Sesi 3

Paper II
GIS Application in Multidisiplinary Research Institutions for sustainable Development
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GIS Application in Multidisciplinary Research Institutions for Sustainable Development

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Abstract

As a multidisciplinary research and development (R&D) institution, the Institute for Environment and Development (LESTARI) utilises extensive secondary data and information for research, training, networking, outreach and policy advocacy. Geographical Information Systems (GIS) applications have been very useful throughout such R&D purposes, especially in the context of promoting sustainable development. This paper discusses LESTARI's experiences in various applications of GIS, particularly in research and database/information management. It focuses on the LESTARI Information System that centralises and manages data from various research programs at LESTARI. GIS integrates seamlessly with many types of spatial and non-spatial data, especially remotely-sensed data like satellite images, making it a prime tool in research administration and management. Thus, GIS is deployed in management of data in various projects and the technology is applied to the disseminating information, explaining phenomena, modelling scenarios, predicting events and decision-making. Other than map-based analysis or its powerful database system, GIS technology is applied to inventorying, characterisation, and disaster risk assessment and vulnerability analysis. The research on sustainable development carried out with the help of GIS includes data management, policy development, planning and management, decision support system, application and public use of the information.

INTRODUCTION

Most sustainable development decisions are inherently multidisciplinary or **cross-sectoral** because they require trade-offs between conflicting goals of different sectors. However, most natural resource development agencies are **single-sector** oriented. Geographic Information System (GIS) technology can help establish cross-sectoral communication by providing not only very powerful tools for storage and analysis of

multisectoral spatial and statistical data, but also by integrating databases of different sectors in the same format, structure and map projection in the GIS system.

The importance of this **integrated approach** to development and management of natural resources has been emphasised in many international fora on sustainable development. The 1992 United Nations Conference on Environment and Development (UNCED) devoted Chapter 10 of its **Agenda 21** to this topic, noting that:

> *"Expanding human requirements and economic activities are placing ever increasing pressures on land resources, creating competition and conflicts and resulting in suboptimal use of both land and land resources. If, in the future, human requirements are to be met in a sustainable manner, it is now essential to resolve these conflicts and move towards more effective and efficient use of land and its natural resources. Integrated physical and landuse planning and management is an eminently practical way to achieve this. By examining all uses of land in an integrated manner, it makes it possible to minimise conflicts, to make the most efficient tradeoffs and to link social and economic development with environmental protection and enhancement, thus helping to achieve the objectives of sustainable development. The essence of the integrated approach finds expression in the coordination of the sectoral planning and management activities concerned with the various aspects of land use and land resources."*

This paper will demonstrate the use of GIS methodologies for information management based on several projects carried out in LESTARI, namely the Geological Heritage of Malaysia and Geohazard Mapping of the Klang Valley. The use of GIS in integrated research is then demonstrated using the Langat Basin Ecosystem Health and Kundasang Landslide Complex: Hazard Assessment and Control projects. Finally, LESTARI's approach toward a comprehensive data management that encompasses all the databases in various projects is explained.

GIS FOR INFORMATION MANAGEMENT AND PACKAGING

- **Geological Heritage of Malaysia for Conservation and Sustainable Use**

Malaysia is opulent in geological diversity, from its unique rocks and fossils to

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nificent geological-crafted landscapes. A national database for Malaysian geological heritage was set up to inventorise the location of geosites, and sites of geological importance (Ibrahim Komoo *et al*. 2004). This is a new frontier in promoting sustainable conservation and the use of geological resource in Malaysia togather with ongoing efforts in many countries.

Each geosite was characterised, valued and ranked accordingly to its importance in Earth's history and aesthetic value. The information was systematically stored in Microsoft Access to enable access, sorting and classification. This static database was enhanced by the use of GIS. ESRI ArcView was used to display the location of each geosite on the map. The hotlinking function of GIS was utilised to supplement each other in both interfacing and interactively, spatially as GIS maps and detailed information of individual geosites in Microsoft Access in the form of text, figure or picture. Having GIS to host the Malaysian geological heritage eases conservation work considerably in terms of conservation and land use planning. The area of geosites can be overlaid with existing land use and planning maps to formulate future conservation strategies. In the future, web GIS is proposed to promote geological heritage in Malaysia.

- **Geohazard Mapping of the Klang Valley**

Geohazards such as landslide, flood, subsidence and riverbank erosion are some of the predicaments of city dwellers and administrators (Pereira & Ibrahim Komoo 1999). They create constraints and problems. In the Klang Valley, the incidences of intensive hazards (flood) and pervasive hazards (slope failure, riverbank erosion and subsidence) are some aspects to be considered in physical planning that need to be extracted from diverse geoscience disciplines. Below are some experiences from research work carried out for Applications of Geographic Information System for Klang Vallley (AGISwlk) under the auspices of the previously known as Klang Valley Province Development Section (Bahagian Kemajuan Wilayah Persekutuan dan Pembangunan Lembah Klang), the Prime Minister's Department (now Ministry of Federal Territory) for geohazard sub-application in 1999 (BKWPPLK 2000) and also its extension carried out under LESTARI R&D and graduate training programme.

Integrated geoscience information is provided in the form of GIS layers for preparation of

planning tools (Pereira *et al.* 2000). Using the capability of the GIS interface for terrain analysis, several geomorphologic and geologic data were overlaid to provide scientific tools for multiple types of geohazards for management purposes. Almost all analysis and derivative maps were performed in the GIS platform. GIS replaces tedious work in map production and overlaying in most terrain analysis tasks.

Four groups of information are used to develop the geohazard database: basic geohazard inventory (flood, slope failure, riverbank erosion & subsidence), terrain (morphogenesis) maps (topography, slope, drainage & geology), geohazard potential, and geohazard risk maps (Shaharudin Idrus *et al*. 2000).

The main task in this study was to build the geohazard inventory and conduct the analysis. The output expected was an assessment of the susceptibility of physical environment in the form of hazard maps, namely, potential and risk maps for regional planning in the Klang Valley (Ibrahim Komoo *et al*. 2000). The geohazard potential maps were generated based on terrain influences on areas relevant to specific hazards and the data of past geohazard events, together with elements of vulnerability, were used to prepare the geohazard risk map.

In the planning process, integrated information is needed on land susceptibility to geohazard. This information is translated into maps using GIS to enable overlaying with other planning related data, whereby many of the planning data on the environment and land are readly stored digitally. Geohazard occurrences in the context of post-mitigation and prevention are important criteria for land use planning and management as planners need information on some of the frequently occurring geohazards and zoning of such areas (Pereira *et al.* 2000; Lim *et al*. 2000).

A GIS database is ideal for capturing geohazards recorded in order to establish an inventory of incidences occurring in the past, and is used as the basis for most susceptibility mapping techniques. Through constant updating, we not only acquire more knowledge on the characteristics of the geohazard but we also increase our ability to build a more accurate GIS model.

GIS, since the last several decades, has dramatically expended from just being a carto

graphic tool. GIS can be easily updated and refined for analysis through the perfecting GIS/ cartographic model to the prediction of geohazard (real world model). Through extended research and development, the mapping has achieved an increase in working scale and resolution. The use of new techniques in GIS, data model (vector/raster), Digital Elevation Model (DEM) and visualisation tool (3D) facilitate and accelerate R&D (Lim 2004). As a result, DEM and raster-based analysis are widely used to represent the physical surface for many of our study areas. In latter models for geohazard, raster-based and DEM were extensively manipulated for slope unit delineation, hydrological modelling and automated terrain classification for deriving hazard maps.

GIS FOR INTEGRATED RESEARCH

In general, information in GIS maps consists of two types:

a) **attribute data** (e.g. statistics or text such as slope, soil type, land use, demography, vegetative cover type, etc.) contained in tables
b) **spatial information**, contained in the form of lines, points or polygons on maps.

In terms of integrated research, several studies have been conducted at LESTARI within the past five years. In such studies data was received in various formats from different agencies at varying levels and scales. GIS tools were used to put them in one platform for future analysis.

- **Langat Basin Ecosystem Health Project**

The main objective of this project was to examine the status, trends and driving forces affecting ecosystem health in the Langat Basin by conducting a multidisciplinary study involving aspects of economics, sociology, biology, environmental chemistry, geology, human health and governance. An auxiliary objective was to integrate and synthesize findings of this project in an attempt to develop an ecosystem scenario tool which could assist policy and decision makers in planning and managing the Langat Basin in a holistic manner (Mohd Nordin Hasan 2000; Mazlin Mokhtar *et al*. 2002; Mazlin Mokhtar *et al*. 2004).

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major achievement of this project is the integration of primary and secondary data in aspects of economics, sociology, biology, environmental chemistry, geology, human health, and governance, which contributed to a better understanding of the status, trends and driving forces affecting the ecosystem health of the Langat Basin. The development of databases and inventories of resources, state of pollution, habitat quality, human population dynamics, industry and quality of life in the basin was initiated. Proposed lists of sectoral ecosystem health indicators were suggested and these could be tested and validated in future research initiatives involving assessment methodologies for sustainability of the Langat Basin.

As part of this study, the Quite Useful Ecosystem Scenario Tools (QUEST) has been jointly developed between LESTARI and British Columbia University, Canada. QUEST has been developed to cater for Capacity Building, Maximizing Use Of Data, Facilitating Integrated And Strategic Thinking, Promoting Transparency, Accountability, and Participation, Information Dissemination and Education, and Strengthening Inter-institutional Relationships.
In the Langat Basin ecosystem study, GIS contributions can be seen from four aspects (Shaharudin Idrus and Abdul Hadi Harman Shah 2004):

a) To develop a comprehensive and systematic database for planning and development analysis;
b) To determine development impacts and management implications;
c) To determine trends and development impacts towards ecosystem health; and
d) To propose a holistic strategic planning tool for ecosystem management.

- **Integrated Hazard Management**

Today, GIS technology is essential in any multidisciplinary or integrative study. The capability of GIS to render several kinds of data in type, model and scale makes it a nucleus for analysis. In the "Kundasang Landslide Complex: Hazard Assessment and Control" project, 3 sub-studies namely, engineering geology, socio-economic impact and governance (Ibrahim Komoo *et al*. 2004b), needed to be integrated. In this on-going research carried out in Kundasang, Sabah, six large-scale active landslides, approximately one square kilometre each, have been identified. These landslides are colle

ctively called the 'Kundasang Landslide Complex' (Ibrahim Komoo & Morgana 1999; Lim & Ibrahim Komoo 2002). As a result of the landslides, Kundasang incurred damages to its roads, buildings and other infrastructure.

Landslide control and management go beyond areas within geology, geotechnical engineering and engineering geological mapping. It includes socio-economic and governance aspects in dealing with landslide prone areas. This research utilises a lot of technical data that requires a spatial-capable system that integrates various types of data.

GIS has been regarded as an inevitable tool for landslide analysis and modelling the mechanism and causal factors of landslide, especially for regional and large-scale landslide areas. GIS acts as a system to include digital elevation data, geological and structural geology mapping, landslide features and surface deformation, subsurface data and slope monitoring data (Tajul Anuar Jamaluddin *et al*. 2004). Also, land cover mapping is important in addressing framework for vulnerability and risk assessment, especially for remote but populated mountainous areas in relation to landslide threat to community safety.

Also, aerial photographs and satellite images were previously only used for photogeologic interpretations. A robust GIS system here is capable of registering aerial photographs with satellite images, image enhancement through fusion to update existing topographic maps that serve as base maps, a prerequisite for research.

GIS FOR INFORMATION SUPPORT SYSTEM DEVELOPMENT

Information is the basis of any research or criterion for any decision-making. Current decision-making practices and the need for education and training require a clear organisation of such information in order to clearly manage and analyse bits of information and thus produce sound decisions and policies.

Multidisciplinary research entails data from diverse fields of studies, each of which is unique in form and format. Beyond the classification of spatial and non-spatial data, a platform is needed to integrate them. As a multidisciplinary R&D institution advocating susta

inable development, LESTARI stresses the integration and the interconnection of sectoral, multisectoral and intersectoral data. The e-LESTARI or LESTARI Information System was set up as an infostructure to manage research data from various aspects of sustainable development themes (Nik Mohd Noor Faizul Md Saad 2004). This package can be accessed by all researchers in LESTARI while outsiders have more limited accessibility. The main objective of e-LESTARI is to manage the information and data integrated with easy accessibility by researchers in LESTARI. e-LESTARI was divided based on the component functions namely input, system and system applications. The development of e-LESTARI will help to realise LESTARI's vision in facilitating access to and exchange of information for research and development.

The development of e-LESTARI utilises the concept of integration of information and data based on systematic data packaging and GIS interfacing. All available data and infrastructure generated by LESTARI is screened, evaluated and validated, and then repackaged in a harmonised format. e-LESTARI can be applied to management, R&D and special database applications, all of which utilise GIS for data harmonising and retrieval. Ultimately, all LESTARI R&D activities will use e-LESTARI as a tool for information retrieval and analysis as of the research culture.

CONCLUDING REMARKS

It is clear the GIS is useful for the entire spectrum of R&D activities, including packaging of data and use of data for management and research. Managing data in research is critical as multiple sets of data are required for synthesis.

LESTARI's experience in sectoral and multisectoral/ multidisciplinary research shows that the application of GIS requires a through assessment, screening and verification of data and a suitable method has to be found for harmonising data from several sources in various formats and at different levels and scales before it can be applied effectively. The process is time consuming and requires high artistic and scientific skills which have to be developed within the organisation.

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