Pertanika J. Trop. Agric. Sci. 22(2): 171-177 (1999)
ISSN: 1511-3701

Conceptual Design and Implementation of Geographic Information System(GIS) for Hutan Simpan Ayer Hitam, Selangor

ISMAIL ADNAN ABDUL MALEK
Department of Forest Production
Faculty of Forestry
Universiti Putra Malaysia
43400 Serdang, Selangor Darul Ehsan, Malaysia

Keywords : Geographical Information System, Decision Support System, forest management planning, spatial analysis

ABSTRAK

Sistem Maklumat Geografi(SMG) memberikan ruang yang besar untuk pembangunan pendekatan yang baru dalam pemprosesan data spatial atau geografik berkomputer seterusnya menambahkan dimensi yang baru dalam pengurusan, penganalisan dan persembahan jumlah maklumat yang besar yang diperlukan untuk menyokong proses membuat keputusan. Satu SMG dicadangkan diguna untuk automasi dan penganalisan data dalam pengurusan sumber hutan di Hutan Simpan Ayer Hitam, Puchong, Selangor. Selain dari operasi-operasi asas pertanyaan attribut dan spatial menggunakan SMG, kaedah modeling spatial dan permukaan juga dapat digunakan untuk menolong perancangan dan pengurusan hutan di Ayer Hitam.

ABSTRACT

Geographic Information System (GIS) has created a large field of opportunity for the development of new approaches to computer processing of spatial or geographically referenced data, hence adding a new dimension to the management, analysis, and presentation of the large volumes of information required in the decision making processes. A GIS is proposed to be used for automation and analysis of data in the management of forest resources at Hutan Simpan Ayer Hitam, Puchong, Selangor. In addition to basic attribute and spatial query operations in the GIS, spatial modeling and surface analysis methods should also be used to assist forest planning and management at Ayer Hitam.

INTRODUCTION

Hutan Simpan Ayer Hitam, Puchong, Selangor plays a major role in teaching and research at the Faculty of Forestry, Universiti Putra Malaysia (UPM). However, a major challenge presented by the forest is the handling and organizing of information about the resource from past and future research. The second challenge is how this information can be analyzed to support decision making. The advent of Geographic Information System (GIS) has created a large field of opportunity for the development of new approaches to computer processing of spatial or geographically referenced data, hence adding a new dimension to the management, analysis, and presentation of the large volumes of information required in the decision making processes (Healey, 1988). Since, information on Hutan Simpan Ayer Hitam are largely spatial in nature, the question arise whether data management and decision making can be improved using GIS as a tool. This paper proposes a GIS for Hutan Simpan Ayer Hitam, Puchong, Selangor for the purpose of data management and decision support. The conceptual design and implementation of the Ayer Hitam GIS will be highlighted in the paper.

Conceptual Design and Implementation of Hutan Simpan Ayer Hitam Geographical Information System (GIS)

Geographical Information System(GIS) is an organized collection of computer hardware, software, geographic data, and personnel

designed to efficiently store, capture, update, manipulate, analyze and display all forms of geographically referenced information, (ESRI, 1990). Its successful implementation at Hutan Simpan Ayer Hitam largely depends on four requirements. The first requirement is automation of the GIS database. It is costly and time consuming to collect and store large quantities of data. The most cost-effective approach is to collect only data required for specific uses. Secondly, all data collected from various sources, either from existing records, ground surveys, remote sensing and others will need to be integrated by means of GIS methods. Thirdly, the Hutan Simpan Ayer Hitam GIS and its database must be organized so as to facilitate ad hoc query and generation of new information. Finally, it must be possible to perform spatial modeling, in support of decision-making.

The GIS database Automation and Application

The exact information types to be acquired in the database must first be identified. Each data type included in the database will comprise of unique map features and their attributes linked by special geographic identifiers. This will enable data retrieval and ad hoc queries be performed on the spatial features. *Fig. 1* illustrates the conceptual GIS database design for Hutan Simpan Ayer Hitam. It consists of five main data layers: 1) the base map 2) topography 3) drainage 4) infrastructure and 5) forest stand.

For design, automation and implementation of the GIS, the software ARC/INFO and ARCVIEW (ESRI Inc., Redland, CA) will be used because of their wide availability on personal computers. The following stages in the GIS database automation and implementation process are illustrated in *Fig. 2.*

1. Digitizing of existing map sources
2. Updating of existing map coverages from aerial photography, satellite remote sensing and field survey;
3. Development of attribute database for each spatial features;
4. Data query, spatial analysis and modeling
5. Automated mapping and display of results from data analysis and modeling

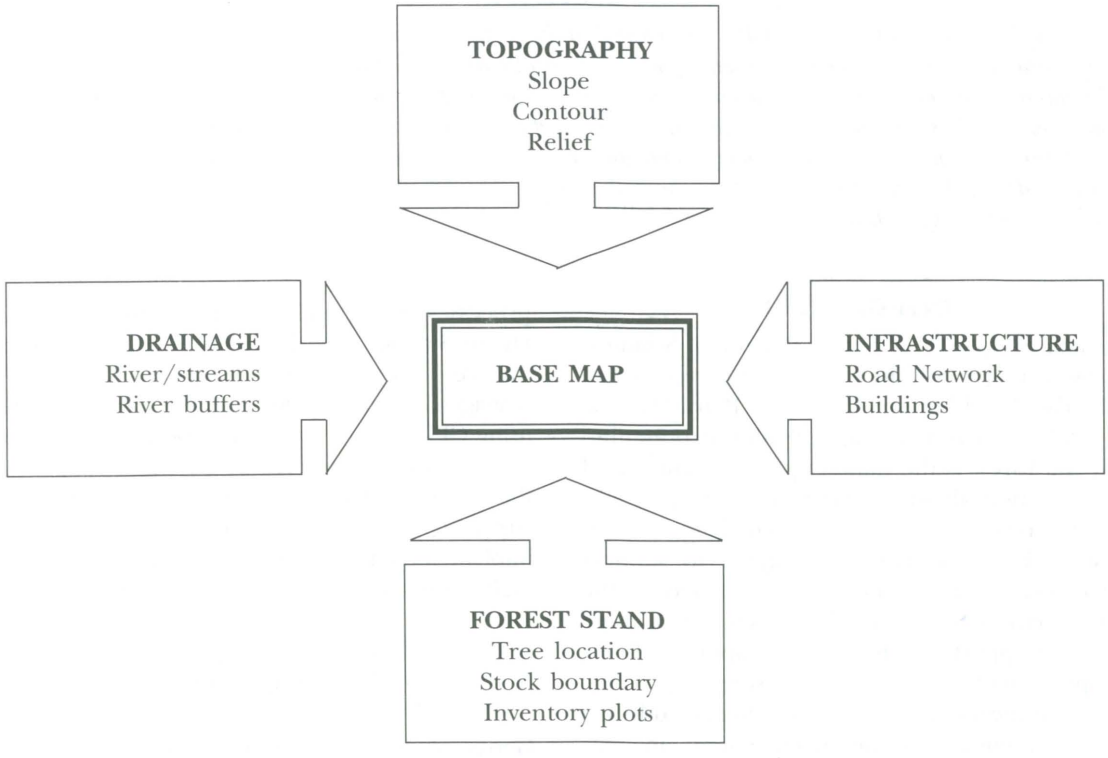

Fig. 1. The conceptual GIS database design for Hutan Simpan Ayer Hitam, Selangor

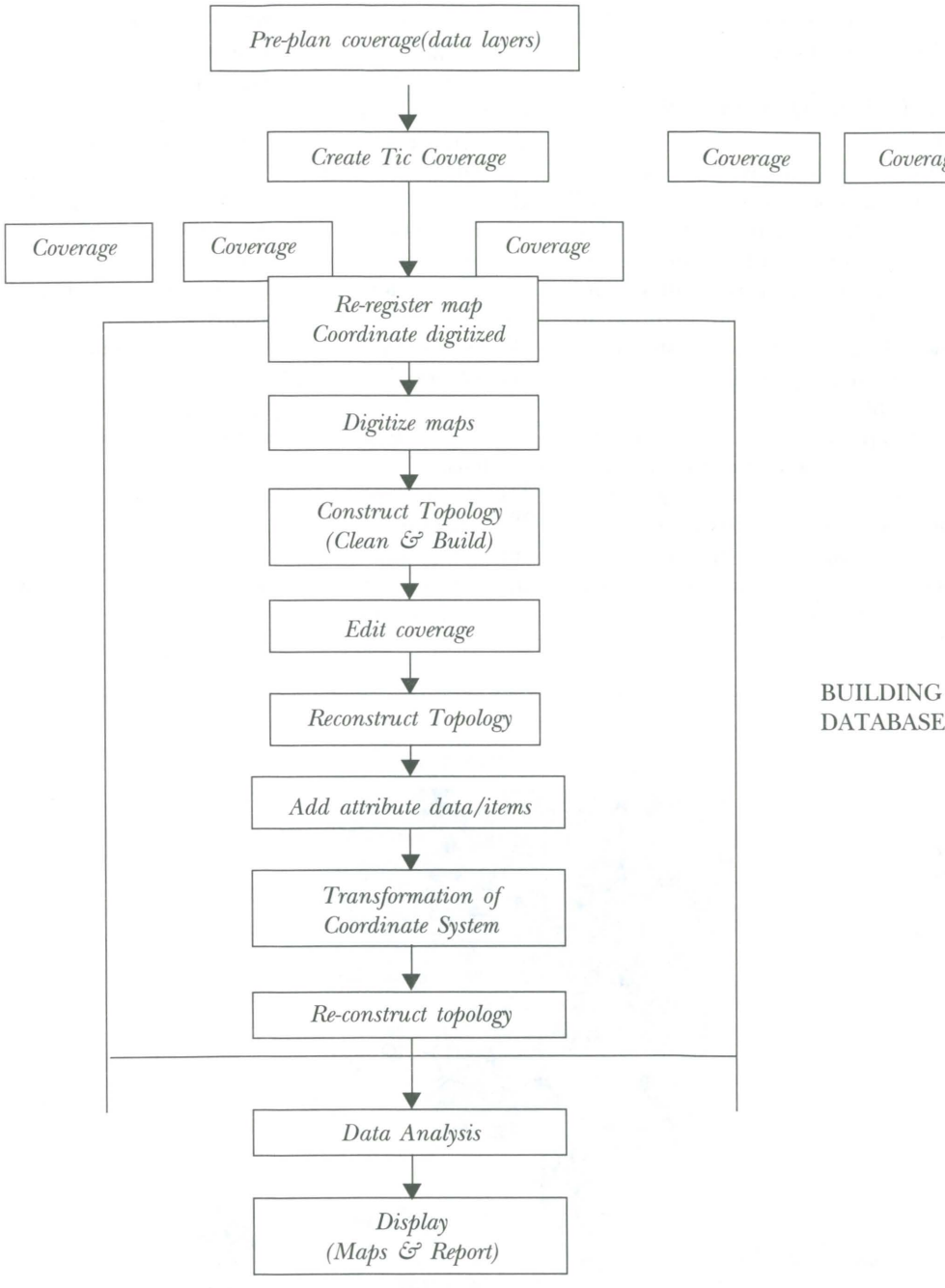

Fig. 2. Combined steps in database automation and Implementation of Hutan Simpan Ayer Hitam, Selangor GIS Using ARC/INFO and ARCVIEW software

Hutan Simpan Ayer Hitam GIS as a Decision Support Tool

The true strength of a GIS lies in its functionality of spatial analysis. The three operations allowed are attribute queries (ad hoc query and retrieval of database), spatial queries and generation of new information (modeling). These operations are in support of decision making processes. In Forestry, GIS has supported decisions in timber harvest planning, timber inventory and stock mapping, fire risk potential, erosion risk assessment and many others (Harem 1998).

Examples of spatial analysis in the Hutan Simpan Ayer Hitam GIS are as follows:

Data Retrieval and Ad Hoc Query (Spatial and attribute queries)

The basic operation in spatial analysis of GIS for decision support is ad hoc query and display of spatial features and their related database. Using the GIS, the questions of 'what' and 'where' the resources are can be answered quickly. Information or attribute about spatial features can also be retrieved because of the existence of linkages between the features and their attribute in the database table. *Fig. 3* shows a map of queried natural and physical features (road, river and forest compartments) in Hutan Simpan Ayer Hitam. These features are queried using Simple Query Language (SQL) commands provided by the GIS. Attribute information on the spatial features can also be retrieved by the user and presented as text or report.

Spatial Modeling and Generation of Scenarios

The advanced operation in GIS as a decision support tool is spatial modeling. Here, lies the overwhelming advantage of GIS over cartographic, database and statistical software. Spatial modeling allows manipulation of the GIS data to generate new information for a specific planning task. Specifically, it allows visualization of alternative scenarios from different decision ('what if'); hence, enabling further analysis and refinements of the decisions before the 'best' decision is chosen. This approach reduces the risk of poor planning.

The following example illustrates the use of spatial modeling technique in site suitability analysis. If the answer required is "the best site for construction at Hutan Simpan Ayer Hitam?", the selection criteria that meet the "best site" must first be identified as follows:

a) the site must be at least 20 meters away from rivers

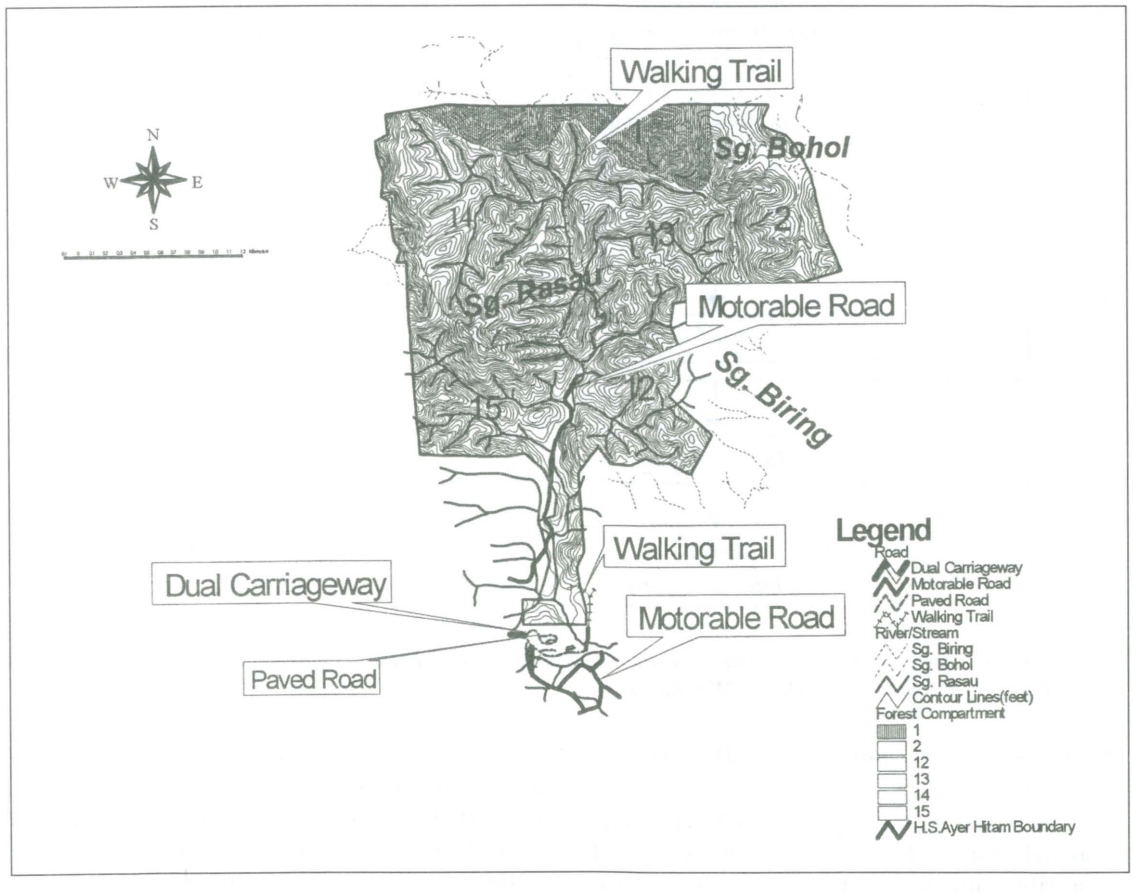

Fig. 3. Map of Natural and Physical Resource in Hutan Simpan Ayer Hitam, Selangor

b) the site must be on less than 15 degrees slope
c) the site must be within 100 meters from existing motorable road

In the site suitability modeling, the method involves creating new digital layers in the GIS and extracting certain information from the database layers. The new layers created are road and river buffers and a layer combining the buffers with slope layer. Buffer creation is done using BUFFERING tool in the ARCVIEW software and the combining of data layers are performed using UNIONING tool. To model suitable site for building construction, the QUERY tool is used. The logical query expression in the model is as follows:

IF	land is 20 meters away from rivers
AND	land is within 100 meters of motorized road
AND	land is less than 15 degrees slope
THEN	the areas are recommended for building

The above expression translated into ARCVIEW QUERY command are:

INSIDE .NE. 1 AND WITHIN = 2 AND SLOPE-CODE = 73
Where

INSIDE	areas within 20 meters river buffer
WITHIN	areas within 100 meter motorized road buffer
SLOPE–CODE	slope code

Where code values:

INSIDE	1(in 20 meter buffers); 0 (outside 20 meter buffer)
WITHIN	2 (in 100 meter buffer); 3 (outside 100 meter buffer)
SLOPE-CODE	73 (0-14.9degrees), 83 (15-24.9 degrees), 84 (25 degrees and greater)

Fig. 4 shows the overall flow of the spatial modeling operation. Statistics of suitable area can also be generated using attribute query tool in the GIS.

The results and output of spatial modeling above is illustrated in *Fig. 5*. Using the STATISTICS tool in the GIS, the extent of areas suitable for construction in the Hutan Simpan Ayer Hitam is 89.4 hectares.

Surface Analysis and Modeling

Surface analysis is a recent and more advanced operation in GIS. It involves the usage of the third dimension of spatial data (the z variable) in addition to the basic x and y variables in the Cartesian coordinate plane (Chou 1997). Elevation is an example of the z variable or 3D attribute representing terrain topography of a study area. In the example of the Ayer Hitam forest, three dimensional surface can be generated in the GIS to enable perspective viewing of the resources *(Fig. 6)*. Other surface analysis operation include earth volume, aspect and relief calculations.

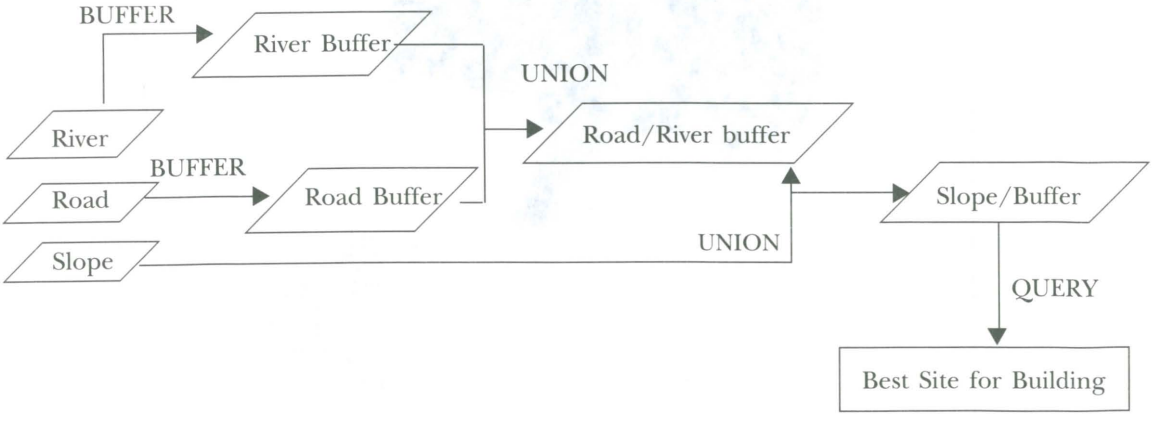

Fig. 4. Flow chart of spatial modeling

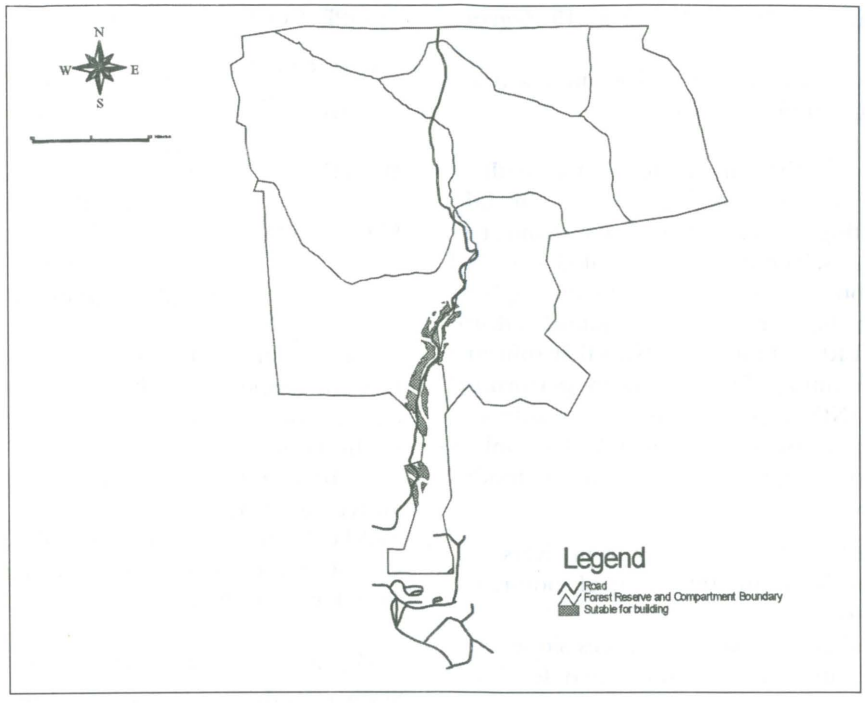

Fig. 5. Map of Area Suitable for Development in Hutan Simpan Ayer Hitam, Selangor

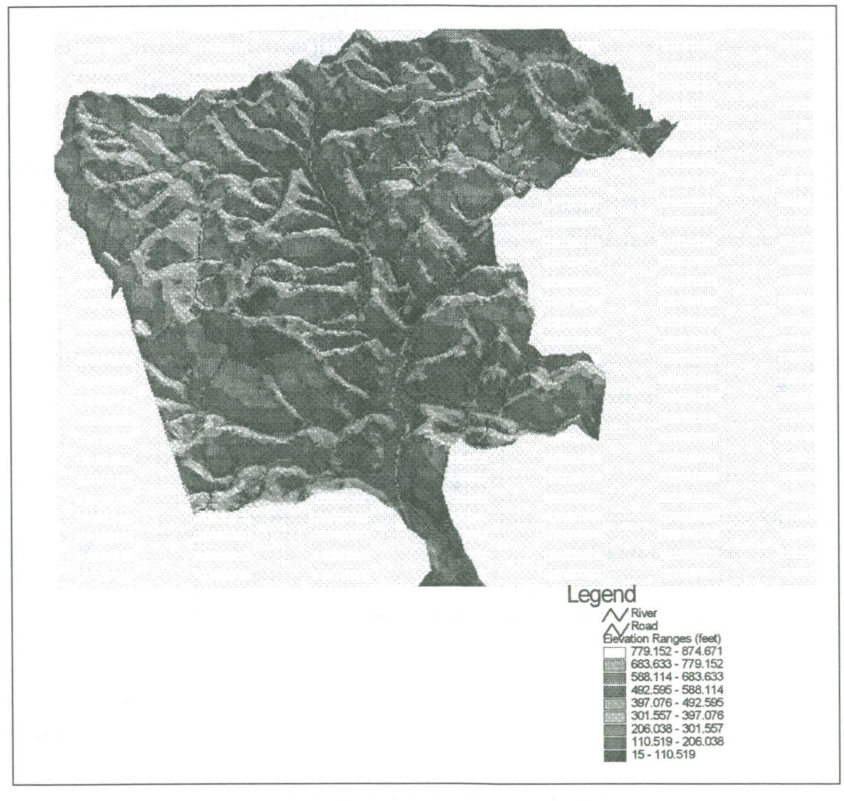

Fig. 6. 3 Dimensional View of Ayer Hitam Forest, Selangor

CONCLUSION

The myriad of operations available in Geographical Information System (GIS) has made the system an important decision support tool in Forestry. Efficient handling and analysis of spatial data provided by GIS enable more efficient planning and management of forest resources. The need for organized data collection, storage and analysis in decision making at Hutan Simpan Ayer Hitam can be met if GIS is developed for the forest area.

REFERENCES

CHOU, Y. H. 1997. "*Exploring Spatial Analysis in Geographic Information Systems*". Santa Fe: OnWord Press.

ESRI. 1990. "*Understanding GIS – The Arc/Info Method*". (ESRI Inc., Redlands, CA)

HAREM, P. 1998. "*Mapping Potential Community Landuse Areas in Sabal Forest Reserve Using Geographic Information System (GIS")*. Unpublished B.Sc. Forestry Thesis. Faculty of Forestry, Universiti Putra Malaysia. 54 p.

HEALEY, R.G. 1988. "Geographic Information Systems: an overview", in Geographical *Information Systems and Remote Sensing for Local Resources Planning* Eds R.A. Vaughn and R.P. Kirby. Remote Sensing Products and Publication, Dundee. p. 11 – 19.