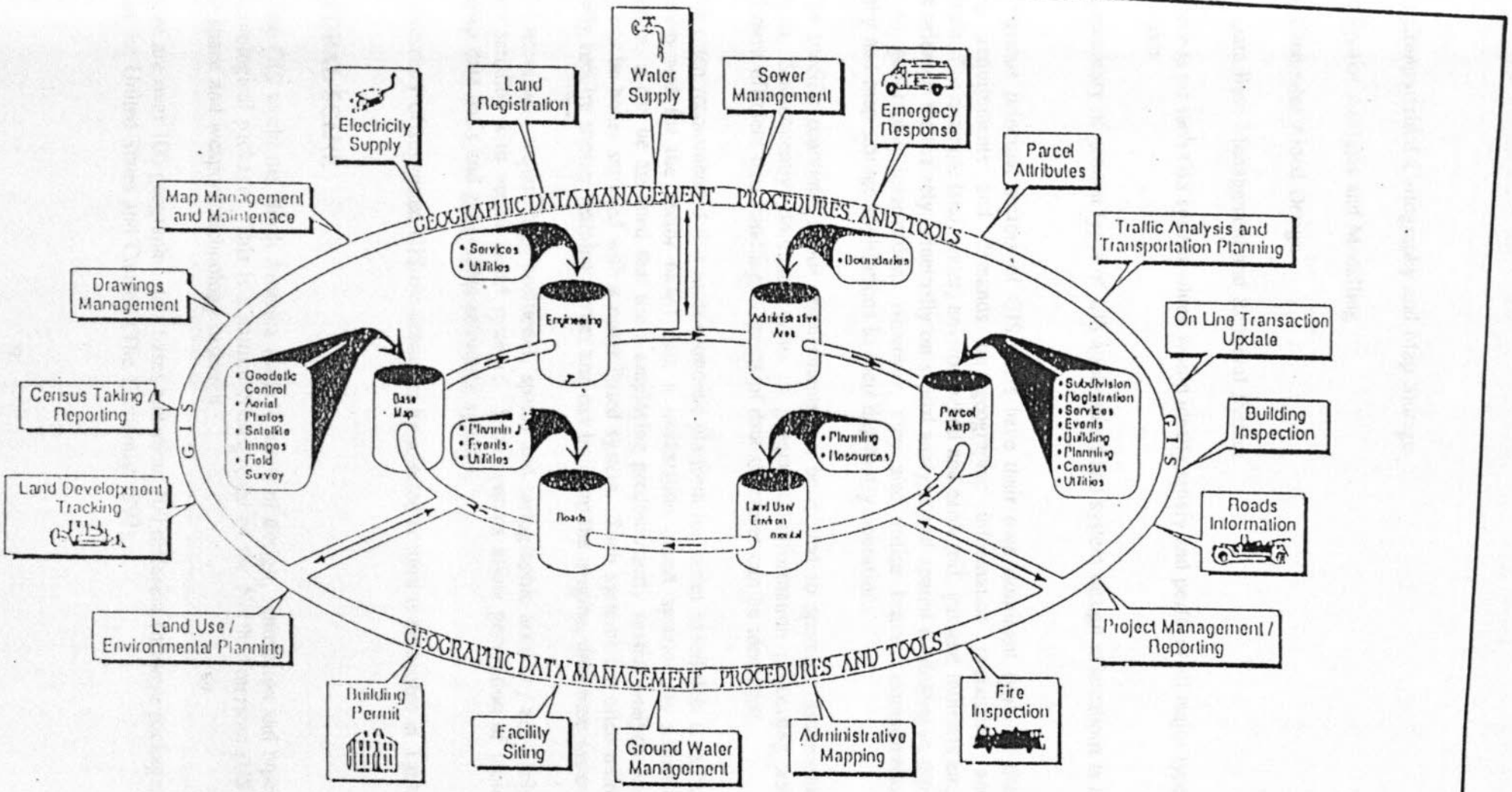


FIG. 5 : SUMMARY OF GIS APPLICATIONS

1) Computerised Cartography and Map Storage

2) Spatial Analysis and Modelling

3) Computer Aided Design

4) Data Base Management and Retreival System

There is no such GIS system which would ideally satisfy and perform all major types of applications.

A summary of general types of GIS applications and system design orientations is in Figure 6.

Various principal sectors of GIS users have their own dominant types of data processing requirements and demands on geographic information processing and manipulation. For example land, water, environmental and earth (oil, gas and minerals etc.) resources oriented sectors rely principally on spatial analysis and spatial modelling in their handling of geographic information. However, they also utilise heavily computerised cartography and map storage applications in their day to day operations.

The specific economic sector requirements can be related to specific institutional requirements. Subsequently, dominant types of geographic information processing and suggested most efficient data handling in terms of data structures can be identified.

It is often recommended that most economic platform for raster based data is a PC based system and for the vector based data a workstation based system. As a broad generalisation, it can be assumed that users employing predominantly spatial analysis and modelling can be better satisfied with a raster based system. Such systems are often more user friendly require shorter learning curves and can build up the original data base faster.

The users who require high positional, spatial and cartographic accuracy are likely to be more satisfied with vector based systems. Such systems allow generation of more accurate map data basis and geographic reference systems.

A summary of suggested GIS requirements by selected sectors is presented in Table 1.

GLOBAL SCENE

In the GIS world the North America leads in terms of design, innovation and types of GIS technological packages. This is a natural consequence of the North American (US) lead in the space and weapons technology research.

There are over 100 geographic data bases and about 200 different software packages available in the United States and Canada (The Economist 1992).

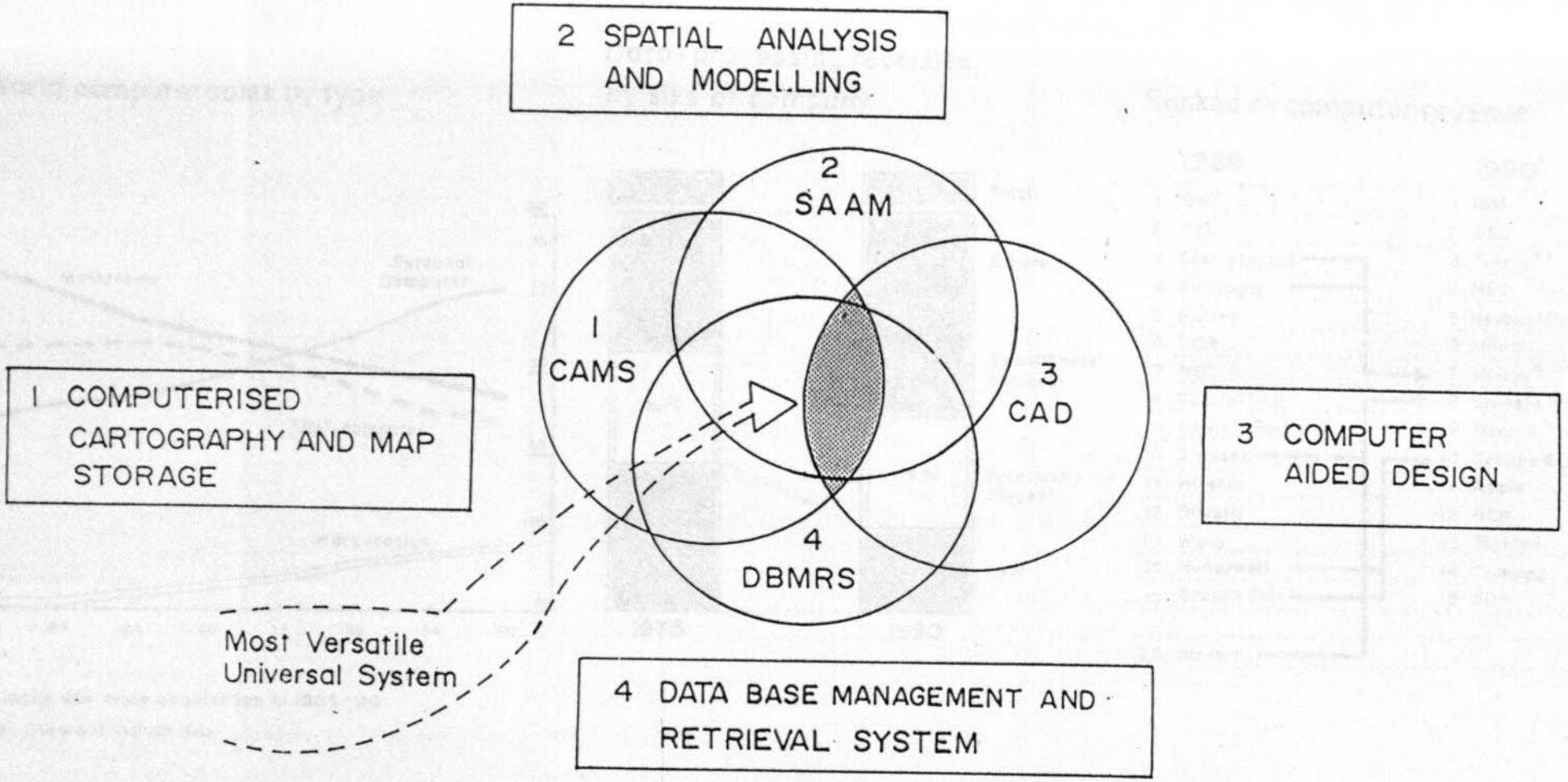
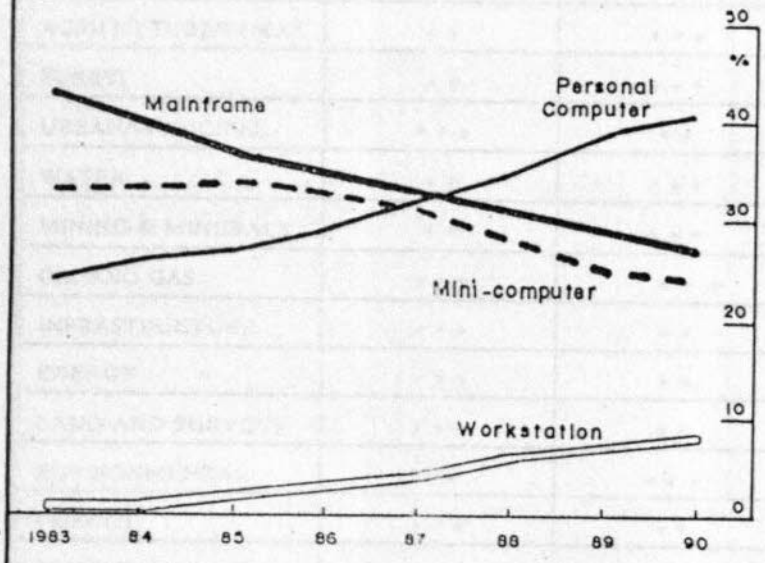
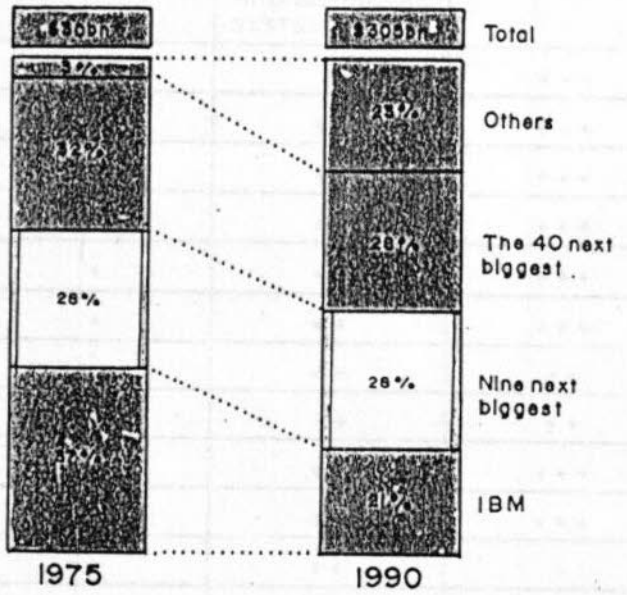


Fig. 6 SUMMARY OF GENERAL TYPES OF GIS APPLICATIONS AND SYSTEMS DESIGN ORIENTATION

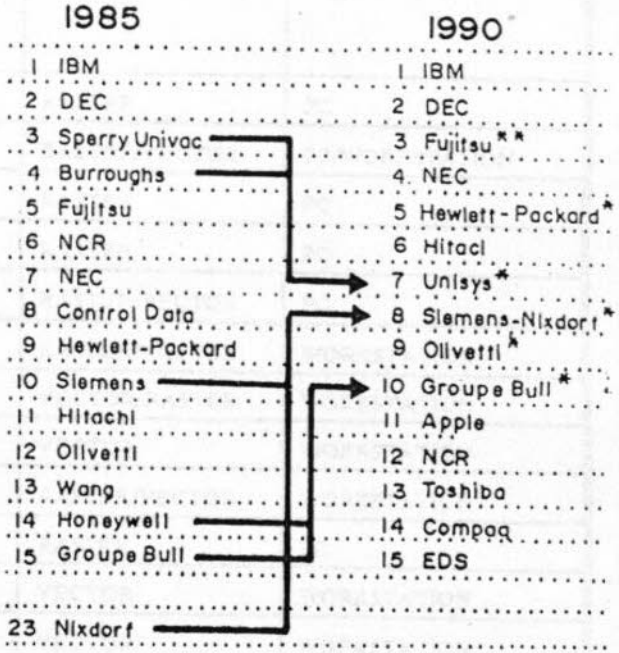
World computer sales by type



Data-processing revenues, by size of company



Ranked by computer revenue



* made one more acquisition in 1985-90

** does not include ICL

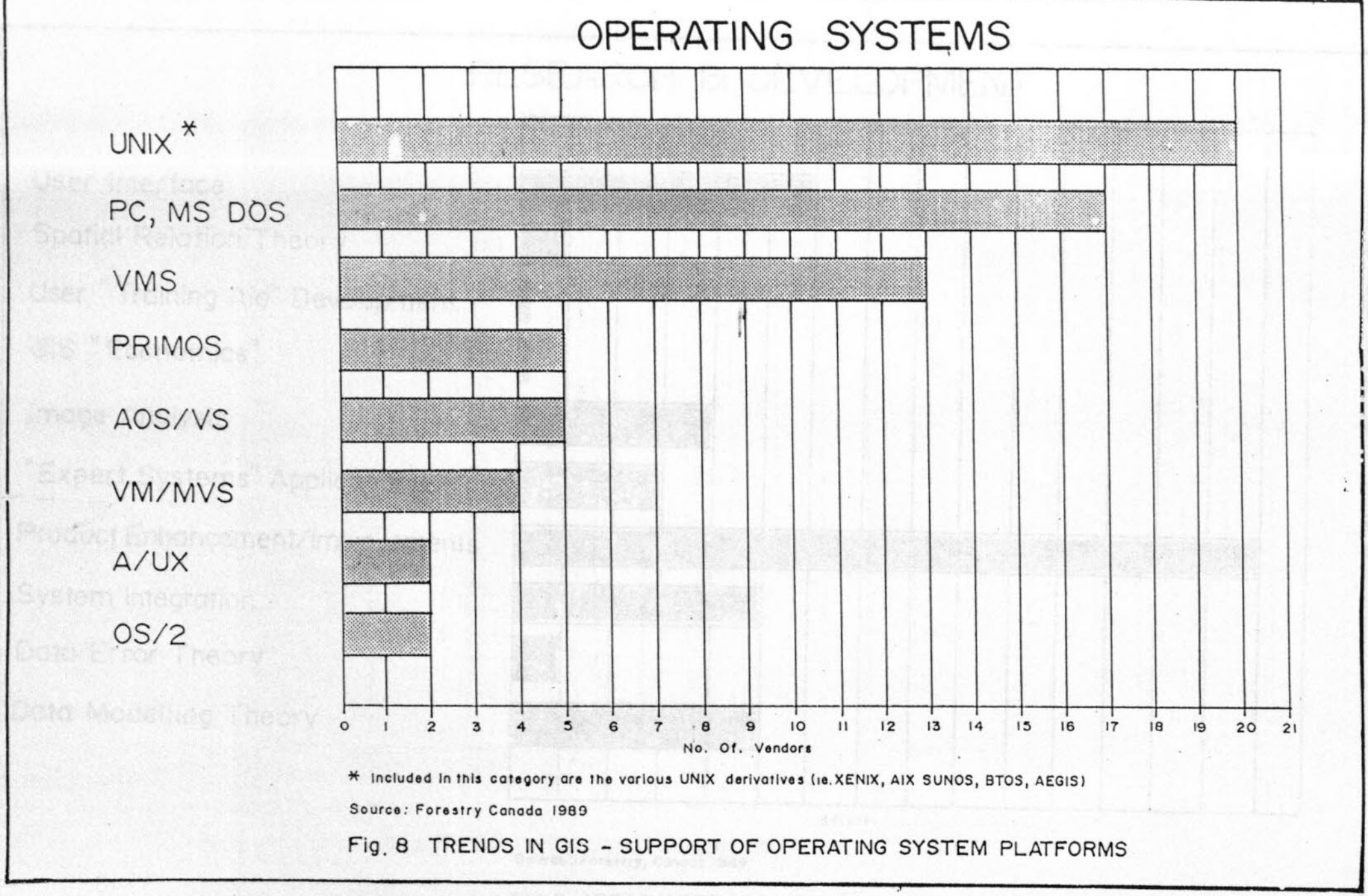
Source: Datamation; Annual Reports; McKinsey, 1992

Fig. 7 World Computer Sales by Type

TABLE 1 SUMMARY OF SUGGESTED GIS REQUIREMENTS BY SELECTED SECTORS

RESOURCES SECTOR	DOMINANT TYPE OF GEOGRAPHIC INFORMATION PROCESSING					SUGGESTED MOST EFFICIENT DATA HANDLING	MINIMUM SUGGESTED PLATFORM
	COMPUTERISED CARTOGRAPHY AND MAP STORAGE	SPATIAL ANALYSIS AND MODELLING	COMPUTER AIDED DESIGN	DATA BASE MANAGEMENT AND RETRIEVAL SYSTEM	REMOTE SENSING		
AGRICULTURE/RURAL	+	+++	+	+	+++	RASTER	PC
FOREST	+	+++	+	++	+++	RASTER/VECTOR	PC/WORKSTATION
URBAN/MUNICIPAL	+++	++	+	++	+++	RASTER	PC
WATER	+	+++	+	++	+++	RASTER	PC
MINING & MINERALS	+	+++	+	++	+++	RASTER/VECTOR	PC
OIL AND GAS	+++	+++	+	++	+++	RASTER/VECTOR	WORKSTATION
INFRASTRUCTURE	+++	++	++	++	++	VECTOR/RASTER	WORKSTATION
ENERGY	+++	++	++	++	++	VECTOR	WORKSTATION
LAND AND SURVEYS	+++	++	+	++	+++	RASTER/VECTOR	WORKSTATION
ENVIRONMENTAL	+	+++	+	++	+++	RASTER	PC
HEALTH	+++	++	+	++	+	VECTOR	WORKSTATION
EDUCATION	+++	++	+	++	+	VECTOR	WORKSTATION
INDUSTRIAL DEV'T/ MANUFACTURING	+++	++	++	++	++	RASTER/VECTOR	WORKSTATION
SOCIO-ECONOMY	+	+++	+	++	+	RASTER/VECTOR	PC/WORKSTATION
MULTI-SECTORIAL PLANNING	+	+++	+	++	+++	RASTER	WORKSTATION
TRANSPORTATION	+++	++	++	++	++	VECTOR	WORKSTATION

NOTE: PRIORITY LEVEL +++ .... Very High, ++ .... High, + ... Moderate.

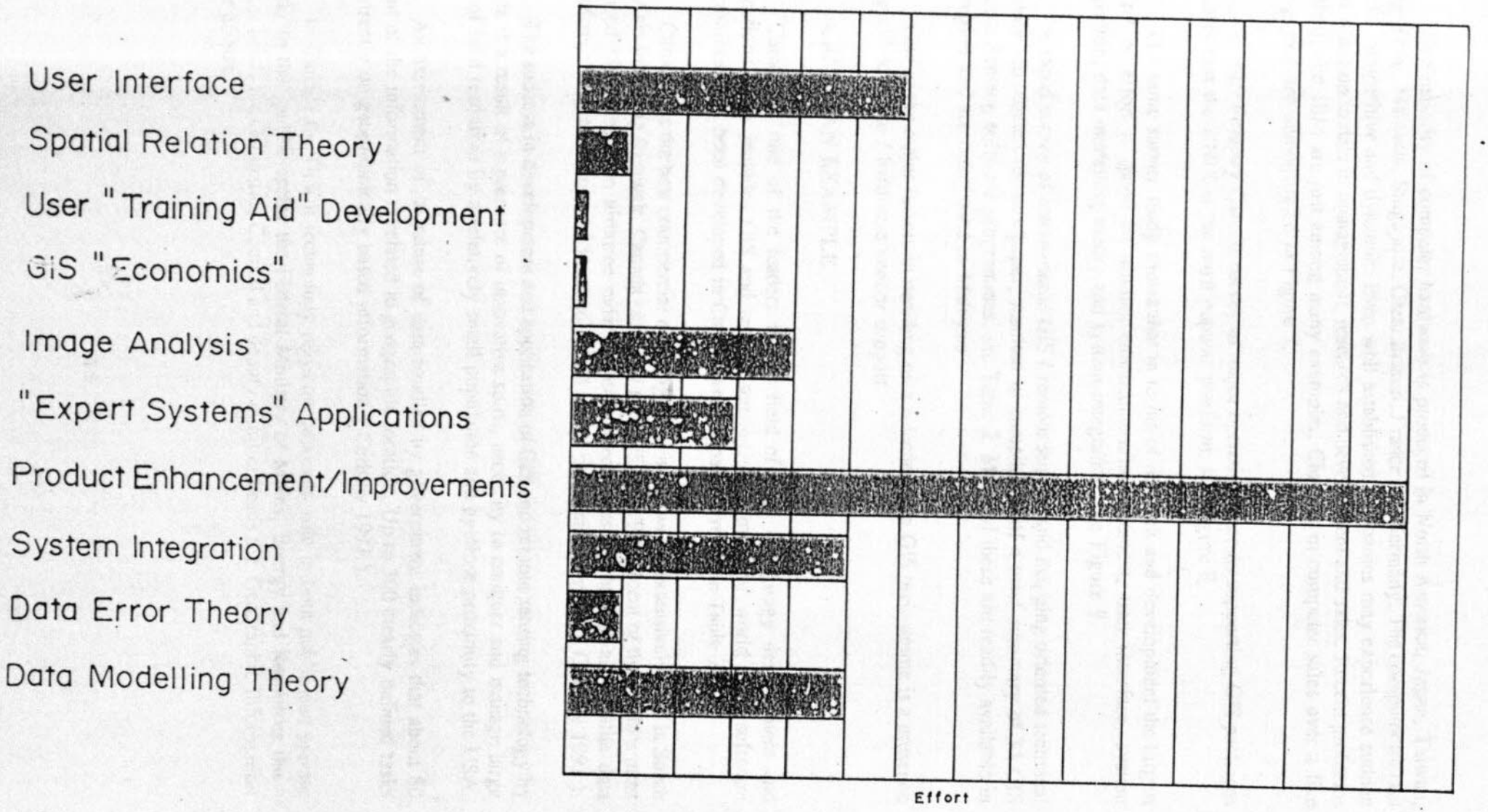


* Included in this category are the various UNIX derivatives (ie. XENIX, AIX SUNOS, BTOS, AEGIS)

Source: Forestry Canada 1989

Fig. 8 TRENDS IN GIS - SUPPORT OF OPERATING SYSTEM PLATFORMS

RESEARCH & DEVELOPMENT



Source: Forestry, Canada 1989

Fig. 9 AREAS OF RESEARCH AND DEVELOPMENT IN GIS TECHNOLOGY

The majority of computer hardware is produced in North America, Japan, Taiwan, Hong-Kong, Malaysia, Singapore, Great Britain, France and Germany. The computer market is very competitive and dynamic. Even well established companies may experience sudden crisis if not up to date in management, research and development and sales. Recent problems of Wang and IBM are just among many examples. Changes in computer sales over a five year period are demonstrated in Figure 7.

A 1989 Forestry Canada survey of major operating systems supporting GIS packages indicates that the UNIX is the most popular platform, see Figure 8.

The same survey study shows that in terms of research and development the largest amount of effort is spend on product enhancement/improvement, user interface, system integration, data modelling theory and system integration, see Figure 9.

A rapid survey of international GIS / remote sensing and mapping oriented technical literature, conducted for this paper, resulted in compilation of a brief summary of 34 GIS /Remote Sensing software programmes, see Table 2. Many of these are readily available in this region and are being used in Malaysia.

One of the major factors in deciding on a selection of a GIS programme is a presence of a good software / hardware vendor support.

CANADIAN EXAMPLE

Canada is one of the leaders in the field of high technology development and applications. This includes GIS and remote sensing. A number of world class software programmes have been developed in Canada as is apparent from the Table 2.

Canada has the best commercial mapping radar in the world extensively used in South East Asia including Sarawak. Canada currently supplies some 90 percent of the world's most advanced high resolution airborne radar systems, electronics for half of all satellite data ground receiving stations and 25 percent of all image processing systems (Corbley 1991).

The success in development and application of GIS and remote sensing technology by Canada is a result of a presence of innovative spirit, necessity to conquer and manage large mass of land resources by a relatively small population and by close proximity to the USA.

An assessment of a nature of data handled by government indicates that about 80 percent of the information is related to geographic location. Up to 300 clearly defined tasks rely directly on geographically based information (Corbley 1991).

In Canada the GIS at technology plays an important role in both public and private sectors. In the public sector the Federal Ministry of Mines, Energy and Resources the minister heads the Geomatics Council and deputy minister heads the Geographic Information Sector affairs.

The GIS education is handled by principally by the Canadian Centre for GIS in Education but also by the Canada Centre for Remote Sensing and the Canadian Remote Sensing Training Institute, see Figures 10 to 12.

Both the Federal and Provincial Governments have been involved in a number of GIS oriented projects. Among significant achievements are for example the National Digital Topographic Database consisting of 917 1 : 250 000 scale and 12 922 1 : 50 000 scale topographic sheets available in digital form, the Automated Canada Land Information System and the Inland Waters, Coastal and Ocean Information Network (External Affairs and International Trade 1991, Anderson 1989).

A summary of some of the major government agencies and programs dealing with GIS technology is in Figure 13.

In the private sector a national non-profit organisation GIAC, or the Geomatics Industry Association of Canada, represents and promotes interests of commercial firms in remote sensing, GIS, surveying and mapping.

It has been formed in 1961 under Federal Charter and has grown from the initial eight to present eighty members (External Affairs and International Trade 1991).

The purpose of the GIAC is to promote its member firms as a source of high quality professional work in all related areas in Canada and around the world. The international work is usually carried out through the Canadian International Development Agency, the World Bank, United Nations Development Programme and various regional Development Banks. The Association is involved in strengthening business climate, marketing, research and development, application of new technology, consulting and promotion with public and private sectors.

The objectives of the Association are being met through the activities of GIAC Standing Committee, and Special Task Forces and Working Groups which are established from time to time (External Affairs and International Trade 1991).

REGIONAL GIS APPLICATIONS IN ASEAN

A rapid economic development and extensive utilisation of biophysical and socio-economic resources in the South East Asian region has been characterised by development and application of high technology such as remote sensing and GIS.

In the East Asia, countries such as India and Japan have developed their own remote sensing satellites and there are satellite receiving stations in Hyderabad, Bangkok, Tokyo, Peking and one under construction in Ujung Pandang.

In the Asean, there is regional remote sensing centre in Bangkok and national remote sensing centres in Kuala Lumpur and Jakarta. These are among the major institutions dealing with applications of remote sensing and GIS.

In Malaysia the National Remote Sensing Centre in Kuala Lumpur is engaged in implementation and support of a national level programe aimed at effective management of agriculture and natural resources based industry and to provide integration between the remote sensing and GIS data into a spatially referenced environment (Nasruddin 1991).

TABLE 2: SUMMARY OF SOME MAJOR GIS/RS SOFTWARE PROGRAMMES

TYPE OF SYSTEM (PROGRAMME)	DATA HANDLING	COUNTRY OF ORIGIN	OPERATING SYSTEM	PLATFORMS	DOMINANT APPLICATION	TYPE OF ANALYSES	USER FRIENDLINESS	PRESENCE OF SUPPORT OFFICES		APPROX. PRICE	SPECIAL FEATURE
								WEST M'SIA	SARAWAK		
1. SPANS-TYDAC	Quadtree	Canada	DOS, OS/2 AIX	PC Workstation (RS 6,000)	GIS	Spatial Analysis Inter. Point Data Modelling	Good	+	+	±US$20,000	Space saving, Good rang of Spatial Analysis. User Friendliness. Complex Digitizing Module
2. TERRASOFT	Vector (Hybrid Raster)	Canada	DOS	PC	RS	Spatial Analysis	Good	+	-	±US$15,000	
3. EARTHPROBE	Raster	Canada	DOS	PC	RS	Image Processing	Moderate	?	?	±US$10,000	
4. PCI E. PACE	Raster	Canada	DOS UNIX OPEN Intergraph 2-6000	PC Workstation Workstation	RS	Image Processing	Good	+	+	±US$5000-46000	Good GIS Modules Good Radar Module
5. ARRIES II & III	Raster	Canada	VAX	Minicomp./ Workstation	RS	Image Processing	Good	+	-	±US$	
6. QUICKMAP	Vector	Canada	DOS	PC	Basic GIS			?	+	±US$3,000	
7. GENASYS	Vector (Hybrid Raster)	Australia	UNIC, SUN, CDC WANG, IBM, RISC/600 etc Open Systems	Workstation	GIS	Topological Vector based GIS	Moderate	+	-	±US$	
8. GRASS	Raster (Hybrid)	USA	UNIC MASSCOMP	Workstation	GIS/RS	Area Analysis and Modelling	Moderate	?	-	±US$22,000	
9. ER MAPPER	Raster	Australia	SUN or UNIX (X window)	Workstation	RS/GIS	Mainly Image Processing, Some Area Analysis	Moderate	?	-	±US$14,000	

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10. SICAD-HYGRIS	Hybrid	Germany	Proprietory	Workstation	CAD/GIS/RS	CAD Functions Spatial Analysis Image Processing	Moderate	-	+	±US$	
11. ERDAS	Raster	USA	UNIX-Open DOS DEC VAX (VMS)	Workstation PC Minicomputer	RS Some GIS	Image Processing Overlay Basic GIS	Good	+	-	±US$15,000	Very User Friendly
12. TELLUS	Vector	Canada		Workstation	GIS	Spatial Analysis and Modelling	Moderate	?	?	±US$	
13. IDRISI	Raster	USA	DOS	PC	GIS/RS	Spatial Analysis, Basic Image Processing	Good	+	-	±US$150	Good Training Tool, Project Usable, Very Low Hardware Requirements.
14. ACAD	Raster	USA	DOS	PC	CAD	Overlays, Design	Moderate	+	+	±US$3,500	Good Cartigraogue Products, Not Geo-referenced
15. ARC-INFO	Vector PC Vector Hybrid WS	USA	DOS UNIX, SUN DEC VAX IBM (MUS/XA)	PC Workstation Mini & Mainframe	GIS Cartography	Spatial Analysis, Modelling Interpolation of Point Data Management	Low to Moderate	+	+	±US$3,800 (PC) P1000	Sophisticated Support, Very Good Cartographic Product, Data Management

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								WEST M'SIA	SARAWAK		
16. ILWIS	Hybrid (Vector/Raster)	Nertherland	DOS	PC	GIS/RS	Image Processing, Spatial Analysis Modelling	Good	+	-	±US$	Very User Friendly, Simple Digitizing, Good for Tutories, RS/GIS Modules.
17. INTERGRAPH	Vector (Hybrid Raster)	USA	Intergraph UNIX (RISC) also Integraph Micro	Worksation, PC	GIS/CAS RS	Image Mapping, Spatial Analysis Modelling CAD Functions.	Moderate	+	+	±US$	Selfcontained Well Established, Very Good Cartographic Product
18. SYSTEM 9	Vector?	Switzerland	Sun	Microsystem/ SPAN	CAD	Date Capture Management	Moderate				
19. MAP INFO	Simple Vector	USA	Dos Macintosh MS DOS SUN HP	PC PC PC Workstation Workstation	CAD Some GIS	Spatial Data Management Area and Perimeter Calculations	Good	-	+	±US$3,500	
20. GEOVISION	Vector	Canada	UNIX Multi Hardware	Workstation	GIS	Spatial Analysis and Modelling	Mod	?	?	±US$	
21. RMS	Simple Vector	USA	Apple	PC	CAD	Resource Measurement System	Good	-	+	±US$	
22. I²S	Raster	USA	SUN DEC Micro Vax	Minicomputer	RS	Image Processing	Moderate to Good	?	-	±US$	
23. DRAGON	Raster	USA	?	Minicomputer	RS	Image Processing	Moderate to Good	?	+	±US$	Good for Training
24. RAMAP	Hybrid?	Canada	UNIX	Workstation	GIS	Ingegration of GIS and RS Data, Spatial Analysis	Moderate to Good	?	?	±US$	

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								WEST M'SIA	SARAWAK		
25. R SVGA RSV 1-3	Raster	Canada	DOS	PC	RS	Image Processing	Good	?	?	±US$	Very Cheap. Easy to Operate
26. OVERVIEW	Raster	Canada	SUN Open Windows	Workstation	RS	Image Processing	Good	?	?	±US$	Easy to Operate
27. SPANS MAP	Raster	Canada	OS/2	PC	DBMS for GIS	Integration of Spatial and Management Data	Good	+	+	±US$700	
28. MARIDIAN	Raster	Canada	Micro VAX	Minicomputer PC	RS	Image Processing	Moderate	+	+	±US$	
29. MAP	Raster (Grid)	USA	DOS	PC	GIS	Spatial Analysis Interpolation Point Data	Low to Moderate	?	?	±US$	Extensively Used by Canadian Remote Sensing Centers
30. CARIS	Vector	Canada	UNIX SUN	PC:Workstation	GIS	Mainly Marine Applications, Some Gen. GIS	Moderate	+	+	±US$33,000	
31. LANDSCAN	Raster	Canada			RS	Image Processing	Moderate	?	?	±US$	
32. GIMMS	Vector	England		Mainframe	CAD/GIS	Automated Cartography, Mapping, Spatial Analysis.	Moderate	-	-	±US$	
33. PERI COLOR	Raster	France	?	Workstation	RS	Image Processing	Moderate	?	?	±US$	
34. IMAGINE	Vector (Hybrid)	?	SUN	Workstation	GIS?			?	?	±US$	
35. RADARSOFT TM (PCI)	Raster	USA	UNIX, SUN IBM RISC/6000 PC	Workstation PC	RS	Radar Image Processing	Moderate to Good	+	+	±US$	

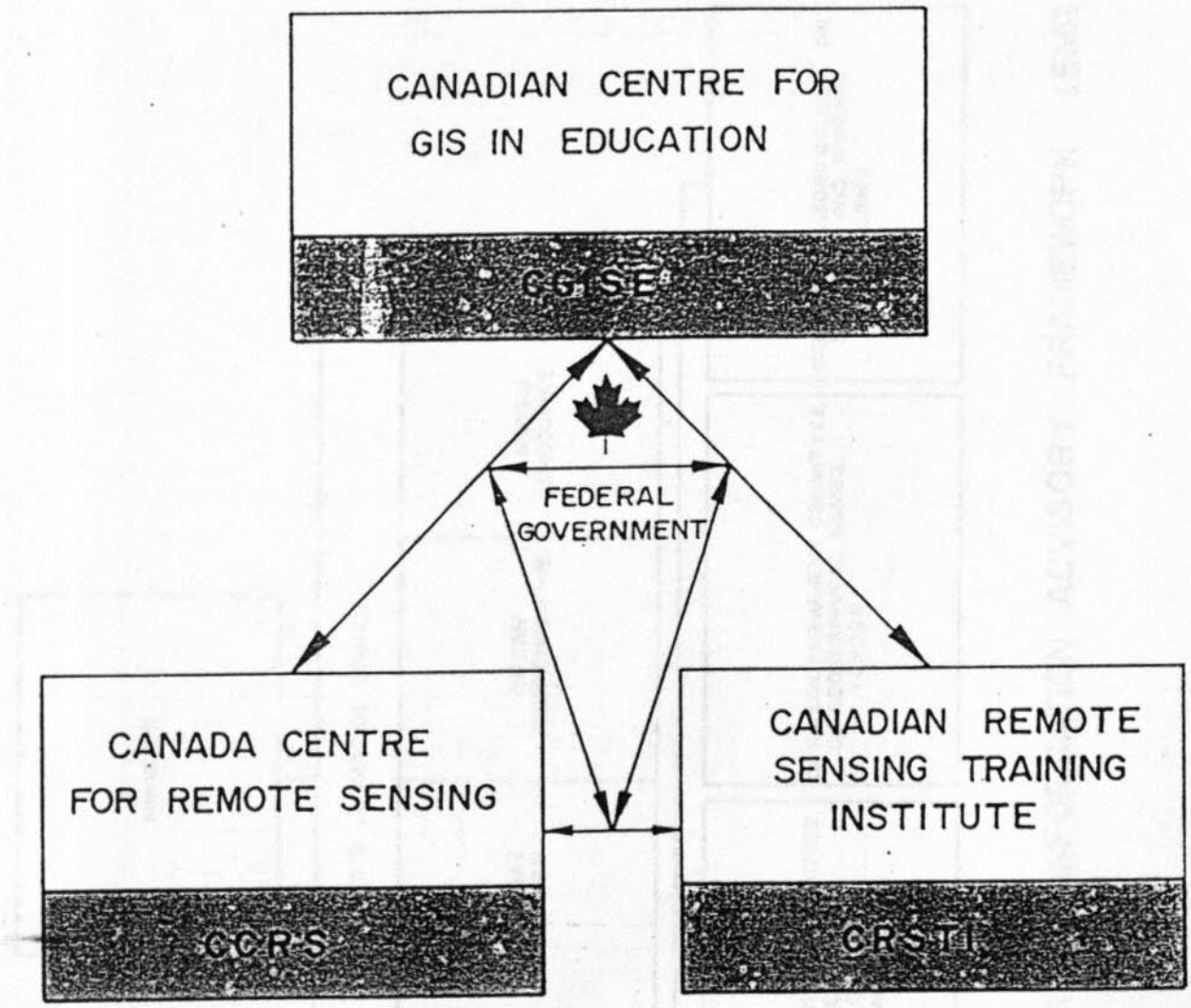


FIG. 10 PRINCIPAL CANADIAN EDUCATION INSTITUTIONS IN APPLICATION OF GEOGRAPHIC INFORMATION.

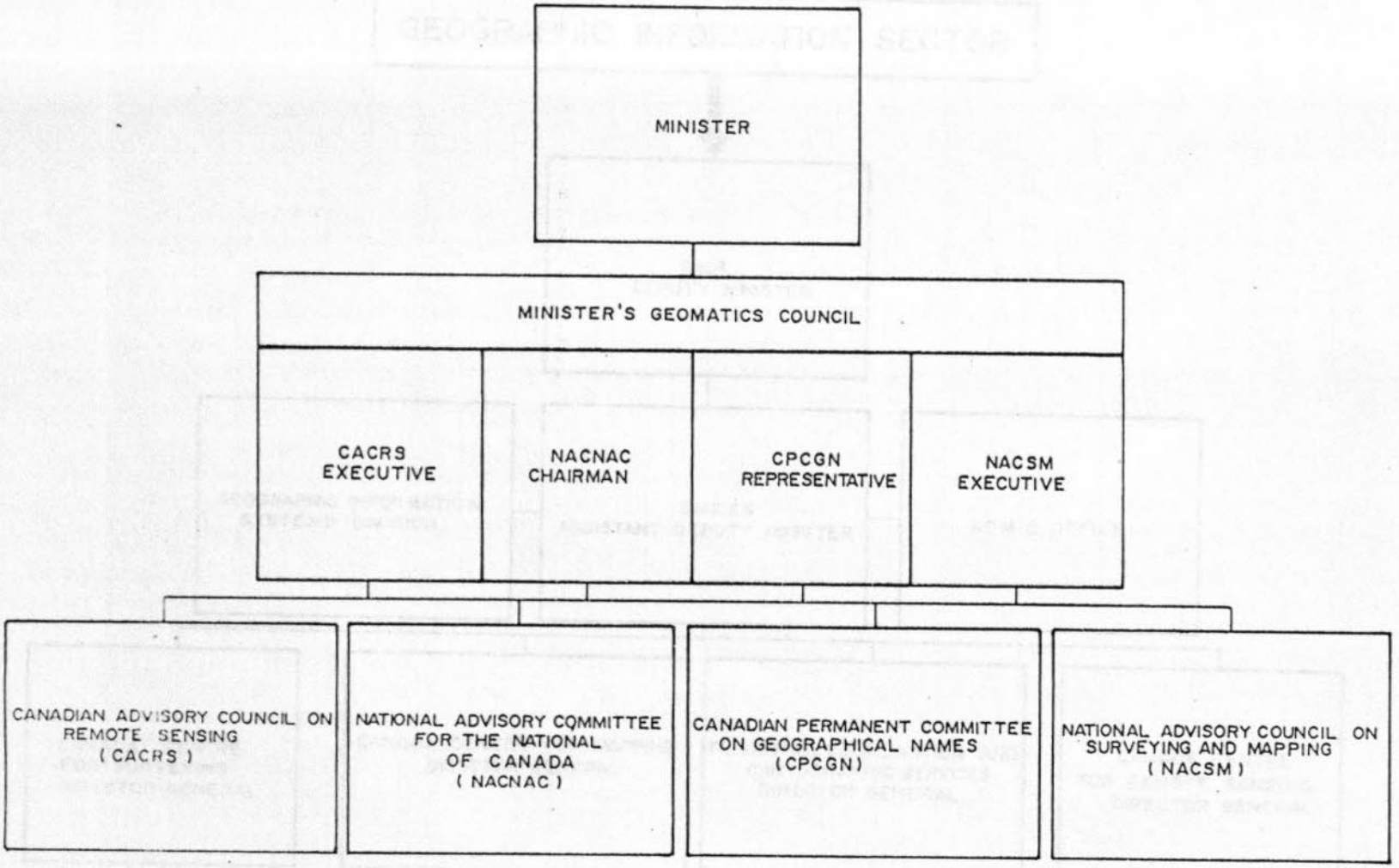


FIGURE 11 : SCHEME OF GEOGRAPHIC INFORMATION ADVISORY FRAMEWORK (EMR 1990)

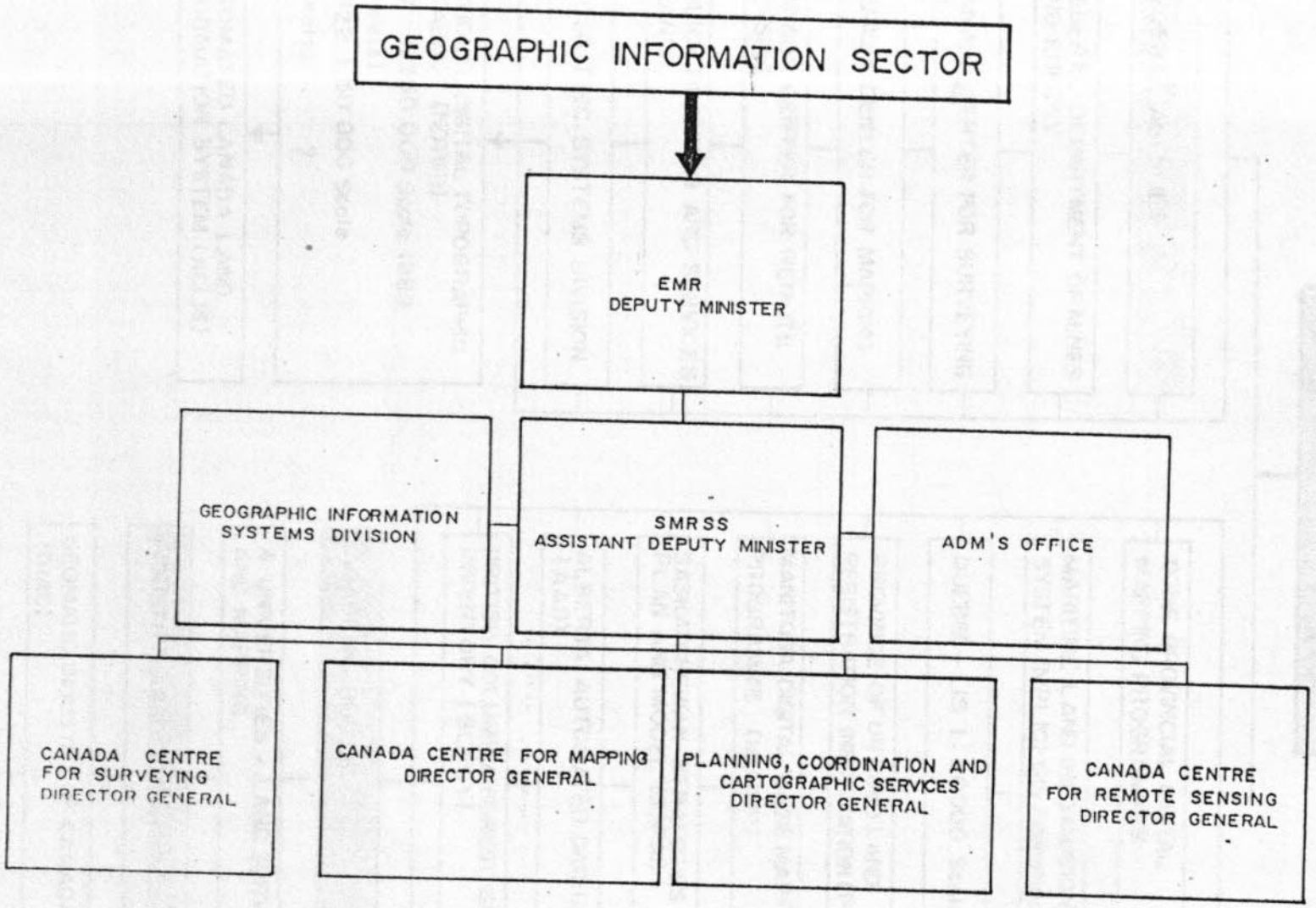
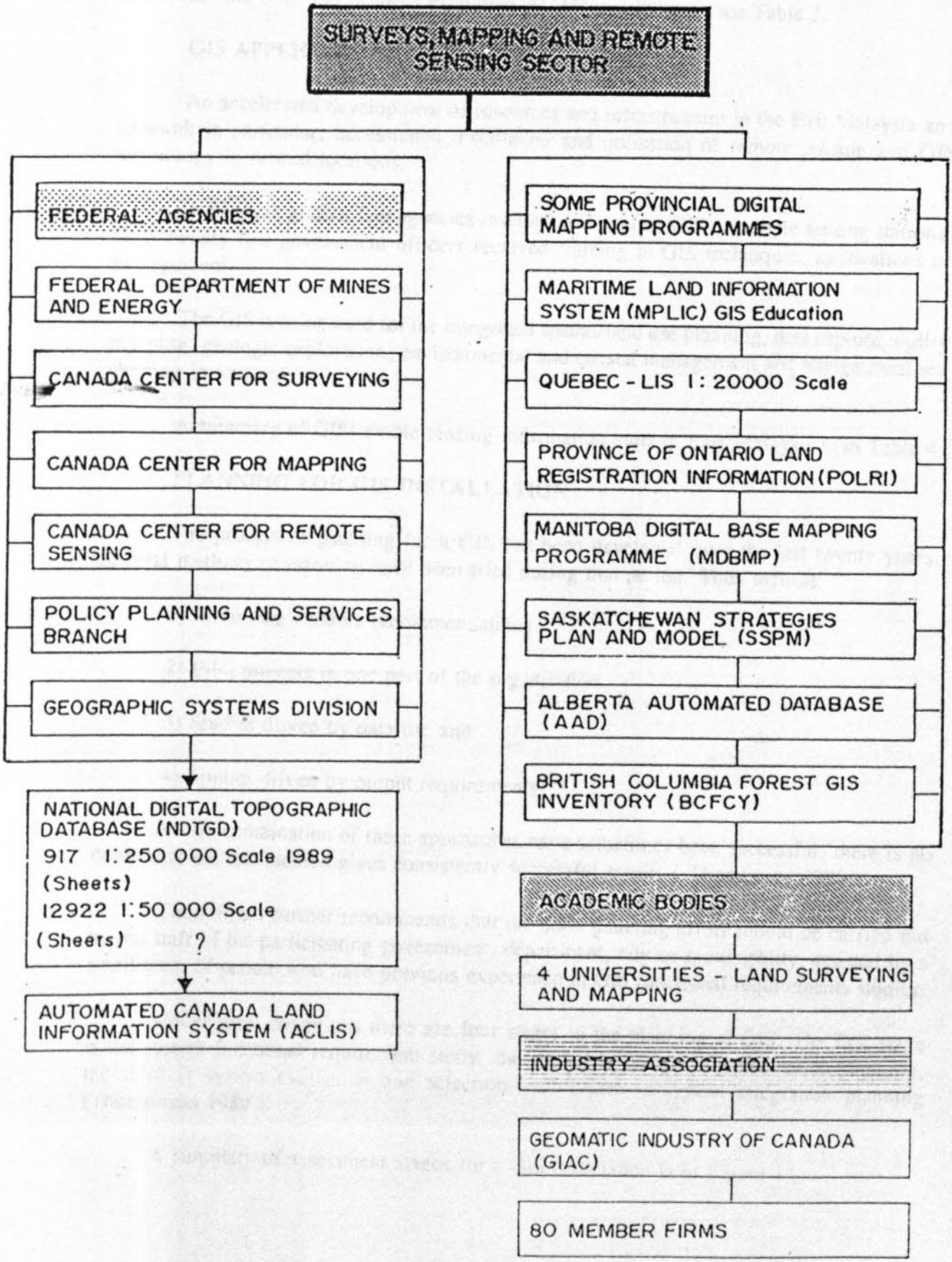


FIGURE 12 : SCHEME OF SURVEYS MAPPING AND REMOTE SENSING SECTOR OF ENERGY, MINES AND RESOURCES DPT.

SOURCE : EMR 1990.



Source: The Canadian Geomatics Industry, EAITC, Canada, 1991

Fig. 13 SUMMARY OF SOME MAJOR AGENCIES AND PROGRAMMES ASSOCIATED WITH GIS TECHNOLOGY IN CANADA

There are over 150 sites with installed and operating GIS facilities in the Asean countries and over 450 licences excluding ACAD installations, see Table 3.

GIS APPLICATIONS IN SARAWAK AND SABAH

An accelerated development of resources and infrastructure in the East Malaysia and Sarawak in particular, necessitated installation and utilisation of remote sensing and GIS technology in several locations.

In Sarawak at least five agencies installed and operate GIS or remote sensing stations. Over twenty five government officers received training in GIS techniques, applications or management.

The GIS is being used for the integrated spatial/land use planning, data capture, utility mapping, geologic exploration, environmental and coastal management and navigational sea charting in Sarawak.

A summary of GIS/remote sensing information units in East Malaysia is in Table 4.

PLANNING FOR GIS INSTALLATION

The process of planning for a GIS has been developed over the last twenty years. Several methods of planning have been tried during that period. They include:

1) Following vendors recommendations

2) Pilot projects in one part of the organisation

3) Studies driven by data use and

4) Studies driven by output requirements

While combination of these approaches have sometimes been successful, there is no doubt that the last method gives consistently successful results (Thomlinson 1989).

Thomlinson further recommends that the main planning effort should be carried out by the staff of the participating government, department, city or municipality, assisted by a small team of people who have previous experience in GIS functional requirements studies.

Under ideal conditions there are four stages in the planning of GIS. The first stage is the system functional requirement study, the second is system implementation planning, the third is system evaluation and selection, and fourth is system integration planning (Thomlinson 1989).

A summary of assessment stages for a GIS installation is in Figure 14.

An installation, operation and maintenance of a GIS system is very costly and demanding on high quality staff. However, a good well managed system will pay for itself within 3 to 5 years (Sugarebaker 1992, The Economist 1992), see Figure 15.

Town and city planning projects in the US can cost between U$ 500 000 to 20 million. The Bureau of Land Management and the Forest Service are talking of spending U$ 1 billion on a GIS public land information service. The Federal Government recently pledged U$ 111 billion to repair its roads and bridges. Against such costs the GIS technology alone is cheap. It is expected that the GIS industry will grow 25 percent a year for next decade (The Economist 1992).

In the US, government and utilities offices make up three quarters of GIS industry customers. There are 70 000 government departments in America, each one could become a GIS customer (The Economist 1992).

In Sarawak, if one would consider nine divisions and say nine major agencies with divisional HQs and twenty eight district HQs for the nine major agencies involved in spatial planning, vendors could find over three hundred and thirty potential customers within the mainstream public sector alone.

The operation of a GIS in a particular project usually includes three basic phases - inventory (including data input), analysis and management design. The inventory, consisting of data collection, design and setting up of a data base and data input consumes up to and even over 70 percent of a total project activity effort, see Figure 16.

PLANNING INFORMATION SYSTEM AT THE STATE PLANNING UNIT

The Sarawak Agricultural Development Project funded by the Canadian International Development Agency has installed a hardware supporting the SPANS - TYDAC GIS software developed in Canada.

Apart from supporting the project in developing the Sarawak Agricultural Perspective Plan with spatial data and analysis, the GIS was used to design and develop a state level integrated planning information system.

The Sarawak State Planning Information System has been designed to provide a tool for decision makers at the highest corporate or executive level of the Government. It is expected to consist of 1 : 1 000 000, 1 : 500 000 and 1 : 250 000 scales series of standardised data bases.

Presently the 1 : 1 000 000 scale series data base has been completed and consists of over 100 maps including the source and combined analytical maps. The 1 : 500 000 scale series has been designed in terms of data structure and data is being digitised.

For the 1 : 250 000 scale series a pilot planning project is being executed to facilitate a design of the data base structure and spatial planning framework at this level of analysis.

The GIS system utilises a manual cartographic and GIS applications conceptualiser GIS operator and support staff for standardisation and design of the data base for the input into the electronic GIS, see Figures 17 and 18.

The GIS Planning Information System utilises remote sensing techniques, land system and agro-ecological zoning approach in facilitating the compilation of geographic information, integration of bio-physical, socio-economic and infrastructure data and for basic data storage, spatial analysis and modelling, and spatial planning.

A scheme of the basic data structure is in Figures 19 to 21. A summary of the planning information data base is in Figures 22 and 23.

SUGGESTED GIS NETWORK FOR SARAWAK

In Sarawak there are number of Federal and State Government Agencies involved in handling geographic information or spatial planning.

There are at least six major Federal Agencies and about twenty five associated Agencies using geographic information and spatial planning, see Figure 24.

In addition to these there are at least nine State line Agencies, excluding the State Planning Unit, also involved utilising spatial planning and using geographic information on almost day to day basis, see Figure 25.

It is suggested that a State level strategical plan is prepared for eventual installation of GIS systems in all of the above agencies.

Three types of GIS system units are recommended:

1) Macro station - corporate and semi-corporate (State Agency HQ etc.)

2) Mini station -line Agency (Regional or Divisional HQ)

3) Micro station - line Sub Agency (District HQ)

CONFIDENTIALITY AND SECURITY

A number of data handled by GIS systems in government agencies is confidential and not readily available. In order to maintain an efficient system of confidentiality and security, a data security classification system has to be developed for the installed Government GIS systems.

Four classes of security classification are suggested:

1) Unclassified

2) Restricted

3) Confidential

4) Secret

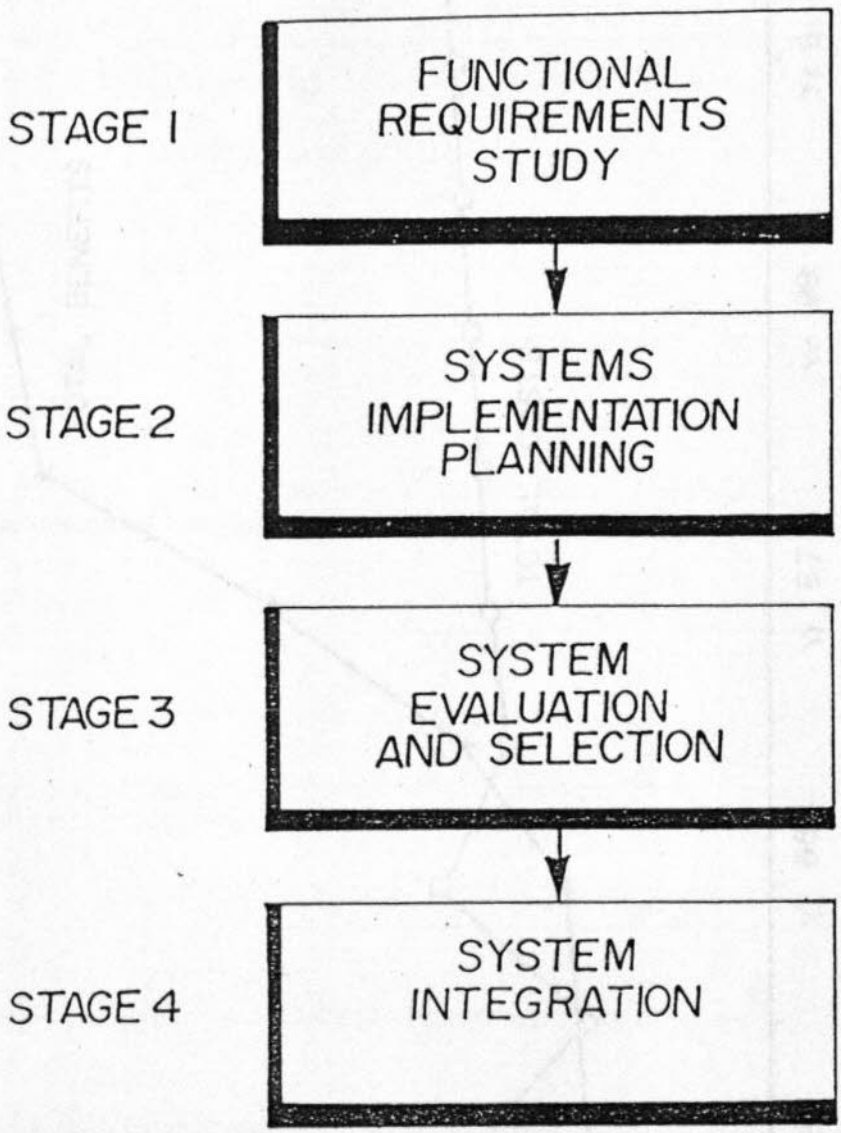
TABLE 3: SUMMARY OF MAJOR GIS/RS INFORMATION UNITS IN ASEAN COUNTRIES

COUNTRY	APPROXIMATE NUMBER OF SITES	APPROXIMATE NUMBER OF LICENCES
MALAYSIA	3	140
INDONESIA	50	150
THAILAND	30	100
BRUNEI	3	10
SINGAPORE	> 20	> 50
PHILIPPINES	> 15	> 30

TABLE 4: SUMMARY OF GIS/RS INFORMATION UNITS IN EAST MALAYSIA

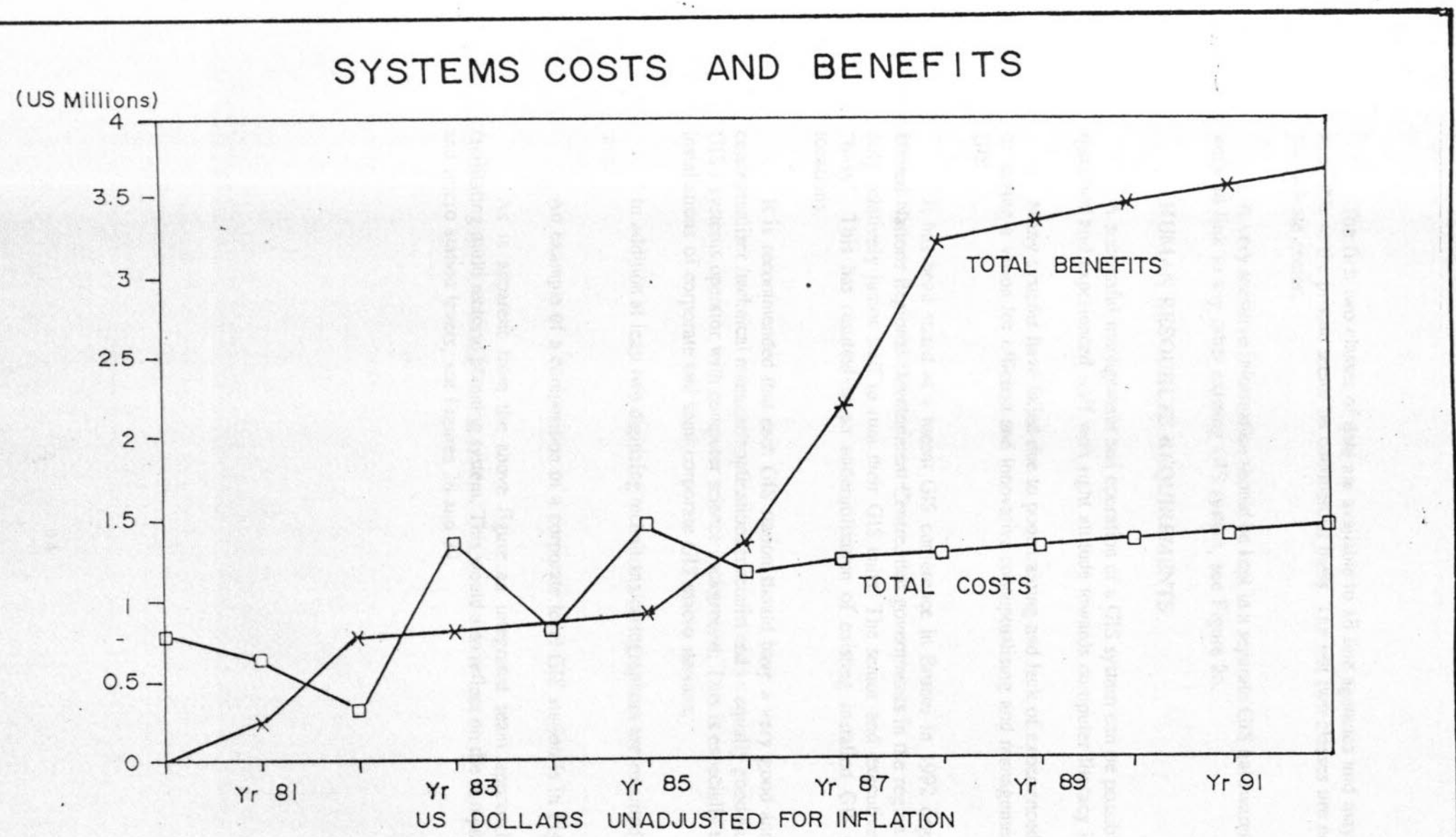
COUNTRY	AGENCY	DOMINANT APPLICATION	TYPE OF SYSTEM
SARAWAK	State Planning Unit of Development	GIS - Integrated Spatial/Land Use Planning	SPANS-TYDAC
	Department of Forestry	RS - Image Processing GIS - (Basic)-Data Capture	PCI, EARTHPROBE QUICKMAP
	Land and Surveys	LIS - land Information System	INTEGRAPH
	Petronas/Shell	GIS/RS - Utility Mapping, Exploration, Environmental Management	INTEGRAPH
	Marine Department	GIS - Navigational Charting	CARIS
SABAH	Sabah Foundation	GIS - Forest Management	ARC-INFO
	Department of Forestry	RS - Image Processing	ERDAS?
	Department of Fisheries	GIS - Coastal Management	SPANS-TYDAC

Note: Excludes ACAD installations



Source: (Tomlinson, 1989)

Fig.14 ASSESSMENT OF REQUIREMENTS IN PLANNING FOR INSTALLATION OF A GIS



Total System Costs And Benefits (Sugarbaker, 1992)

Fig.15 COSTS AND BENEFITS OF OPERATING A GIS AT STATE LEVEL BY THE WASHINGTON DEPT. OF NAT. RESOURCES.

The first two classes of data are available to all line agencies and may be also made available to the private sector on commercial basis. The last two classes are not available to the private sector.

A very sensitive information should be kept in a separate GIS hardware/ software unit with no link to any other existing GIS system, see Figure 26.

HUMAN RESOURCES REQUIREMENTS

A successful management and operation of a GIS system can be possible only if well qualified and experienced staff with right attitude towards computer literacy is used.

Many systems have failed due to poor training and lack of experienced staff capable of having a vision for efficient and innovative conceptualising and management of installed GIS.

It has been stated at a recent GIS conference in Brunei in 1992 organised by the United Nations Regional Development Centre, that governments in the region use generally only relatively junior staff to rum their GIS units. The senior and executive staff are too "busy". This has resulted in an underutilisation of existing installed GIS units in most locations.

It is recommended that each GIS station should have a very good and experienced conceptualiser /technical manager/applications specialist and an equally good and experienced GIS / systems operator with computer science background. This is especially true in case of installations of corporate and semi-corporate GIS macro stations.

In addition at least two digitizing technitians/cartographers are required for each GIS unit.

An example of a composition of a corporate level GIS station is in Figure 27.

As is apparent from the above figure an integrated team approach is required facilitating multi sectoral planning system. This would also reflect on the composition of mini and micro station levels, see Figures 28 and 29.

SOME GENERAL RECOMMENDATIONS

It is recommended that installation of GIS systems within the Sarawak Government Agencies is carried out as a strategical long term, step by step integrated effort rather than an tactical short term Agency by individual initiative.

This should be accompanied by implementation of an integrated multi-level and multi-sectoral standardised spatial planning framework based on utilisation of remote sensing and GIS technology.

An example of a multi-level spatial planning system is in Figure 30.

A State level network of GIS stations should be installed after identification of appropriate hierarchical and coordination institutional linkages for spatial planning and exchange of information. Design and planning of GIS systems should be based on evaluation of individual agencies spatial planning and geographic information requirements.

FIGURE 16: THE MIX OF GIS APPLOCATIONS OVER TIME

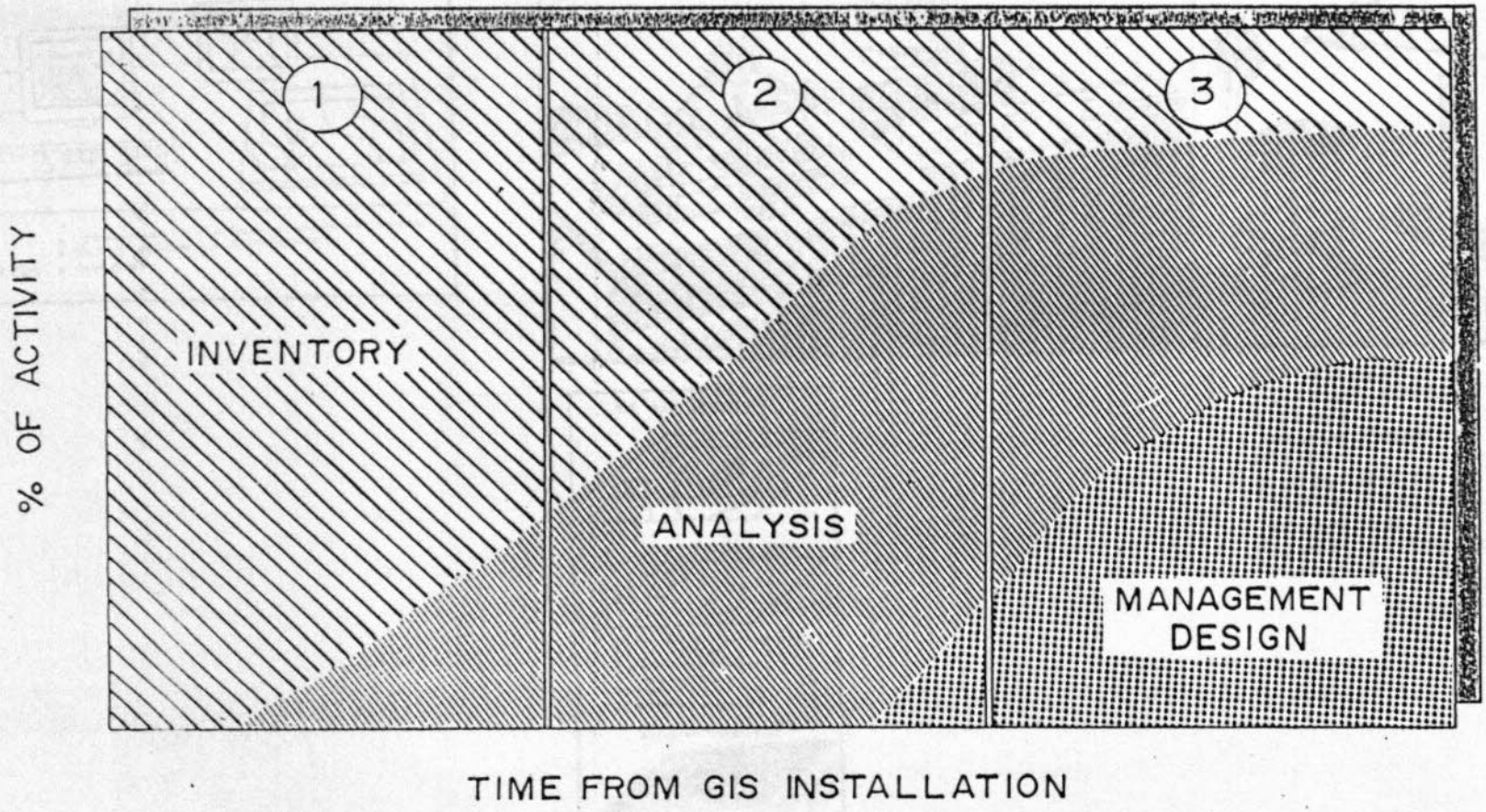
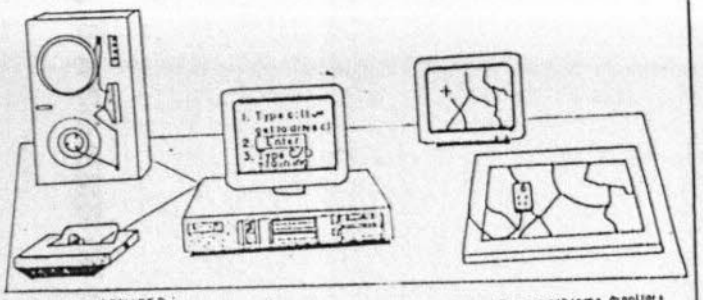


FIGURE 16 : THE MIX OF GIS APPLICATIONS OVER TIME (ADAPTED FROM CRAIN AND MACDONALD 1983).

ELECTRONIC GIS

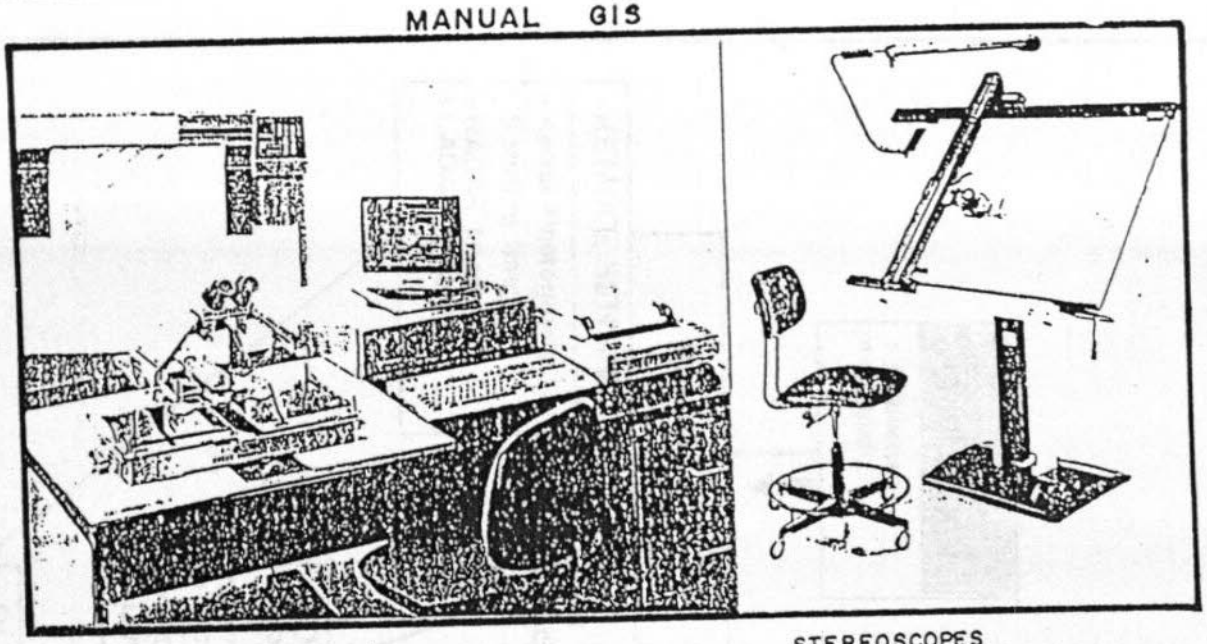
SPANS and EASI/PACE: The complete GIS/Image Analysis workstation on a micro-computer.



HARDWARE REQUIRED:

- 386 micro-computer
- 70 Mb hard drive
- Number 9 32-bit graphics card
- 1,20 Mb RAM
- Math co-processor
- Tape drive
- Colour & monochrome monitors
- Digitizing table

MANUAL GIS



STEREOSCOPES
PC Micro Computer
Disc drive
Computer Processing Unit
Printer
Drafting Boards
Drafting Equipment
Transparent Overlays
Reproduction, Scale Change and Printing Facilities

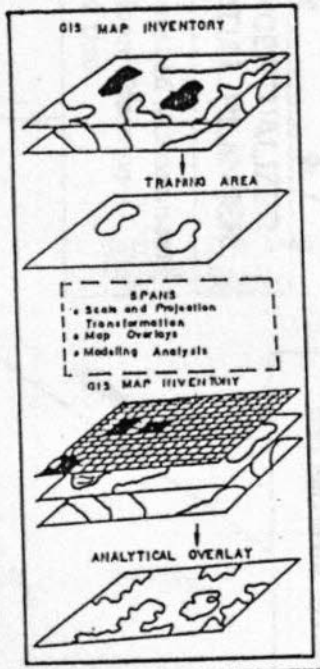


Fig. 17 A Scheme of A Parallel Manual and Electronic GIS Processing Facility.

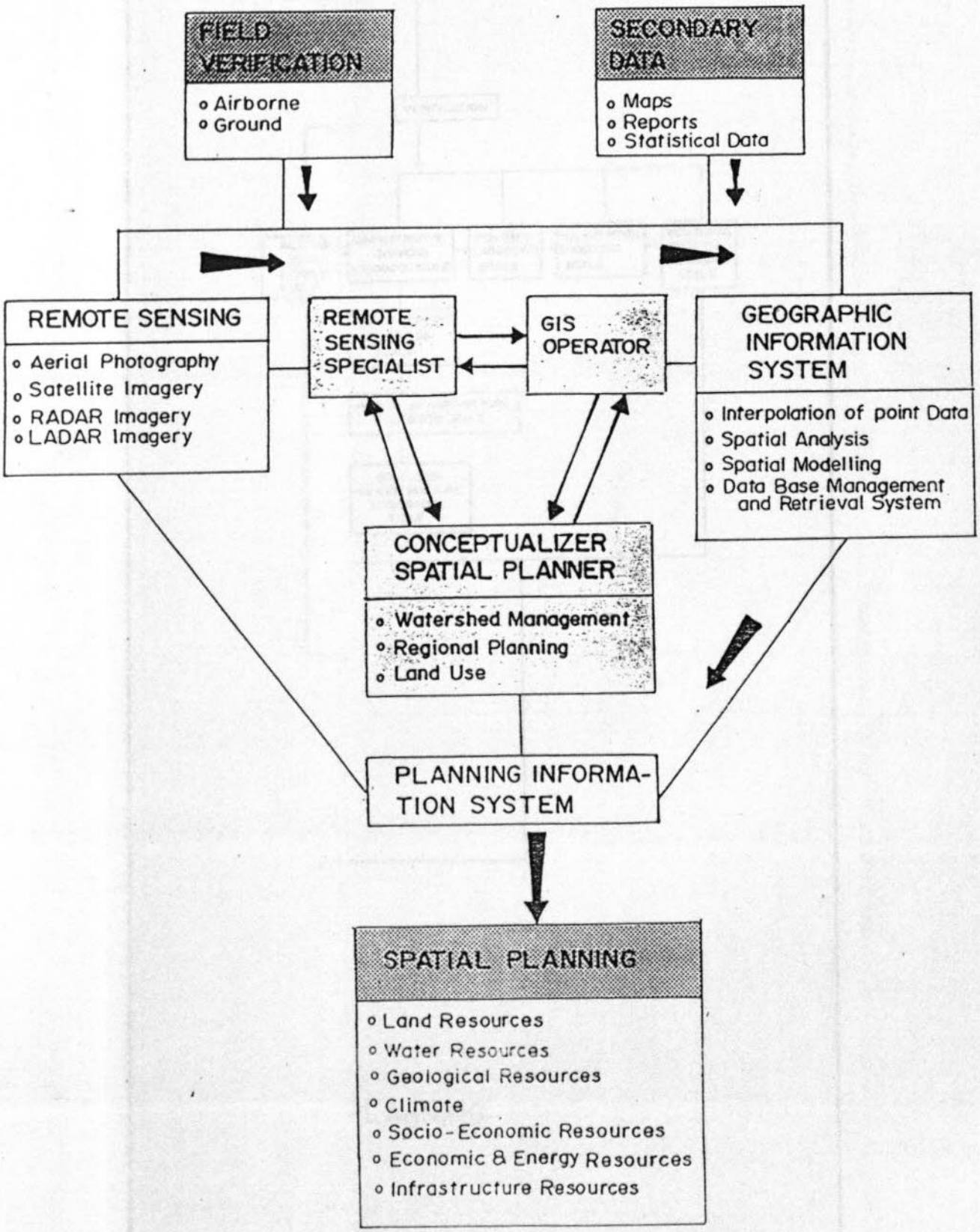
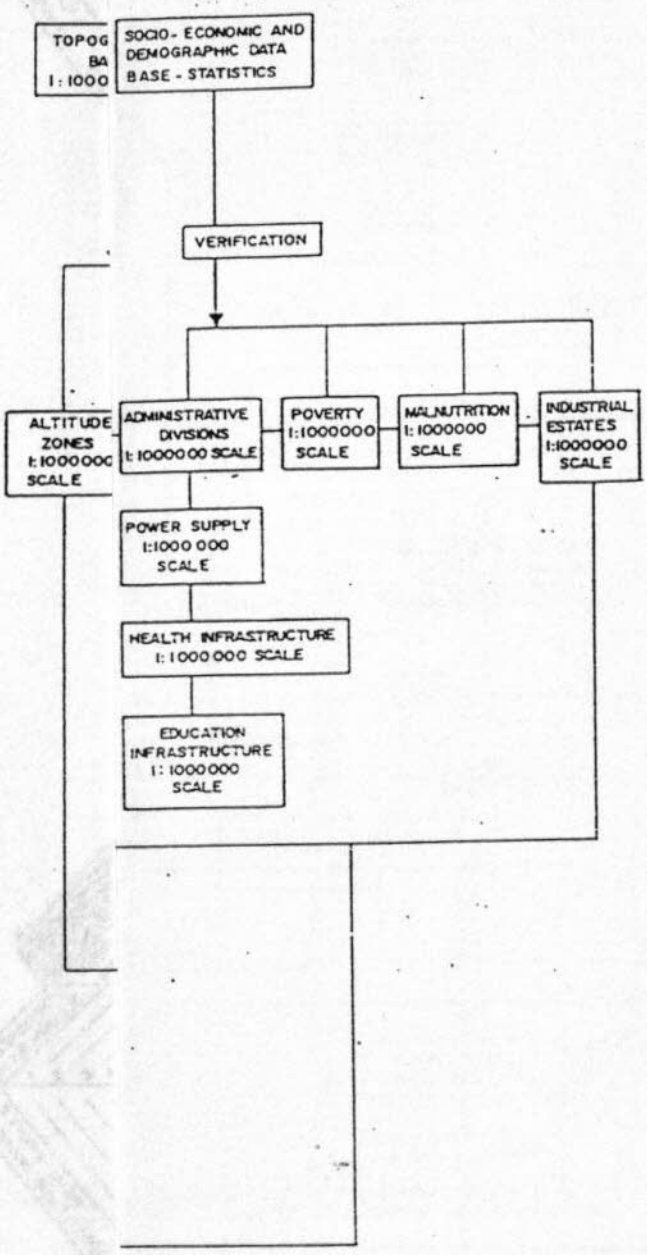


Fig.18 A SCHEME OF SPATIAL PLANNING MECHANISM


TOPOG
BA
1:1000
SOCIO-ECONOMIC AND DEMOGRAPHIC DATA BASE - STATISTICS
VERIFICATION
ALTITUDE ZONES 1:1000000 SCALE
ADMINISTRATIVE DIVISIONS 1:1000000 SCALE
POVERTY 1:1000000 SCALE
MALNUTRITION 1:1000000 SCALE
INDUSTRIAL ESTATES 1:1000000 SCALE
POWER SUPPLY 1:1000 000 SCALE
HEALTH INFRASTRUCTURE 1:1000000 SCALE
EDUCATION INFRASTRUCTURE 1:1000000 SCALE

PL-ANNING

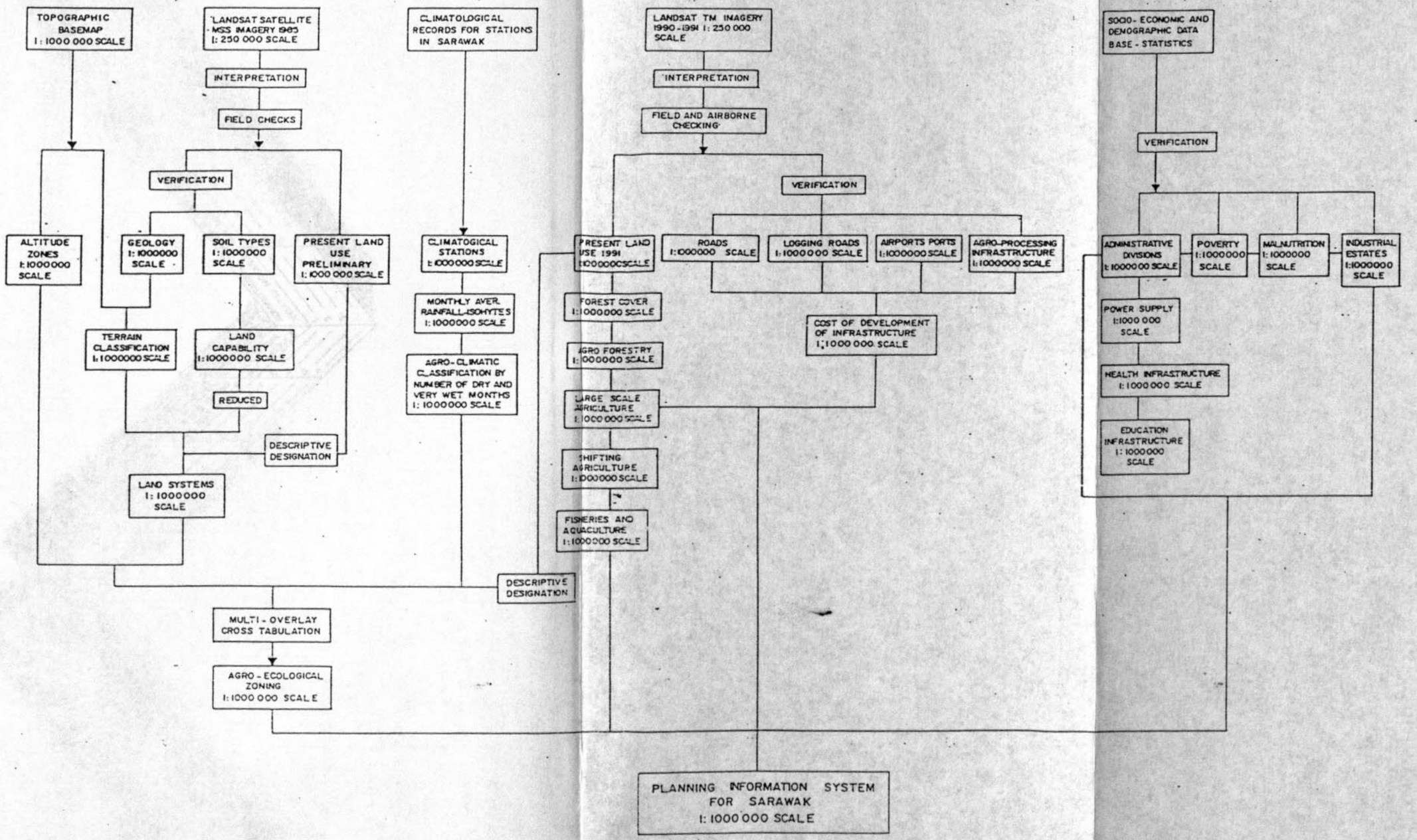


FIG. 19 A SCHEME OF BASIC DATA STRUCTURE OF STATE LEVEL GIS PLANNING INFORMATION SYSTEM FOR SARAWAK PREPARED BY SADP.

Fig. 20 A SCHEME OF THE GIS MATRIX CROSS TABULATION PLANNING INFORMATION DATA BASE

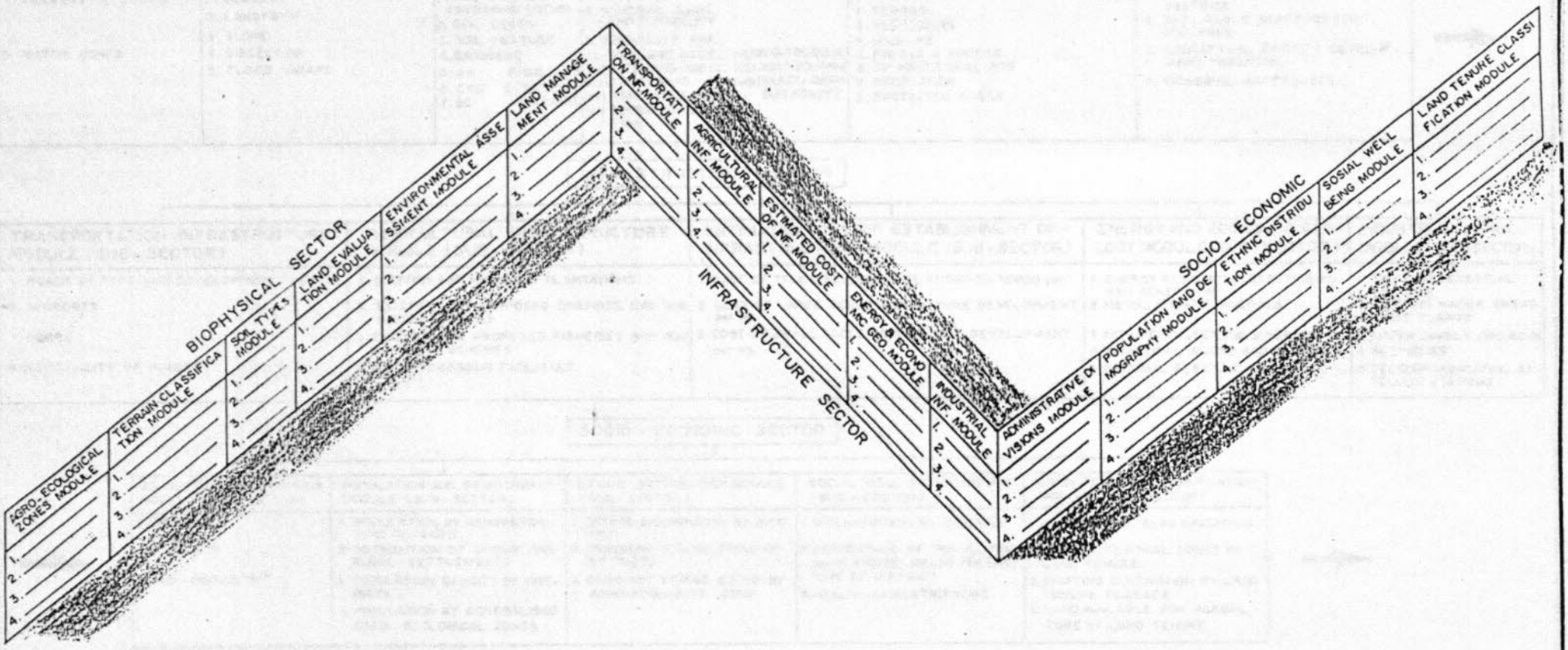


Fig. 21 PLANNING INFORMATION SYSTEM - MACRO PLANNING GIS DATA BASE
1 : 1 000 000 SCALE
(SPANS - TYDAC PROGRAMME)

BIOPHYSICAL SECTOR

AGRO-ECOLOGICAL ZONES MODULE (SUB-SECTOR)	TERRAIN CLASSIFICATION MODULE (SUB-SECTOR)	SOIL TYPE MODULE (SUB-SECTOR)	LAND EVALUATION MODULE (MODULE SUB-SECTOR)	ENVIRONMENTAL ASSESSMENT MODULE (SUB-SECTOR)	LAND MANAGEMENT MODULE (SUB-SECTOR)
1. TERRESTIAL ZONES 2. WATER ZONES	1. GEOLOGY 2. LANDFORM 3. SLOPE 4. DISSECTION 5. FLOOD HAZARD	1. SOIL TAXONOMY (SARAWAK USDA) 2. SOIL DEPTH 3. SOIL TEXTURE 4. DRAINAGE 5. pH 8. SALINITY 6. CEC 9. EROSION HAZARD 7. BC	1. LAND USE 2. GENERAL AGRIC. LAND SUITABILITY 3. SUITABILITY FOR : (i) DRYLAND AGRIC. (vi) ECO-TOURISM (ii) WETLAND AGRIC. (vii) AGRO-TOURISM (iii) TREECROPS (viii) MULTI-CROP SUITABILITY (iv) AGRO-FORESTRY (v) FOREST EXPLOITATION	1. SOILS 2. TERRAIN 3. VEGETATION 4. WILDLIFE 5. FISHING & HUNTING 6. ARCHEOLOGICAL SITE 7. RECREATION 8. PROTECTED AREAS	1. APPLICABLE DOMINANT FARMING SYSTEMS 2. APPLICABLE AGROFORESTRY PACKAGES 3. CONCEPTUAL PRIORITY DEVELOPMENT POTENTIAL 4. PRINCIPAL WATERSHEDS

INFRASTRUCTURE SECTOR

TRANSPORTATION INFRASTRUCTURE MODULE (SUB-SECTOR)	AGRICULTURAL INFRASTRUCTURE MODULE (SUB-SECTOR)	ESTIMATED COST OF ESTABLISHMENT OF INFRASTRUCTURE MODULE (SUB-SECTOR)	ENERGY AND ECONOMIC GEOLOGY MODULE (SUB-SECTOR)	INDUSTRIAL INFRA. MODULE (SUB-SECTOR)
1. ROADS BY TYPE AND DEVELOPMENT PRIORITY 2. AIRPORTS 3. PORTS 4. NAVIGABILITY OF RIVERS	1. EXISTING AND PROPOSED PLANTATIONS 2. EXISTING AND PROPOSED DRAINAGE AND IRRIGATION SCHEMES 3. EXISTING AND PROPOSED FISHERIES AND AQUACULTURE SCHEMES 4. AGRO-PROCESSING FACILITIES	1. COST OF TRUNK, FEEDER AND PLANTATION ROADS per km 2. COST OF LARGE SCALE AGRICULTURE DEVELOPMENT per ha 3. COST OF SMALL SCALE AGRICULTURE DEVELOPMENT per ha.	1. ENERGY RESOURCES - ELECTRIC POWER GENERATOR 2. METALLIFEROUS MINERALS 3. NON-METALLIFEROUS MINERALS 4. INDUSTRIAL ROCKS AND MINERALS 5. NATIONAL ELECTRIC GRID	1. EXISTING INDUSTRIAL ESTATES 2. EXISTING WATER TREATMENT PLANTS 3. WATER SUPPLY PROJECTS 4. REFINERIES 5. TELECOMMUNICATION SATELLITE STATIONS

SOCIO - ECONOMIC SECTOR

ADMINISTRATIVE DIVISIONS MODULE (SUB-SECTOR)	POPULATION AND DEMOGRAPHY MODULE (SUB-SECTOR)	ETHNIC DISTRIBUTION MODULE (SUB-SECTOR)	SOCIAL WELL BEING MODULE (SUB-SECTOR)	LAND TENURE CLASSIFICATION MODULE (SUB-SECTOR)
1. DIVISIONS 2. DISTRICTS 3. SUB-DISTRICTS	1. POPULATION BY ADMINISTRATIVE DIVISIONS 2. DISTRIBUTION OF URBAN AND RURAL SETTLEMENTS 3. POPULATION DENSITY BY DISTRICTS 4. POPULATION BY GENERALISED AGRO-ECOLOGICAL ZONES	1. ETHNIC DISTRIBUTION BY DISTRICT 2. DOMINANT ETHNIC GROUP BY DISTRICTS 3. DOMINANT ETHNIC GROUP BY AGRO-ECOLOGICAL ZONE	1. MALNUTRITION BY DISTRICT 2. PERCENTAGE OF POPULATION WITH INCOME BELOW POVERTY LINE BY DISTRICT 3. HEALTH INFRASTRUCTURE	1. LAND TENURE CLASSIFICATION 2. AGRO-ECOLOGICAL ZONES BY LAND TENURE 3. SHIFTING CULTIVATION BY LAND TENURE CLASSES 4. LAND AVAILABLE FOR AGRICULTURE BY LAND TENURE

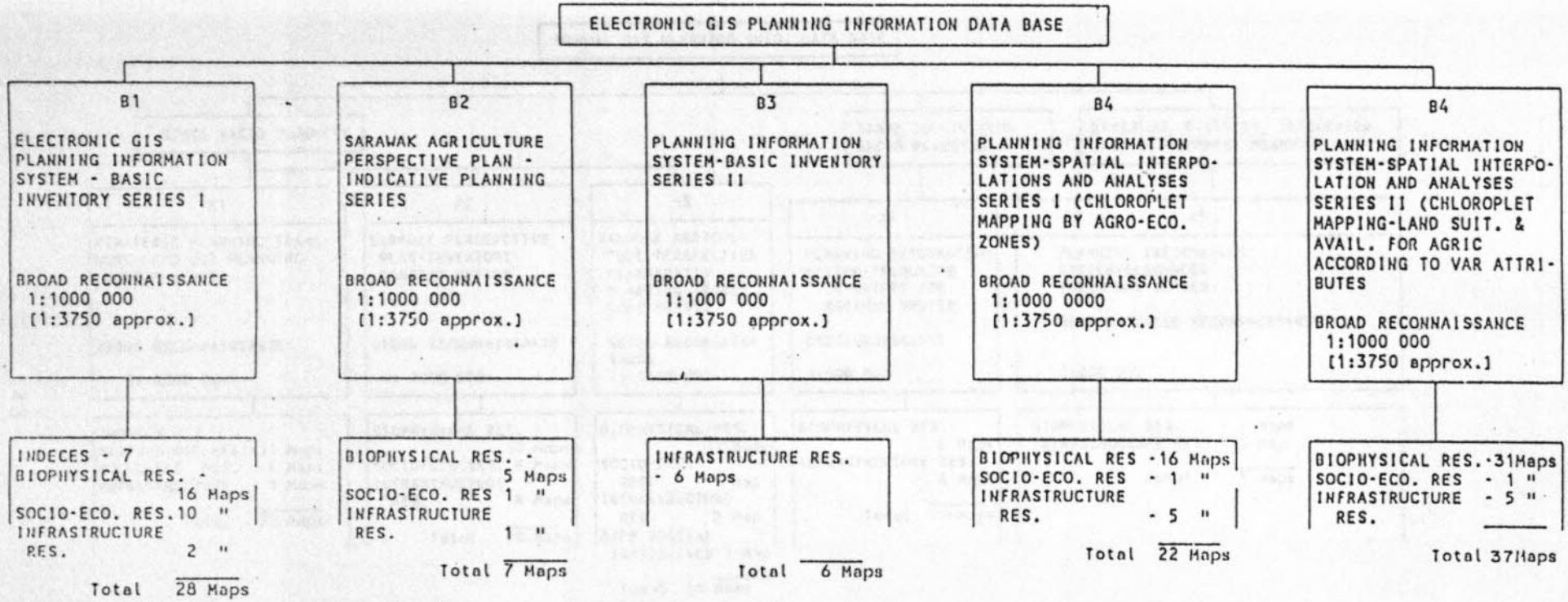


FIG. 22 SUMMARY OF ELECTRONIC GIS PLANNING INFORMATION DATA BASE - SADP

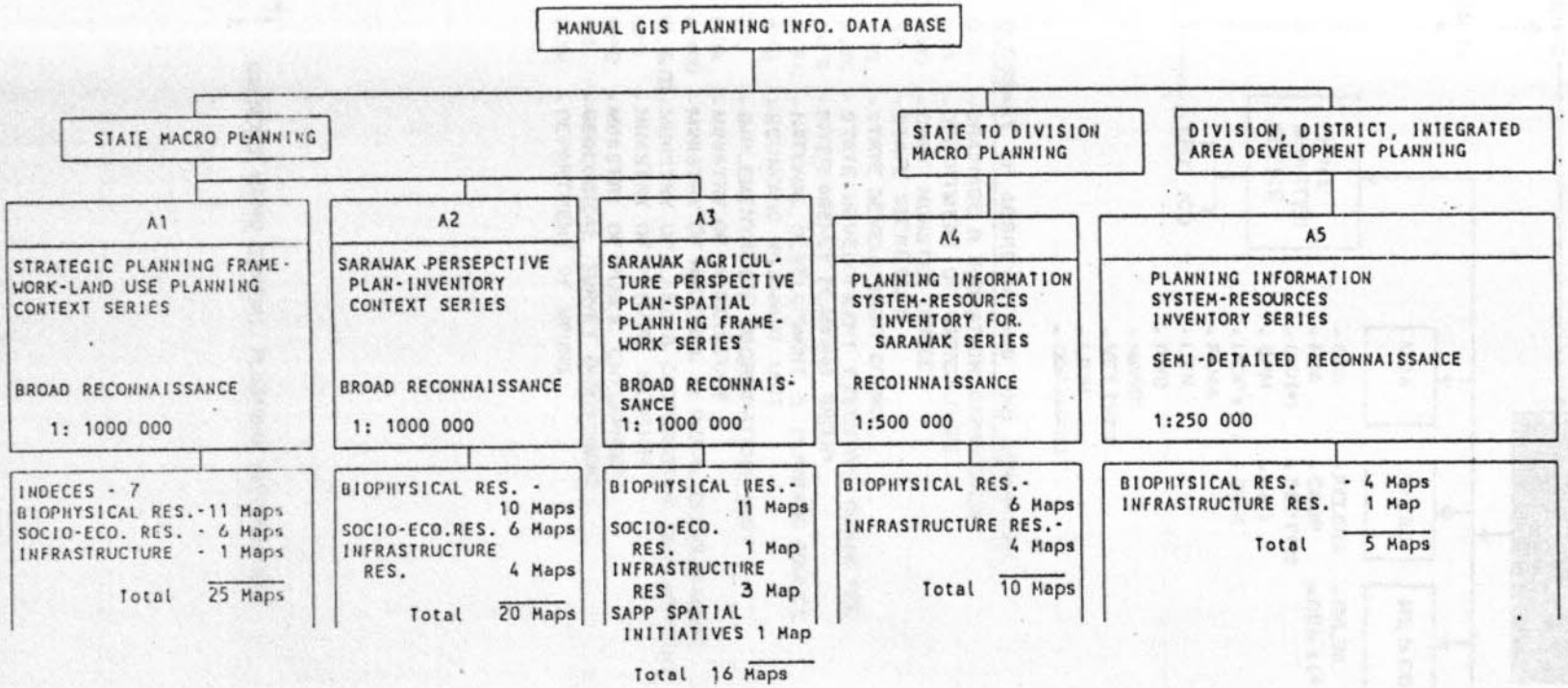
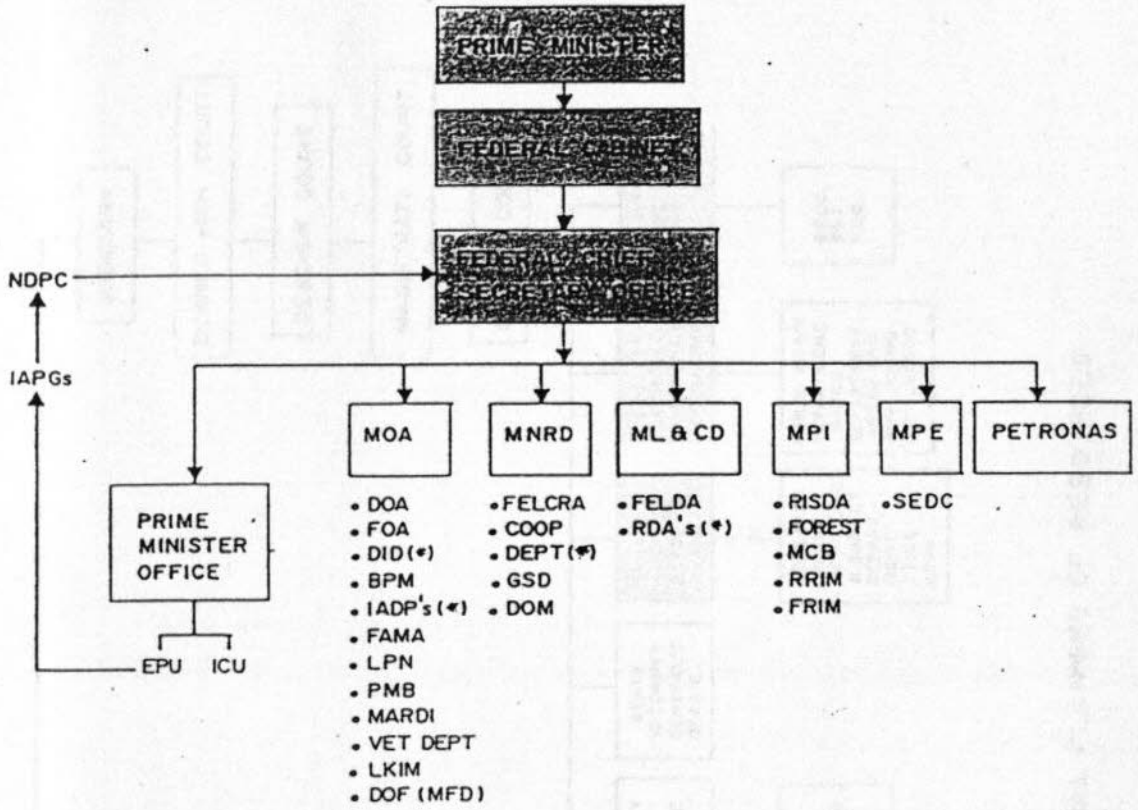


FIG. 23 SUMMARY OF MANUAL GIS PLANNING INFORMATION DATA BASE - SADP



GLOSSARY OF ABBREVIATIONS AND ACRONYMS

DID	- DRAINAGE & IRRIGATION DEPARTMENT
DOA	- DEPARTMENT OF AGRICULTURE
CMO	- CHIEF MINISTER OFFICE
SS	- STATE SECRETARY
SDC	- STATE DEVELOPMENT COUNCIL
SDEC	- STATE DEVELOPMENT EXECUTIVE COMMITTEE
IAPG	- INTER AGENCY PLANNING GROUP
NDPC	- NATIONAL DEVELOPMENT & PLANNING COUNCIL
EPU	- ECONOMIC PLANNING UNIT
ICU	- IMPLEMENTATION COORDINATION UNIT
MOA	- MINISTRY OF AGRICULTURE
MNRD	- MINISTRY OF NATIONAL & RURAL DEVELOPMENT
ML & CD	- MINISTRY OF LAND & COOPERATIVE DEVELOPMENT
MPI	- MINISTRY OF PRIMARY INDUSTRY
MPE	- MINISTRY OF PUBLIC ENTERPRISE
GS	- GEOLOGICAL SURVEY DEPARTMENT
DOM	- DEPARTMENT OF MINING

AGENCIES USING SPATIAL PLANNING INFORMATION

FIG. 24 PRINCIPAL FEDERAL AGENCIES USING SPATIAL PLANNING IN SARAWAK

ORGANISATION CHART OF SARAWAK STATE GOVERNMENT

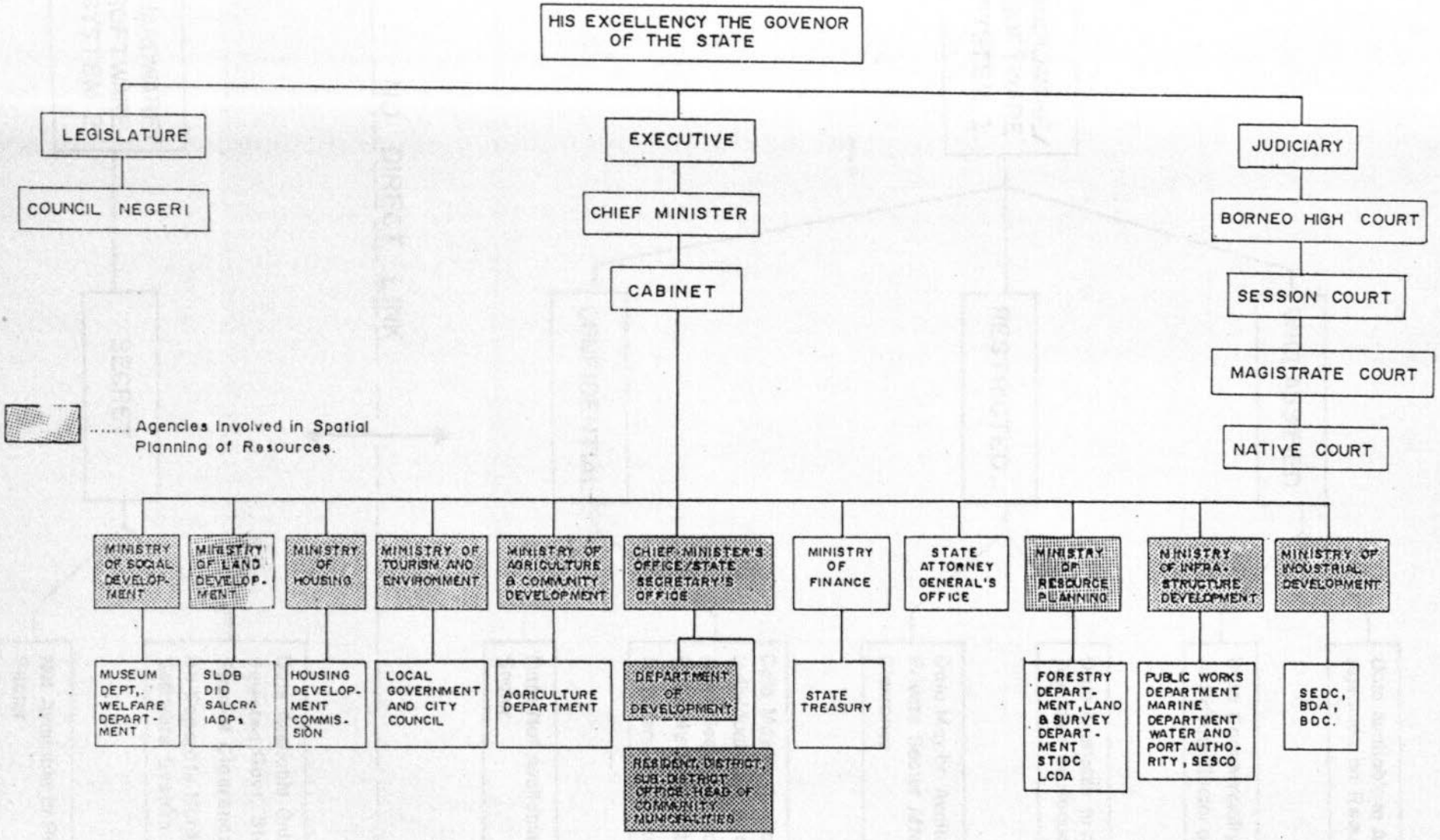
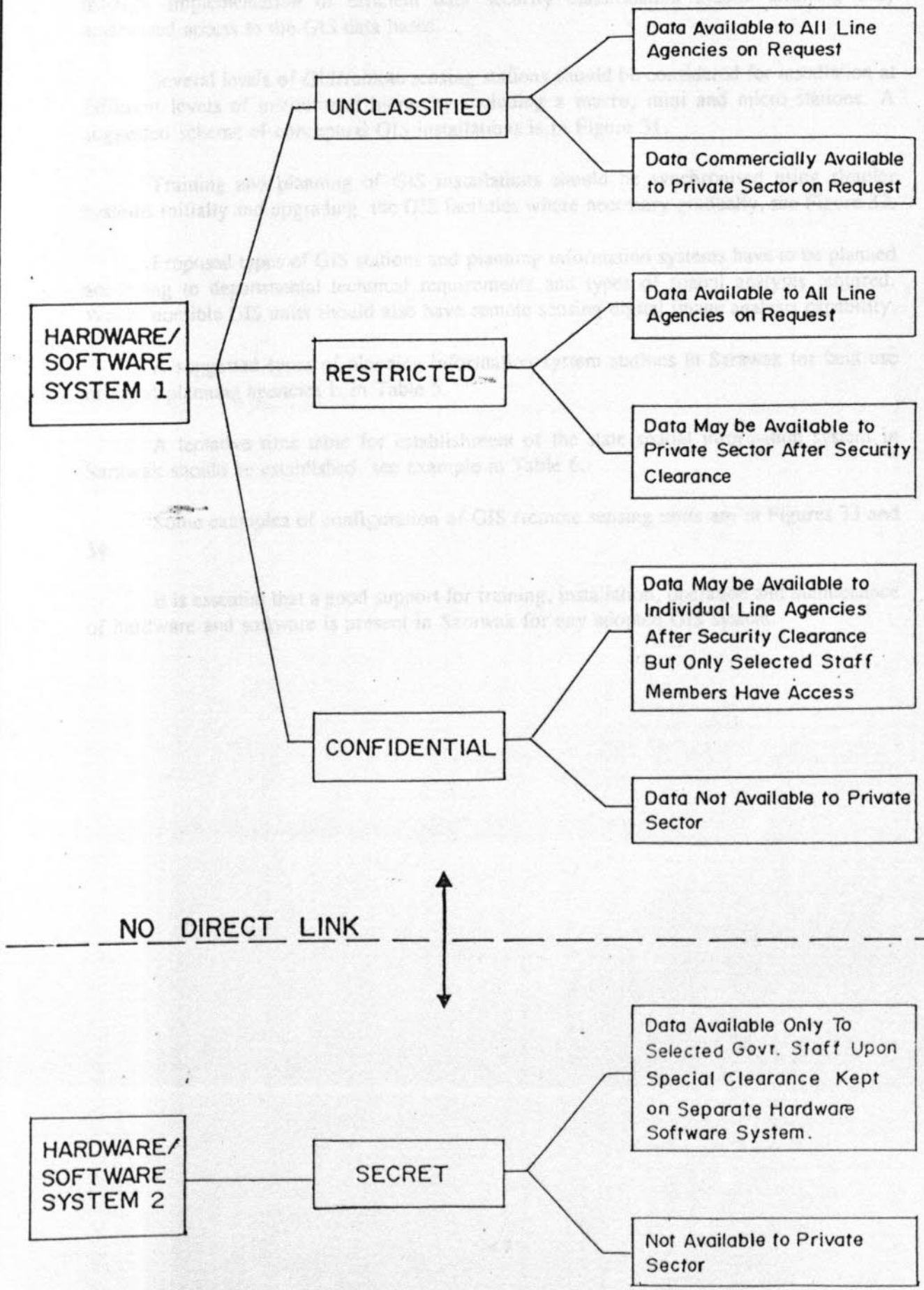


Fig.25 SARAWAK GOVERNMENT AGENCIES DIRECTLY INVOLVED IN SPATIAL PLANNING OF RESOURCES AND LAND USE PLANNING.

Fig. 26 SECURITY AND CONFIDENTIALITY OF GIS INFORMATION HANDLING



A security and confidentiality of spatial geographical information has to be secured through implementation of efficient data security classification system allowing only authorised access to the GIS data bases.

Several levels of GIS/remote sensing stations should be considered for installation at different levels of institutional hierarchy including a macro, mini and micro stations. A suggested scheme of conceptual GIS installations is in Figure 31.

Training and planning of GIS installations should be synchronised using simpler systems initially and upgrading the GIS facilities where necessary gradually, see Figure 32.

Proposed types of GIS stations and planning information systems have to be planned according to departmental technical requirements and types of spatial analyses required. Where possible GIS units should also have remote sensing digital image analysis capability.

A suggested types of planning information system stations in Sarawak for land use oriented planning agencies is in Table 5.

A tentative time table for establishment of the state spatial information system in Sarawak should be established, see example in Table 6.

Some examples of configuration of GIS /remote sensing units are in Figures 33 and 34.

It is essential that a good support for training, installation, operation and maintenance of hardware and software is present in Sarawak for any adopted GIS system.

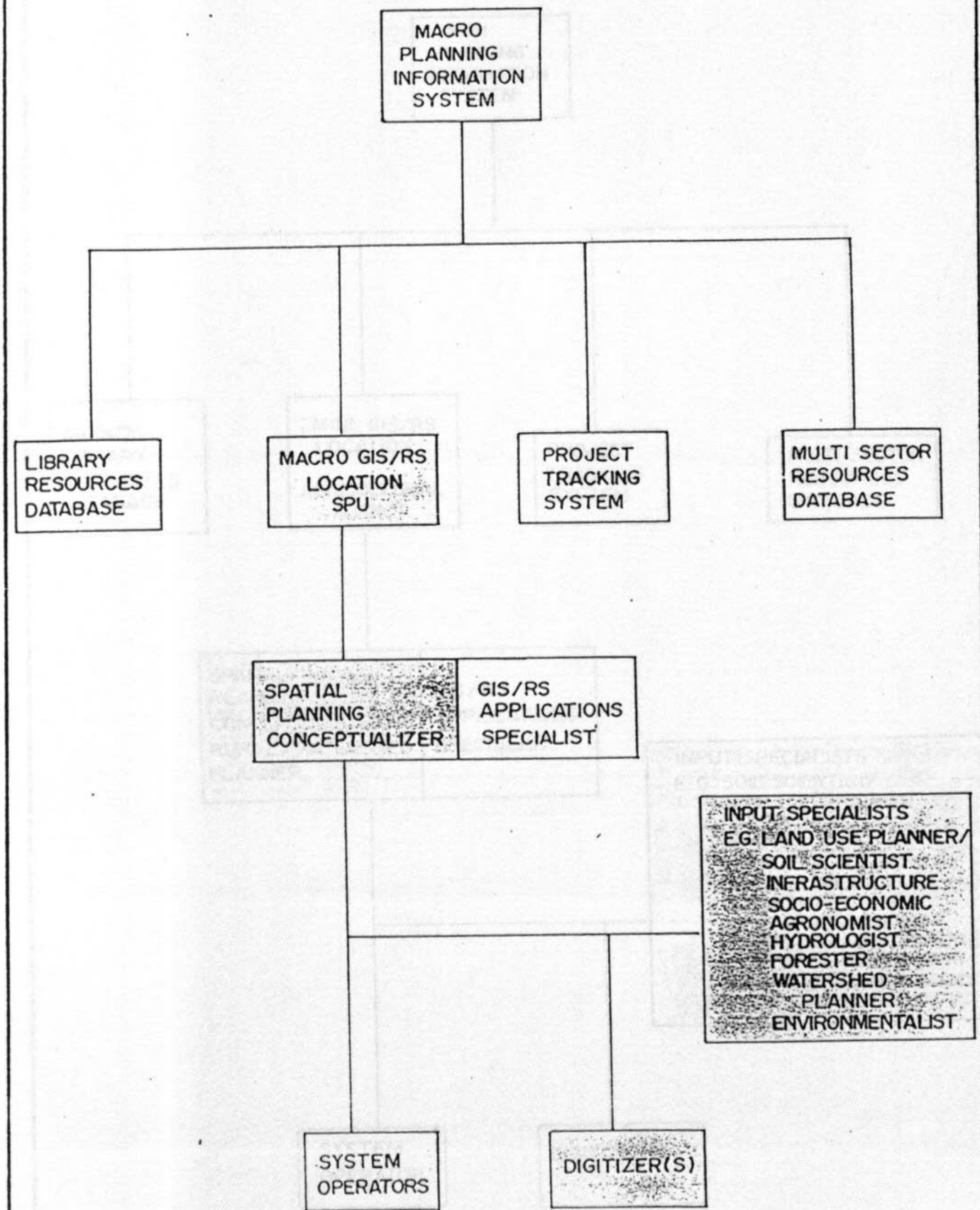


Fig. 27 PROPOSED MACRO GIS/RS UNIT - CORPORATE AND SEMI-CORPORATE SYSTEM

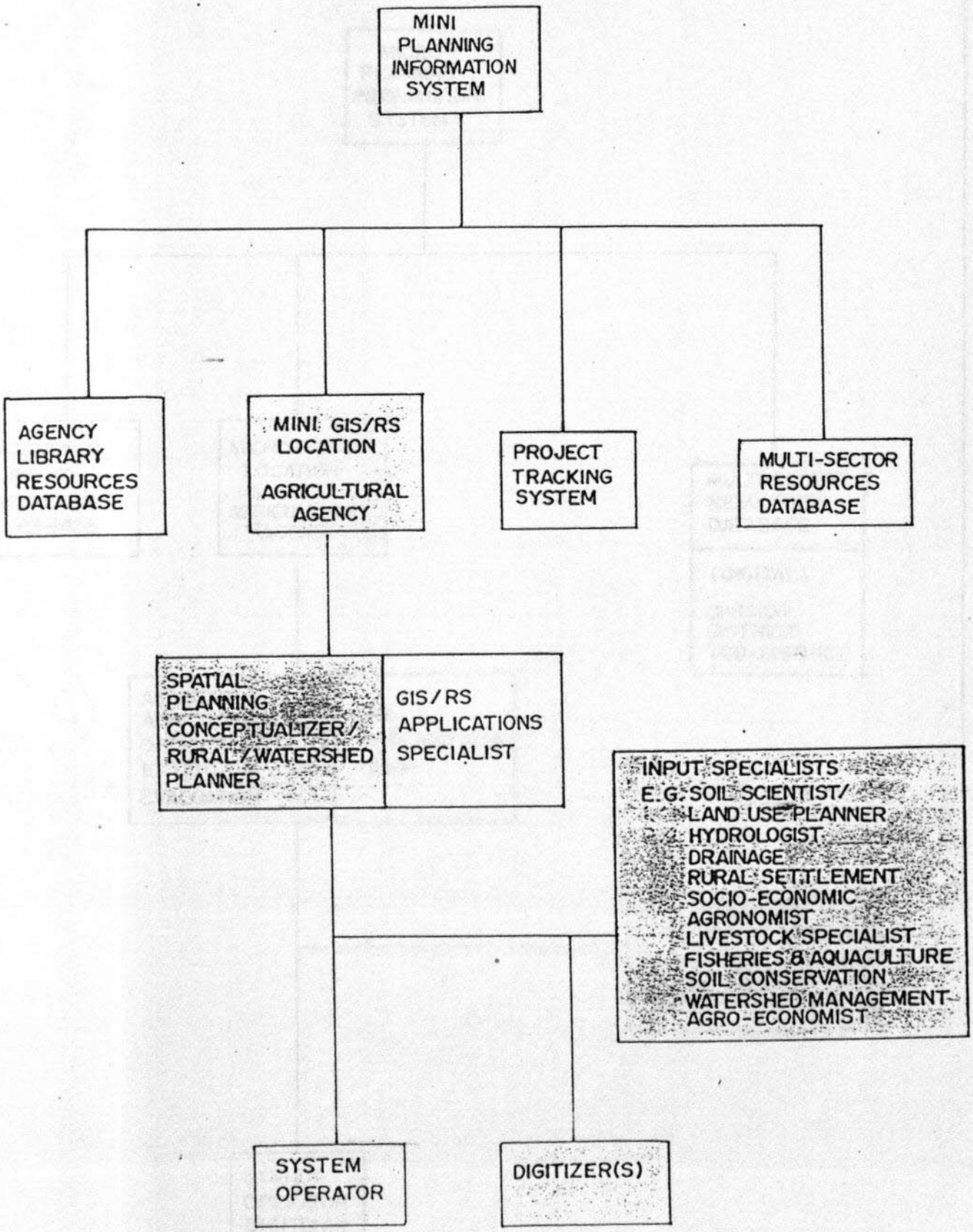


Fig. 28 PROPOSED MINI GIS/RS UNIT IN AGRICULTURAL AGENCIES.

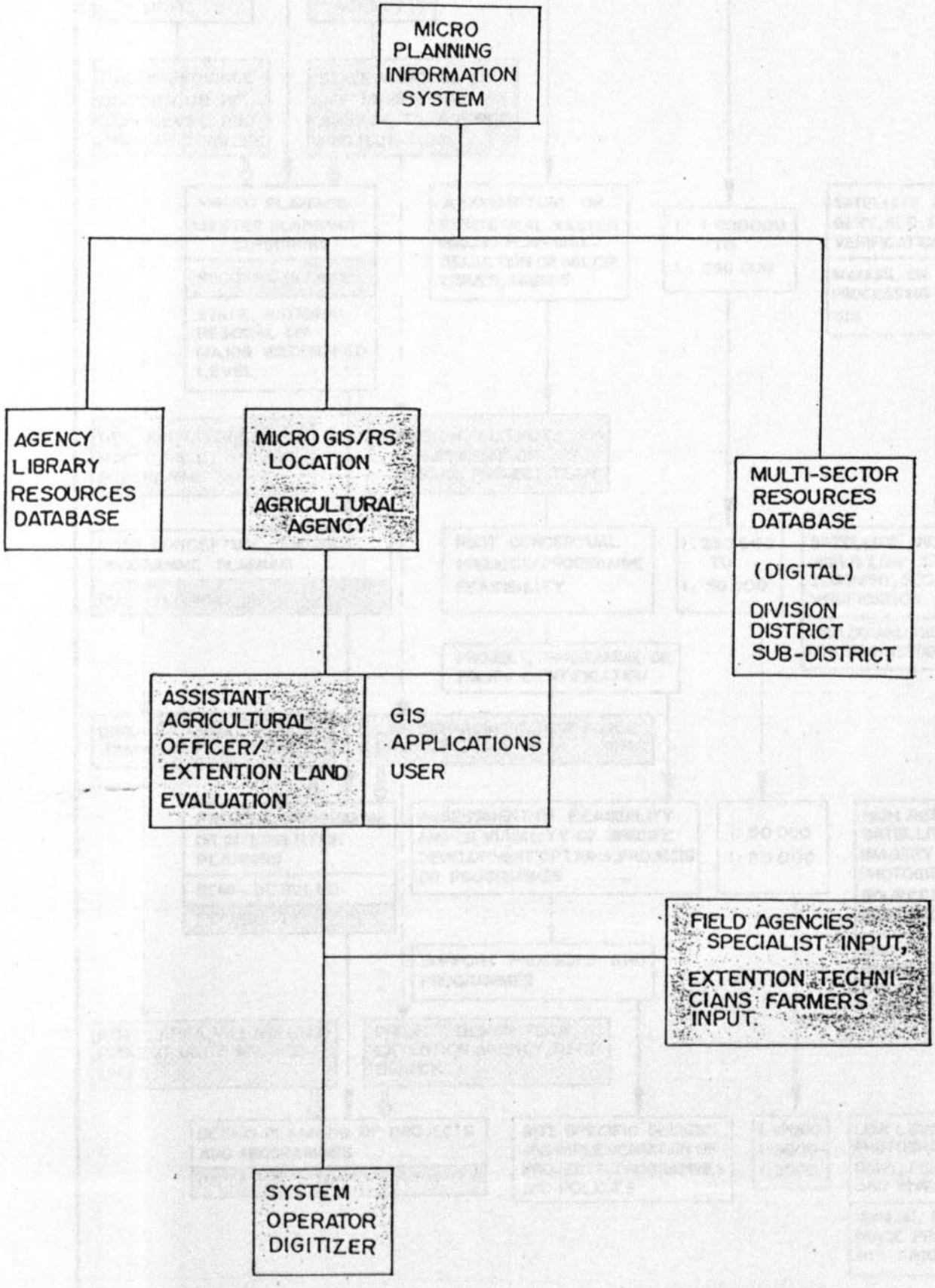


Fig.29 PROPOSED MICRO GIS/RS UNIT IN AGRICULTURAL AGENCIES.

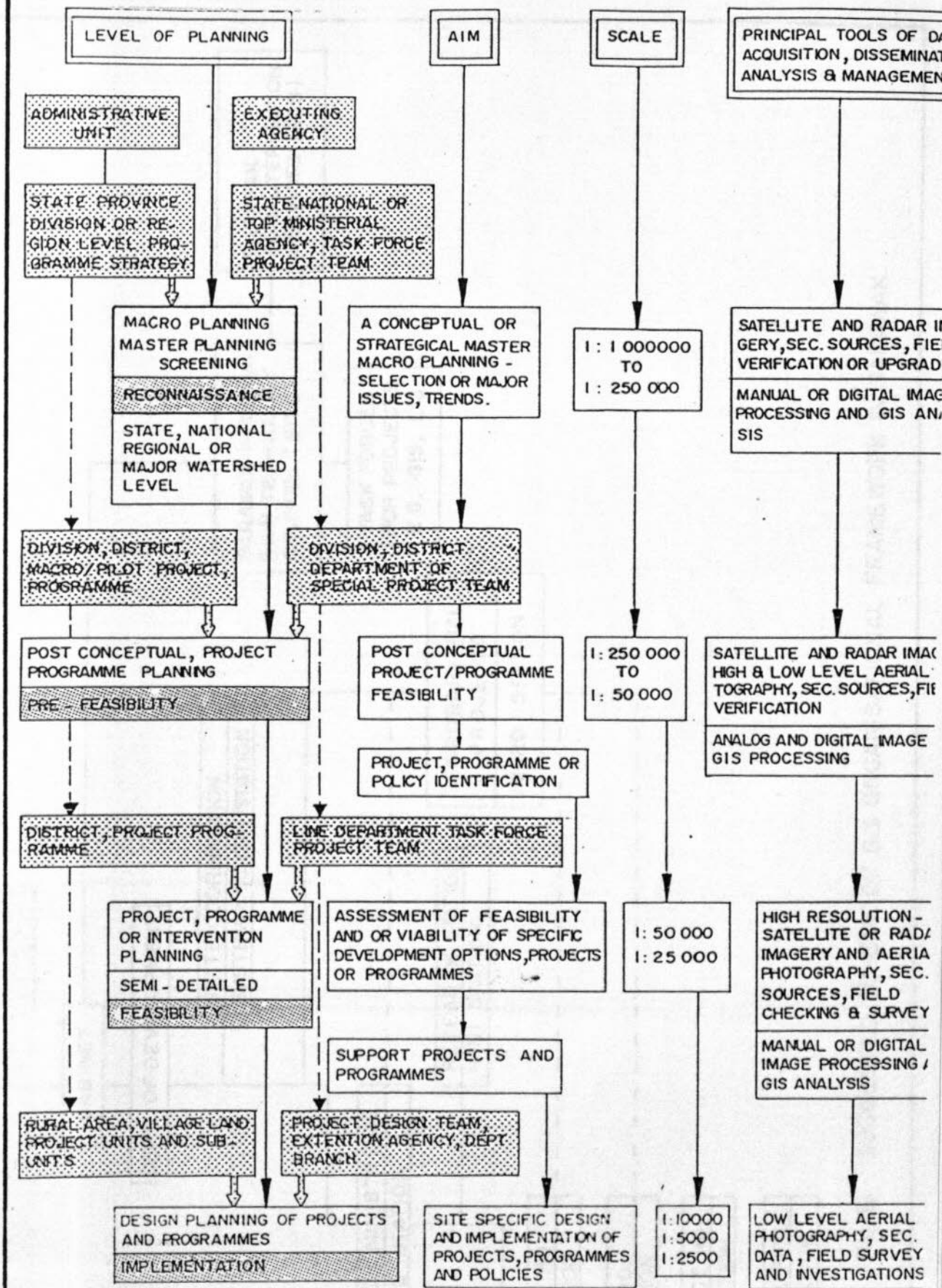


FIG. 30 A RECOMMENDED SYSTEM OF MULTI LEVEL PLANNING OF RESOURCES DEVELOPMENT FOR SARAWAK.

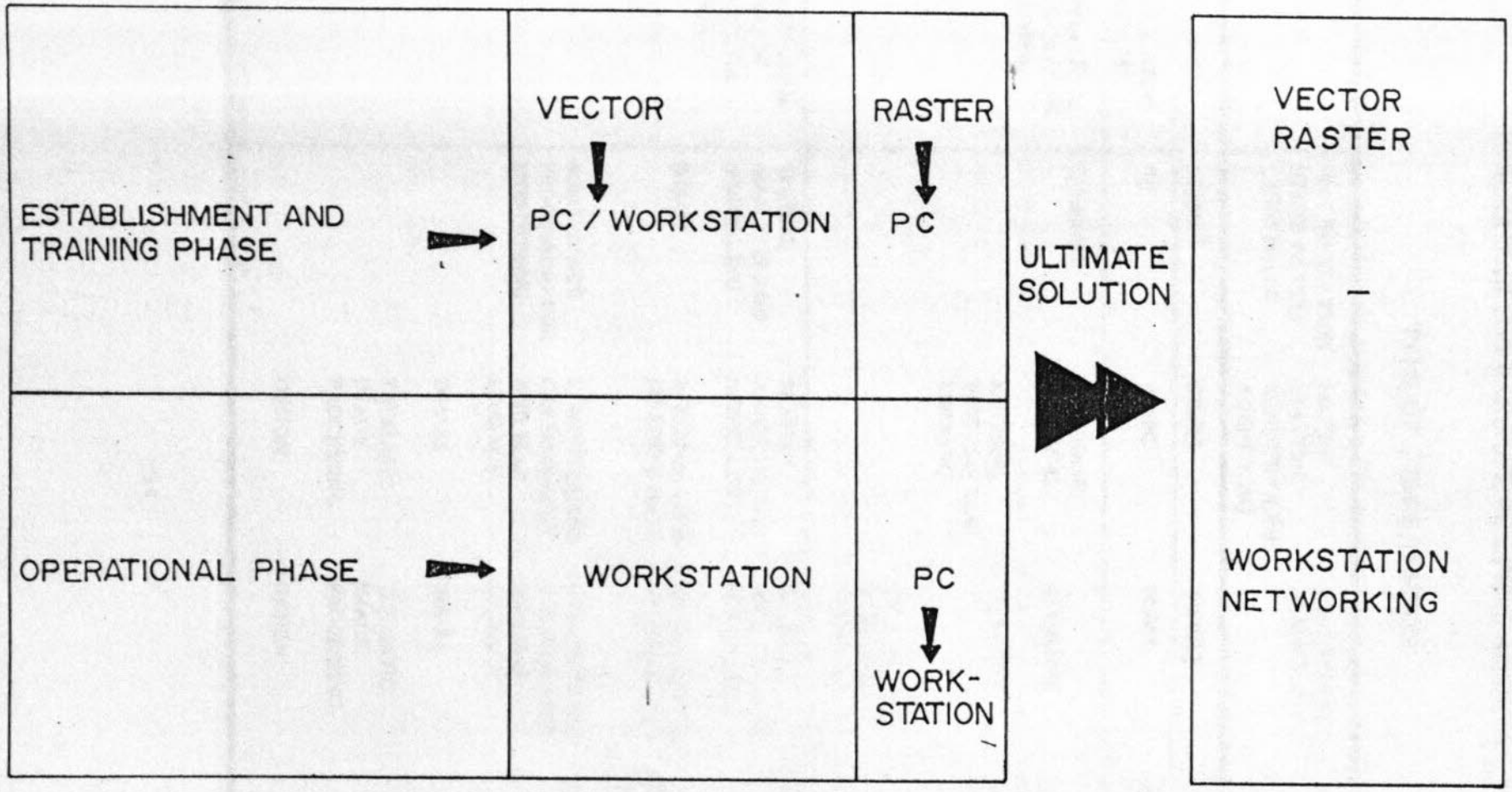


FIG. 32 SUGGESTED POSSIBLE STEPS IN ESTABLISHING A MACRO AND A MINI STATION IN AN AGENCY.

TABLE 5 SUGGESTED TYPES OF PLANNING INFORMATION SYSTEM STATIONS IN SARAWAK FOR LAND USE PLANNING AGENCIES (AGRIC. SECTOR)

TYPE OF GIS/RS STATION

	MACRO STATION STATE LEVEL/ CORPORATE	MACRO STATION MINISTRY/LINE AGENCY HQ	MINI STATION AGENCY DEPT.	MICRO STATION
FACILITY	GIS/RS	GIS/RS	GIS/(RS)	GIS
OPERATING SYSTEM	WS	WS/PC	PC/WS	PC
PRINCIPAL LOCATIONS (SITES)	KUCHING	1ST PHASE: REGIONAL- KUCHING, BINTULU, MIRI, LIMBANG	DIVISIONS DISTRICTS LINE AGENCY RESEARCH STATION	SUBDISTRICT FIELD (TEMPORARY PROJECTS)
EXPECTED MAJOR APPLICATIONS	SPATIAL ANALYSIS AND MODELLING DBMRS SOME IMAGE PROCESSING FOR MONITORING	SPATIAL ANALYSIS AND MODELLING INTERPOLATION OF POINT DATA COMPUTERISED CARTOGRAPHY AND MAP STORAGE DBMRS THEMATIC IMAGE PROCESSING DESIGN	SPATIAL ANALYSIS AND MODELLING INTERPOLATION OF POINT DATA COMPUTERISED CARTOGRAPHY AND MAP STORAGE BBMRS THEMATIC IMAGE PROCESSING DESIGN	DBMRS SPATIAL ANALYSIS AND MODELLING DESIGN

LEVEL OF PLANNING TASKS	1990	1995	2000	2010	2020
	1. ESTABLISHMENT OF A STATE MANAGEMENT INFORMATION CENTRE OF INTEGRATED SPATIAL PLANNING UNIT. 2. ESTABLISHMENT OF MIC AND MIU AT ALL MINISTRIES AND LINE DEPARTMENTS DEALING WITH SPATIAL PLANNING OF RESOURCES	1. ESTABLISHMENT OF A REGIONAL REGIONAL MIC (MIRI-BINTULU REGIONAL) 2. ESTABLISHMENT OF DIVISIONAL LEVEL MIC OR MIU 3. ESTABLISHMENT OF DISTRICT LEVEL MIU. 4. INFO. LINK TO EXTENSION OFFICES	1. ESTABLISHMENT OF MIU IN SUB-DISTRICTS AND AGRICULTURE, FORESTRY, HEALTH AND PUBLIC SERVICE EXTENTION OFFICES CENTRES. 2. ESTABLISHMENT OF BOTTOM UP SPATIAL PLANNING FRAMEWORK FOR LOCAL LAND DEV. PLANNING OF RESOURCES	COMPLETION OF ESTABLISHMENT OF NATIONAL (STATE) DIGITAL MANAGEMENT INFORMATION SYSTEM FOR RESOURCES PLANNING DOWN. TO VILLAGE OR SITE SPECIFIC LEVEL.
NATURE OF PLANNING TASKS	1. CENTRALISED DATA CAPTURE ASSESSMENT, VERIFICATION STANDARDISATION, DIGITIZATION, STORAGE, MONITORING, PERIODIC UPDATING. 2. STANDARDISED RESOURCES INVENTORY DATA POOL AT STATE LEVEL. 3. ADOPTION OF INTEG. SPATIAL PLANNING FRAMEWORK,	1. DIVISIONAL NETWORK OF DATA CAPTURE, ASSESSMENT, VERIFICATION, STANDARDISATION, DIGITISATION, STORAGE, MONITORING PERIODIC UPDATING. 2. AS ABOVE FOR DISTRICTS. 3. ESTABLISHMENT OF INTEG. SPATIAL PLAINNING NETWORK FOR BOTTOM UP PLANNING. 4. ESTABLISHMENT OF LOCAL LAND DEVELOPMENT PLANNING FRAMEWORK CONCEPT.	1. SUB-DISTRICT NETWORK OF DATA CAPTURE, ASSESSMENT, VERIFICATION, STANDADISATION DIGITISATION, STORAGE, MONITORING AND UPDATING. 2. FULL IMPLEMENTATION OF LOCAL LAND DEV. PLANNING ON VILLAGE LEVEL-BOTTOM UP PLANNING.	NATIONAL (STATE) MANAGEMENT INFORMATION SYSTEM FOR INTEGRATED SPATIAL PLANNING USED ON ROUTINE BASIS DOWN TO VILLAGE OR SITE SPECIFIC LEVEL
SCALE OF IMPLEMENTATION	DIGITAL DATA POOL: 1 : 2 000 000 1 : 1 000 000 1 : 500 000 1 : 250 000 1 : 50 000	DIGITAL DATA POOL: 1 : 250 000 1 : 100 000 1 : 500 000 1 : 25 000 1 : 10 000 1 : 5 000	DIGITAL DATA POOL: 1 : 25 000 1 : 10 000 1 : 5 000 1 : 2 500 1 : 1 000	ALL SCALES

TABLE 6 A SCHEME FOR ESTABLISHMENT OF STATE SPATIAL MANAGEMENT INFORMATION PLAINNING SYSTEM IN SARAWAK.

MIU - Management Unit

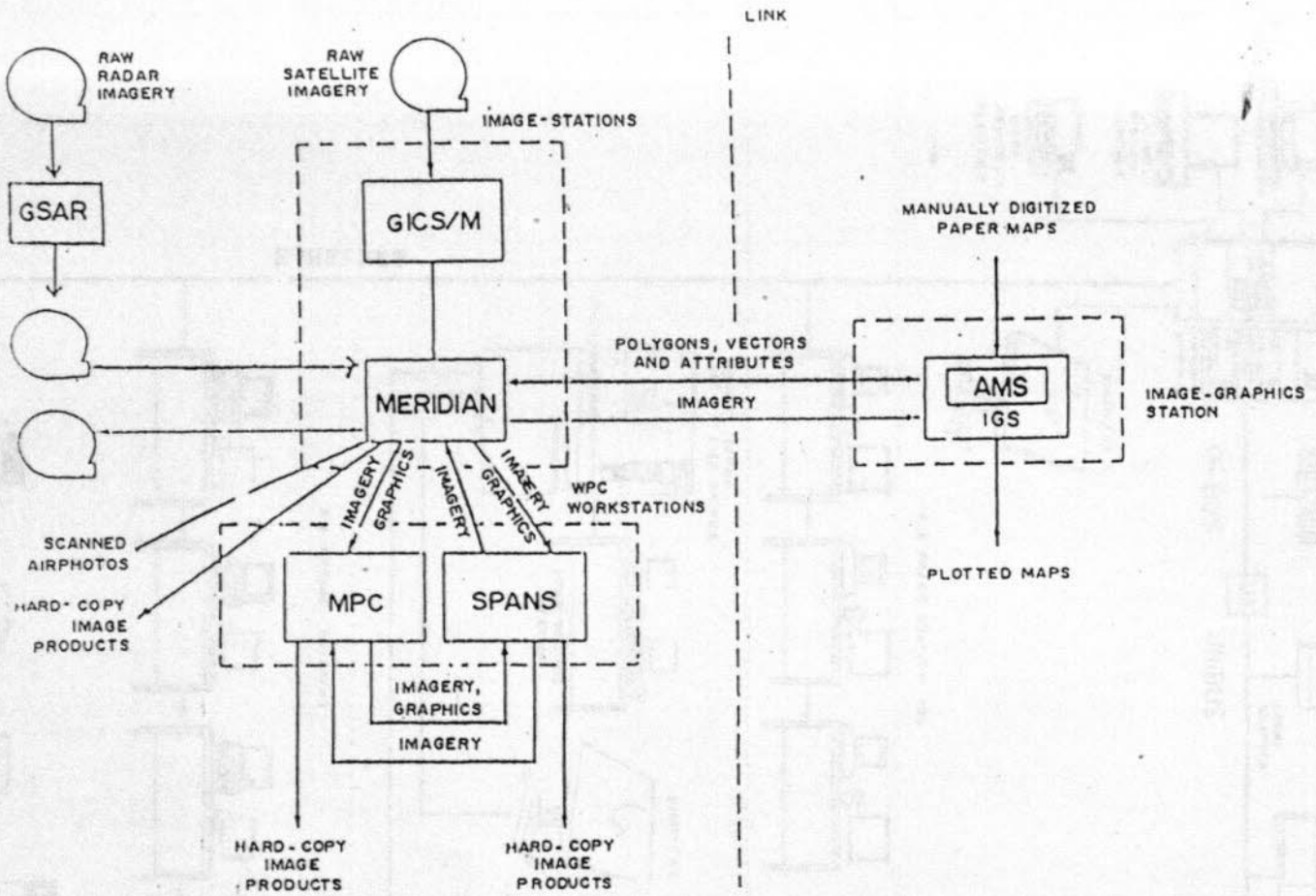


FIG. 33 AN EXAMPLE OF A SOFTWARE CONFIGURATION IN A REMOTE SENSING CENTER (Malaysian Center For Remote sensing)

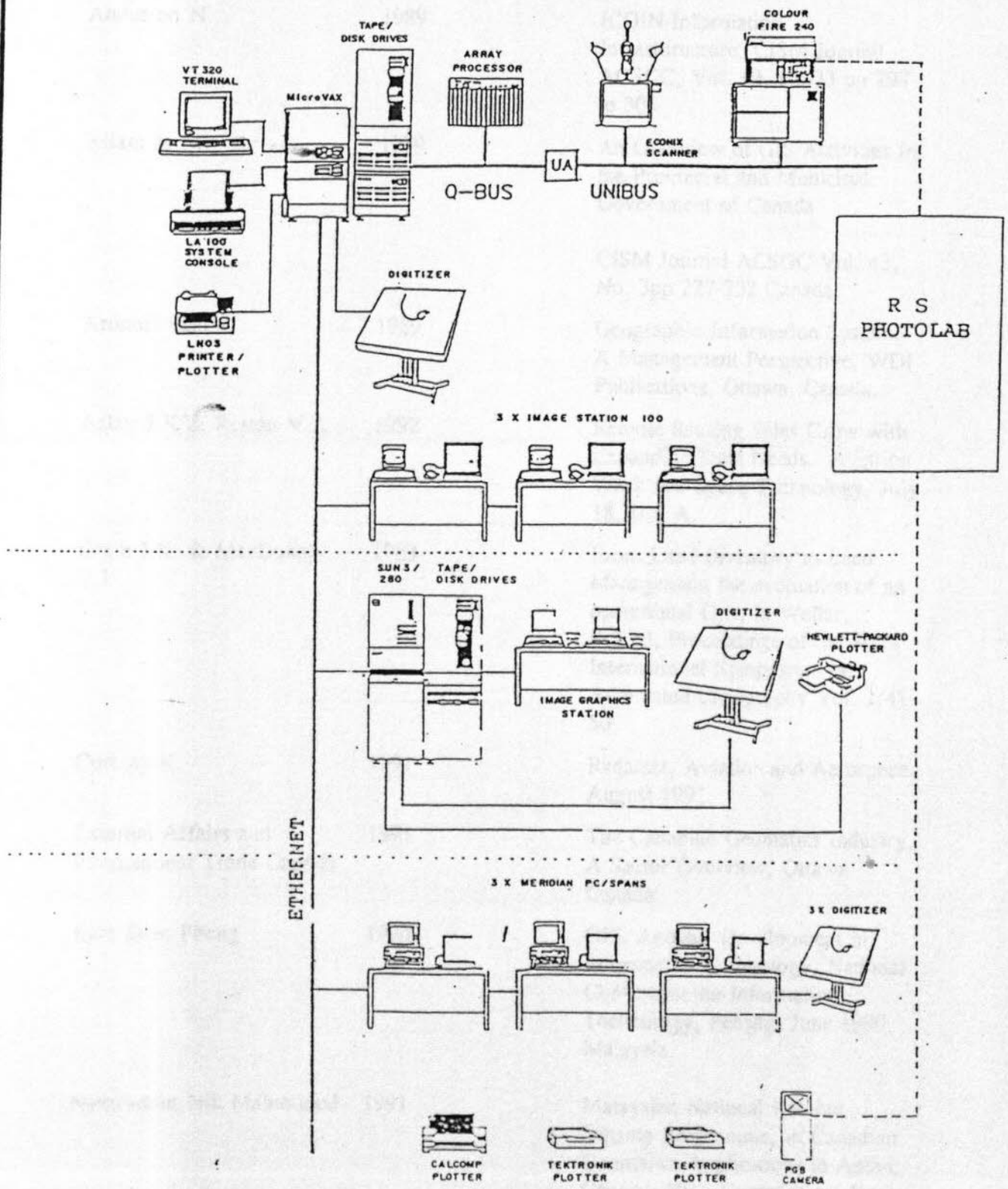


FIG. 34 AN EXAMPLE OF A SYSTEM CONFIGURATION FOR A CENTRE FOR REMOTE SENSING (MALAYSIA)

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