

AN ANNOTATED BIBLIOGRAPHY ON GEOGRAPHIC INFORMATION SYSTEMS APPLICATIONS IN DEVELOPING COUNTRIES*

by
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INTRODUCTION

Geographic Information Systems (GIS) are needed to assist national development because GIS can manipulate and analyze geographically-referenced data to support the decision making process of an organization. A problem faced in developing countries is that decision making is not always based on integrated information.

This annotated bibliography is compiled for three reasons:

1. The lack of GIS research in developing countries.
2. Although GIS are potentially useful, because of the limited amount of published research, there is little information available about GIS applications. This bibliography presents relevant publications to remedy this deficiency.
3. It is believed that geographic information systems in developing countries need to be improved to facilitate the use of the integrated, comprehensive information to assist the country's development.

This bibliography summarizes GIS procedures in general and GIS on selected countries: Costa Rica, Argentina, India, Bangladesh, Sri Lanka, and Indonesia.

* This bibliography is mostly based on an annex to the author's thesis entitled "Micro-computer Geographic Information Systems in Developing Countries with Emphasis on Indonesia". Graduate College of Oklahoma State University, Stillwater, OK., December 1984.

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**SECTION A: GEOGRAPHIC INFORMATION SYSTEMS
IN GENERAL**

- Bartolucci, L.A. *et al.* 1980. Building Locally Adapted Remote Sensing Programs in Developing Nations. In: *Proceedings of the 14th International Symposium on Remote Sensing of Environment*, 1:179–188. 1

This paper identifies four phases in the development of local understanding and adoption of technology. The first phase involves the acquisition of an understanding of the fundamentals of remote sensing. The second is to develop capability of visually interpreting remote sensing imagery. In the third phase, digital approaches to image enhancement and data analysis are introduced; at this point a significantly higher level of natural resources information can be obtained. The fourth phase involves the definition, design, and implementation of digital geographic information systems for efficient access, storage, and retrieval of natural resources information.

- Conitz, Merrill W. and Donald S. Lowe. 1977. Remote Sensing Utilization of Developing Countries: an Appropriate Technology. In: *Proceedings of the International Symposium on Remote Sensing of Environment*, 2: 1055–1064. 2

The Agency for International Development has initiated training programs in information extraction techniques for personnel from developing countries. The agency has also sponsored a study on the economic activity of Landsat data for developing countries. From these efforts, a number of techniques have evolved for making technicians, managers, and policy makers aware of the usefulness of Landsat data and encouraging them to employ Landsat information in their decision making process. This paper describes a number of AID's remote sensing projects designed to strengthen various aspects of remote sensing information systems for developing countries.

- Darmoyuwono, Kardono. 1982. 'Monitoring' Dalam Rangka Pembangunan Regional (Monitoring in a Regional Development). Paper presented at *Seminar Alumni Fakultas Geografi, Universitas Gadjah Mada*, December 14–15, 1982, 13pp. 3

To evaluate natural resources, a system that can collect, retrieve and store information and carry out a comparative and integrated analysis is needed. Four activities: preparing a data base, monitoring developments/changes, constructing a data base and analyzing the results of development are described.

- Robinson, Vincent B. and Colner, Jerry C. 1981. Microcomputer Geoprocessing as a Minimum Technology Solution for Data Management in Developing Countries. In: *Proceedings of the Urban and Regional Information Systems Association Annual Conference*. New Orleans: URISA. 4

One of the major impediments to the efficient use of data in developing countries has been the lack of capital to provide a rational context for processing a large amount of spatial data generated by development activities. As compared with the short-term benefits, investment in large computer systems is often prohibitively expensive for capital poor regions. Microcomputer technology promises to eliminate this barrier. This paper presents the rationale and design strategy for a prototypical microcomputer geoprocessing system developed by the United Nations Centre for Human Settlements for transfer to developing countries.

- Robinson, Vincent B. and Colner, Jerry C. 1983. Diffusion of a Microcomputer Geoprocessing Package and Infrastructure for Urban Modeling Activities. *Urban and Regional Information Systems Association Annual Conference*. Atlanta: URISA. 5

Urban modeling formerly has been conducted on large mainframe or minicomputer systems. This has limited the spread of urban modeling activities to developed countries. The spread of increasingly low-cost microcomputers provides a necessary, but insufficient infrastructure for the development and diffusion of urban modeling activities. In 1980 the United Nations Centre for Human Settlements (UNCHS), sponsored development of a microcomputer-based software package, the Urban Data Management Software (UDMS) package, and integrated spatial data basing with urban modeling. This paper describes the UDMS package and traces its diffusion throughout the world.

- Shelton, Ronald L. and Hardy, Ernest E. 1974. Design Concept for Land Use and Natural Resource Inventories and Information Systems. In:

Proceedings of the Ninth International Symposium on Remote Sensing of Environment. 1: 517—535. 6

The decision making process of constructing a GIS requires that the designer not only be aware of the range of available possibilities, but also that design be carried out efficiently. Objectives of this presentation are twofold. A formal, canonical approach to the construction of a GIS is proposed, and an array of geographic information system design possibilities is assembled from existing systems. The intent is to provide a conceptual framework within which countries can best meet their own specific needs.

Steiner, Dieter. 1980. A Minicomputer-Based Geographic Data Processing System. In: *Map Data Processing*. Herbert Freeman and G.G. Pieroni (eds.). New York: Academic Press, pp. 1—25. 7

An interactive digital system for the processing of geographical data is described. It consists of a minicomputer, a color display unit and a map digitizer; it has offline access to a drum scanner or recorder. It can handle data from various sources (image data, map data, statistical data) and it uses different data formats (raster, polygon and serial) side by side with some possibilities of converting from one format type to another. An image display and manipulation software system that operates on both raster and polygon data is completed and operational. A statistical software system that accepts serial data as input and produces output in graphical and map form is being developed. Beyond its application for academic teaching and research needs, the processing system presented here is believed to have a potential as a possible tool for local and regional planning units. It is seen as a flexible and highly user-oriented alternative to large centralized geographical information systems.

**SECTION B: GEOGRAPHIC INFORMATION SYSTEMS
ON SELECTED COUNTRIES**

- Abiodun, A.A. 1977. The Transfer of Remote Sensing Technology in the Developing Nations—An Observation. In: *Proceedings of the 11th International Symposium on Remote Sensing of Environment*. 1: 339–352. 8

While some nations have yet to grasp the full advantage of aerial surveys in their development efforts, many do yearn to take advantage of recent developments and progress in space and technology. In this regard, the cooperation and assistance of the industrialized nations, and the United Nations and its agencies through training programs, workshops, and seminars, and the on-going globally scattered demonstration projects are highly commendable. Emphasis should shift from centralized training to scheduled regional training programs, resulting in larger local participation and on the spot application of the technology to solve the local problems. Standardization of products will reduce investment cost and provide ready access to all categories of data. Through the training programs the remote sensing technology can be transferred in order to support the geographic information systems in developing countries.

- Asmoro, Pranoto. 1978. The Application of Remote Sensing of National Program for the Inventory and Evaluation of the Indonesian Natural Resources. In: *Proceedings of the 12th International Symposium on Remote Sensing of Environment*. 1: 27. 9

Since 1976 the Indonesian Government has launched a comprehensive national resources inventory and evaluation program encompassing the entire national land territory. This program is to be completed in a timespan of two Five Year Development Plans. This paper describes the goals and objectives of the program and the pragmatic approach to its implementation. The most effective and efficient remote sensing system has been adapted to local conditions in regions outside Java. Program implementation integrates the resources inventory with base map production, providing the geometric base for data presentation and physical planning.

- BAKOSURTANAL. 1976. *Design Sistem Informasi Sumber Daya Alam Daerah Muara Bungo* (The Design of Natural Resources Information Systems in

Muara Bungo Area). Sutikno and Surastopo Hadisumarno (eds.) Joint Cooperation between BAKOSURTANAL and the Faculty of Geography, Gadjah Mada University, Yogyakarta. 10

This report consists of three parts: (i) a design of natural resource information systems in Muara Bungo in particular, and Sumatra in general, (ii) the application of such systems—thematic maps of natural resource data at the scale of 1 to 250,000, and (iii) the application of such systems into operational works like coding form of natural resources data.

BAKOSURTANAL. 1976. *Design Sistem Informasi Sumber Daya Alam Daerah Lembah Serayu* (The Design of Natural Resources Information Systems in Serayu Valley Area). Karmono M. and O.T. Simorangkir (eds.). Joint Cooperation between BAKOSURTANAL and the Faculty of Geography, Gadjah Mada University, Yogyakarta. 11

This report presents the application of GIS to determine a suitable location for planting wet paddy in Serayu Valley area. After evaluating the data requirements for paddy, this activity can be done by overlaying 13 topical maps. Those maps consist of information about Serayu Valley drainage basin, Purbolinggo area cell systems, administrative boundary, soil texture, effective depth, soil permeability, soil drainage, soil pH, elevation, temperature, slope and rainfall.

BAKOSURTANAL. 1977. *Design dan Persiapan Sistem Informasi Sumber Daya Alam dan Lingkungan* (Design and Preparation of Natural Resources and Environmental Information Systems), Surastopo Hadisumarno (ed.). 12

At the beginning of this paper, the development of natural resources information is discussed. It also generally presents a design and preparation of natural resources and environmental information systems including how to formulate the data and information requirements, natural resources information needed; information users, etc. Results from integrated survey have been tried to input computer as a case study for GIS in Indonesia.

Campbell, Robert Jr. *et al.* 1980. Design of a Nationwide Natural Resource Inventory and Information System for Costa Rica. In: *Proceedings of the 14th International Symposium on Remote Sensing of Environment*, 1: 325—340 13

The Government of Costa Rica, in conjunction with the United States Agency of International Development and with Resource Development Associates, has recently completed a pilot project to design an operational natural resource inventory and information system for Costa Rica. This system employs aerial photographs and Landsat images to generate baseline data cover information which can be integrated with other resource data in a thematic mapping procedure to create a resource information system. The technical capabilities of the Costa Rican Government have now been upgraded sufficiently, so that they may proceed with nationwide implementation.

- Chowdhury, M.I. and S. Dara Shamsuddin. 1979. National Land Use and Settlement Assessment—An Areal Data Base Model for Landsat Information for Bangladesh. In: *Proceedings of the 13th International Symposium on Remote Sensing of Environment*, 3: 1619—1628. 14

Bangladesh needs an integrated system of data collection, storage, retrieval and analysis, where the existing techniques are suitably combined with the Landsat technology. Standard grid is developed to which Landsat imageries, topo-maps, aerial photographs and cadastral survey maps are related. A three level land use classification is also provided.

- DeVries, Mary *et al.* 1982. The Use of a Geographic Information System to Combine Land Use Information Derived from Landsat with Soils Data to Stratify an Area in Argentina for Crop Forecasting. In: *Proceedings of the 16th International Symposium on Remote Sensing of Environment*, 1: 381—391 15

A technique is demonstrated utilizing the Area Resource Analysis System (AREAS). This geographic information system is capable of processing the soils and land-use information in order to obtain output products which are useful for homogeneous area delineations. This area chosen for test includes portions of the Argentine provinces of La Pampa and Buenos Aires. Political boundary (*partido*) information was also processed by AREAS in order to provide areal tabulation on a *partido* basis.

- Darmoyuwono, Kardono. 1982. *Evaluasi Pemukiman Transmigrasi/Resettlement di Kabupaten Lampung Utara*. (An Evaluation on Transmigration/Resettlement in the District of North Lampung). Sukendra Martha (ed.), unpublished. National Coordinating Agency for Surveys and Mapping

(BAKOSURTANAL), Cibinong, March 1982.

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This paper is based on BAKOSURTANAL's exhibition of computer mapping in the Office of State Ministry of Development Supervision and Environment (PPLH) on August 13, 1981. Primary and secondary data and information from North Lampung were collected in order to evaluate a land suitability for locating transmigrants. The general information needed for such assessment in that area included slopes, area of forest cover, agricultural capability, water quality and quantity, and related data. The data were mapped, but analysis was done manually.

Martha, Sukendra. 1984. *Micro-Computer Based Geographic Information Systems for Developing Countries with Emphasis on Indonesia*. Master Thesis Report of Graduate College, Oklahoma State University, Stillwater, Oklahoma.

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This study begins with a description of a geographic information system (GIS) and its elements. The experience of developing countries with GIS is reviewed. Some barriers to implementing GIS in developing countries are identified, and the special obstacles for the Indonesian case are described. It is argued that the geographic information system approach offers considerable advantage to the planning and resource development efforts in developing countries. The fear that computer systems may exacerbate unemployment is refuted, for GIS technology is capable of addressing tasks that manual techniques cannot handle. In terms of GIS implementation, developing countries generally face six obstacles. Indonesia is confronted with two additional problems: lack of standardized data collection and classification systems, and interagency disputes. The United Nations' effort to provide technical assistance and to distribute a computer-based information system for developing countries is very helpful. Lower cost minicomputer systems seem to be capable of overcoming most of the barriers to implementing GIS technology in developing countries. Additional training for personnel in developing countries is necessary before GIS can be fully operated.

Nanayakkara, Chris and Harvey Wagner. 1977. Digital Processing for Developing Countries. In: *Proceedings of the 11th International Symposium on Remote Sensing of Environment*, 2: 1123—1126

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An effort was made in Sri Lanka to perform simple digital processing tasks using existing general purpose digital computers. An experimental

software package, LIGMALS, was obtained and modified for this purpose. The experience gained in this project indicates a possible direction which may be used by other developing countries to obtain digital processing capabilities.

- Nanayakkara, Chris. 1978. Problems Associated with Organizing Remote Sensing Applications in a Developing Country. In: *Proceedings of the 12th International Symposium on Remote Sensing of Environment*. 3: 1665—1670. 19

The problems that one is to face in organizing an operational remote sensing unit in a developing country are discussed; solution to these problems are offered. The case in Sri Lanka and its approach to the problems are described. Methods of improving technology transfer and training are suggested.

- Robinson, Vincent B. 1982. Development of a Microcomputer Urban Information System Unit in Colombo, Sri Lanka. In: *Proceedings of the Urban and Regional Information Systems Association Annual Conference*. Minneapolis: URISA. 20

In many developing countries some organizations are in need of computerized spatial data management systems. However, these organizations rarely have the capital necessary to purchase, maintain, and staff a mainframe or minicomputer system. The Urban Development Authority in Colombo, Sri Lanka has, with the aid of the United Nations Development Programme and the United Nations Centre for Human Settlements (UNCHS), begun the installation and development of a Land Use Data Bank (LUDB). The LUDB is a geographic data base which is linked to the mapping and analysis capabilities of the Urban Data Management Software (UDMS) package developed by UNCHS. The system is being developed on a WANG 2200 VP microcomputer. This paper presents an overview of the project with special emphasis on the problems encountered and the compatibility of this project with development of local government computing in the developed countries.

- Robinson, Vincent B. 1983. Microcomputing and the Integration of Spatial Modeling into a Geoprocessing Package. In: *The 14th Modeling and Simulation Conference*, Pittsburgh. 21

This paper describes a geoprocessing package which exploits

interactive characteristics of microcomputer system to apply spatial models to specific development problems. A facility location problem in Madras, India is offered as an example. Problems of data encoding and modeling methodologies should be more systematically studied to determine the advantages and limitations of microcomputer technology.

- Roque, Celso R. 1980. Asean Remote Sensing Program. In: *Proceedings of 14th International Symposium on Remote Sensing of Environment*. 1: 65—70. 22

The member countries of ASEAN (Indonesia, Malaysia, Philippines, Thailand, and Singapore) belong to the active user community of remote sensing technology. These countries have established national programs in remote sensing and have specific government agencies to carry out such programs. To properly harness appropriate remote sensing technology for both national and regional development, the ASEAN cooperative effort is considered a viable strategy. Each ASEAN country has unique capabilities in remote sensing which the other member countries borrow to optimize manpower, equipment, and facilities, and to reduce costs of their operations.

- Shelton, Ronald L. and Stephen E. Tilmann. 1978. Remote Sensing, Geographic Information Systems, and National Land Planning: Some Central American and Caribbean Experiences. In: *Proceedings of the 12th International Symposium on Remote Sensing of Environment*. 1: 567—586. 23

Joint application of remote sensing and geographic information system technology is illustrated by Puerto Rican projects which focus on environmental protection and comprehensive land use planning, and one in El Salvador where information was provided for a national land reform effort.

- Zimbelman, Deborah. 1980. Resource Planning in Indonesia. *Third World Graphics. Computer Graphic World*, 11: 22—24. 24

In 1980, Comarc brought to Indonesia the first geographic information system (GIS) in Southeast Asia. Being located in the new headquarters of National Coordinating Agency for Surveys and Mapping

(BAKOSURTANAL) in Bogor, the system has been assigned the task of translating raw data from Indonesia's 780,000 square mile land area into a cogent and accessible form.