THE GEOGRAPHIC INFORMATION SYSTEM (GIS) - DEFINITIONS AND PROBLEMS IN DEVELOPING COUNTRIES

Ali F. Bakr

Department of Architecture, Faculty of Engineering,
Alexandria University, Alexandria-21544, Egypt

ABSTRACT

This paper covers definitions of Geographic Information System (GIS) technology in both technological and problem solving themes to prepare, educate, and support planners, surveyors, and researchers to be aware with that essential issue in the field of planning. It also describes a personal definition of applying GIS technology in the field of urban planning. It tries to investigate problems associated with GIS technology in developing countries. Moreover, it reveals some points worthy of discussion about the GIS Technology regarding its applicability, validity, and complexity to researchers in developing countries.

Keywords: Geographic Information System (GIS), Urban Planning, Developing Countries

INTRODUCTION

How do we track the influence of global warning on the world's resources? How should political districts be redrawn? Where should I build my shopping center, where it will be the most convenient for shoppers and the least damaging to the environment? [1]. Over the past decade, government agencies at all levels have become extremely cognizant of the importance of maps and geographically referenced data to support routine operations and long-term planning activities [2]. That is why the GIS industry experienced tremendous growth in the last decade. Software and hardware vendors are striving to meet the needs of this rapidly diversifying market. Vendors have a great deal of responsibility on their shoulders. The future of the Earth's dwindling resources may rest on the ability of their software to analyze data quickly and accurately, and in a manner that the general public and politicians can understand. As a result of that, GIS technology, over the past thirteen years, has matured tremendously and offers powerful capabilities for organizations dependent on maps and geographic data [3].

The use of GIS in urban and regional planning in the developing countries is in the early stage of development. GIS is at different stages of development in developing countries. Some countries have developed more comprehensive GIS and have more experience in using GIS than others [4]. But, the Egyptian Government knows the significance, and the weight of GIS technology as a short path to support decision-makers, therefore, starts to originate The National Map of Egypt, and train new cadres to accomplish this map. "We must be careful to separate the goal from the path to the goal, " pointed out Brail in his paper Evolution of Decision Support and Urban Information Systems [5]. because, the GIS technology is not a goal in itself, but, a path to the goal within the decision support system context. GIS technology could be applied in different fields, after understanding the concept, and philosophy of that technology. For example, it could be used in the preservation of buildings [6]. A lot of organizations and authorities started to have their tools and computer software packages in that field [7].

THE GEOGRAPHIC INFORMATION SYSTEMS DEFINITION

With the evolution of Geographic Information Systems Technology much has been written about their definitions, and their recognition. There have been a number of attempts to define a geographic information system, within two main distinguished themes: technological and problem solving.

Technological Theme

The technological theme concentrates on computer-related aspects of the field [8].

Definition 1:

Geographical Information Systems are a powerful set of tools collecting, storing, retrieving at will, transforming, and displaying spatial data from the real world for a particular set of purposes [9].

Definition 2:

The GIS have the capability to represent, store, and manipulate spatial entities to provide a substantial but unrealized potential for more sophisticated geometric representation in facility location problems [10]

Definition 3:

Translating spatial or geographical data from an iconic to analytical level [11].

Definition 4:

A configuration of hardware, software communications networks and analytical procedures for the extraction of information from data to support decision-making and to achieve planning or managerial objectives [12]

Definition 5:

A GIS is one of the formalized computer-based information systems capable of integrating data from various sources to provide information necessary for effective decision making in urban and renewal planning [4,13]

Definition 6:

In GIS, reality is presented as a series of geographical features defined according to data elements. The geographical and data element is used to provide a reference for the attribute (also called statical or non-locational) data element. GIS puts together digital map information in addition to attribute data associated with features that can be located on a map. The usage of these techniques helps to analyze data in a spatial context to address different issues [14].

Definition 7:

GIS has a unique feature, its ability to integrate information from many different sources and at any levels of responsibility in an organization [15].

Definition 8:

GIS is a spatially-defined well-organized databases. The GIS concept has powerful imagery, and the term often implies more in promise, than is delivered in reality [5].

Definition 9:

GIS requires the collection, organization, analysis, and processing of data. It must also make these data accessible to the end-users and satisfy the information policy of the organization responsible for the data [16].

Definition 10:

The GIS is highly an effective tool to store , display, and analyze collected because of its strong data integration and analysis capabilities [17].

Problem Solving Theme:

More recent definitions have concentrated on the problem-solving aspect of GIS and the analytical nature of GIS:

Definition 1:

A GIS is best defined as a system which uses a spatial data base to provide answers to queries of geographical nature [18].

Definition 2:

A GIS is a decision support system involving the integration of spatially referenced data in a problem solving environment [19].

Definition 3:
A GIS is defined as the management, analysis, and manipulation of spat-ially referenced information in a problem solving synthesis [8].

Definition 4:
A GIS is one of the formalized computer-based information systems capable of integrating data from various sources to provide information necessary for effective decision- making in urban and regional planning [4, 13].

Definition 5 :
A GIS can be defined as internally referenced, automated, spatial information systems designed for data management, mapping, and analysis [20].

GIS APPLICABILITY PROBLEMS FOR URBAN AND REGIONAL PLANNING IN DEVELOPING COUNTRIES

As geographical information systems have moved away from more traditional automated mapping systems, they have become increasingly structurally complex, requiring aspects of high performance graphics, Database Management System (DBMS), spatial analysis and modeling technologies [21].

From the above definitions we can deduce that any GIS consists of components as shown in Figure 1:

1. Liveware
2. Data
3. Tool
4. Output

Issues Pertinent to Liveware in The Use of GIS

With reference to Bossard [22, the users could be classified into four categories:

1. Supertech: Design and maintain nearly self-sufficient hardware/software systems

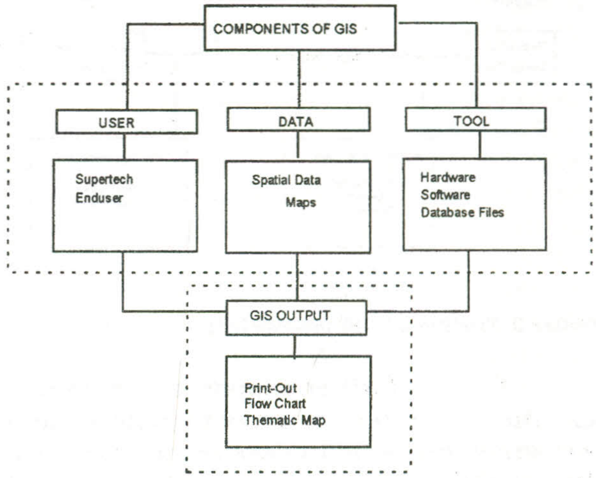

Figure 1 The Main Items of GIS

2. Professional: Specialize in using computer in problem solving
3. Enduser: Main job is to do something else besides work
4 Paraprofessional: Do lesser-skilled programming tasks, often for end users

With reference to Yeh [4]. GIS' users could consists of five categories :

1. Policy makers
2. Planners
3. Programmers
4. Technicians
5. Educators

With elaboration upon Gould [23]. manpower used in GIS could be classified into two main categories as shown in Figure 2:

1. Active Participant: like cartographers, planners, and surveyors directly involved in the data gathering and map making process and, thus, having explicit and implicit control over the information provided.
2 Passive Receptor: not directly involved in the data gathering and map making process and, thus, having no explicit control over the information provided. Such as end users.

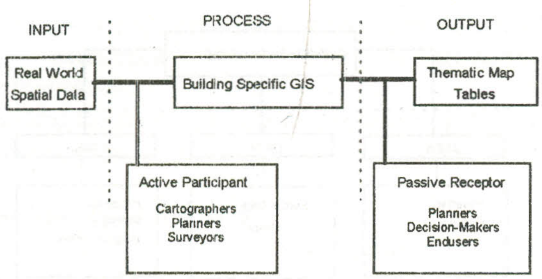

FIGURE 2 Traditional GIS process [23].

We can further support the end user, as the computer is a tool to perform, and accelerate his job. In developing countries, the majority of computer users are end users. They use the software as they are with a very limited modifications in their applications. Furthermore, the user faces a lot of problems such as:

Manpower

With the rapid growth of GIS, there is a shortage of manpower in developing countries both in absolute and relative terms. The shortage of manpower is very severe considering the number of cities and regions in the developing countries that can benefit from GIS [4].

Training

The problem of training is severe because of the lack of expertise and shortage of financial sources, specially, in developing countries.

Using GIS In Planning

Computing technologies have dramatically enriched the tools available to planning practitioners, and researchers in pursuing various aspects of their craft. Yet, while planners have become increasingly adept at working with computers for everything from text processing to sophisticated modeling, desktop computing has not fundamentally affected the way planners interact with the broader information environment. The computerized planner still typically works in isolation of most information resources within his or her organization [24].

With reference to Ding and Densham [24], spatial information is divided into six elements:

1. Spatial Operation: concentrate on Boolean logical operations, or set-based operations on spatial data. Such operations, including map union, intersection, buffering, and reselection, are fundamental capabilities of GIS.
2. Spatial Statical Analysis: focuses on the description and analysis of the patterns in, and relations among, spatial data. Exploratory spatial data analysis and the analysis of spatial autocorrolation and spatial association are typical of this category.
3. Spatial Modeling: concerns the analysis of spatial phenomena, spatial structures, spatial relations, and spatial locations. Examples include network analysis, hill-shading and delineation of drainage basins.
4. Spatial representation/Visualization: focuses on the design and use of tools for the depiction of spatial information and their role in user interfaces.
5. Spatial Database Management: encompasses spatial database design, spatial data structures, spatial data management, and spatial query.
6. Spatial Modelbase Management: concerns the provision and management of flexible modeling environment in spatial decision support systems (SDSS).

Most planners in developing countries are not yet aware of the benefit and potential applications of GIS in planning.

Issues Pertinent to Tools in GIS Applicability

Gordon and Soubra in their study about *GIS and planning in USA* classified tools in GIS as a result of the study into computer hardware, Computer software, and computer education, and training [11]. Problems of data could also be added to previous items defined by Gordon and Soubra.

Hardware

Most of GIS' hardware, which are used, are imported from developed countries. It is something difficult to maintain a piece of hardware, particularly when the necessary components are not readily available, locally. Hardware systems need lots of money to finance. That is not available to end users in developing countries. It is mainly available through central government funding or international assistance, but little is available to maintain the system.

Software

With regard to software development, we know most of them for large scale systems is mainly purchased from developed countries. The user faces lots of problems, such as the high expenses of software, the lack of locally developed software, and the problem to consult the software producers. It is difficult to develop software in developing countries because of the lack of supertechs and funds. The users attempt to perform GIS tasks, by using low cost commercial software. The most popular are the combination of commercial CAD package such as AutoCAD with commercial database packages such as dBASE III [25]. and INFORMIX [26]. These systems, although limited in GIS functions, but can make GIS available to departments and agencies with little funding. But, to convert from the AutoCAD, for example to any other GIS software like Mapinfo or Saladin is somewhat difficult because of the way of each software in drawing. Linguistics is one of the major problems in GIS computer software packages.

Education, and Training

An analysis of the requirements of GIS education suggests the skills are needed at three distinct levels [27].

1. A general awareness of the potential of tools for handling spatial data and their benefits.
2. An understanding of the conceptual basis of GIS operations and analysis.
3. Technical skills with a specific GIS to become more widely accepted and usable.

Two key barriers exist to the rapid attainment of these objectives. The first is the technical complexity of GIS principles and their sophisticated implementation in a computing environment. This factor has inhibited self-teaching and take-up of courses by those with traditional 'spatial skills' such as cartographers, surveyors, planners, and geographers. The second barrier has been the small existing skills base for GIS, especially for those with skills in all three of the areas listed above [27] .

Problems of Data

GIS' data could be categorized into different items such as maps, graphics, textual data, spatial referenced data, etc. In developing countries there is a lack of all kinds of data. For example, textual data requires field surveys which are expensive, time- consuming, training persons, data processing equipment, and data bank to exchange data. There is a lack of standardized data. Data and maps should be standardized if data are to be shared[4].

The development of world-wide computer networks, such as the internet, is leading to a revolution with regard to the quantity and diversity of information available for exchange. At the same time there exists a desire within the GIS community to reduce the high cost of data collection and capture through the sharing of data. Over the thirty year period in which GIS have been used [28,29].

Data exchange is the basic nature of that era. Obtaining data is more important than anything else. Consequently, to secure data is one of the considerable, and significant issues for developed countries, because knowledge is power.

CONCLUSION

GIS is not an aim but a vehicle to achieve a Decision Support System (DSS). One of the basic and most necessary components of GIS design is the user requirements, or functional, analysis because each project is unique and each user has a distinct view of the system and geographic produced by it (Gould, 1994).

According to the discussion outlined above, the author's definition of the GIS can be the way to translate spatial data to an image or a print-out in order to reflect the real situation of the concerned urban fabric for the decision-maker. There should be, what we will call, "The GIS Sense". This term means the 'fields you need to create, combine, display, and present data' to assist the decision-maker in his role.

Developing countries should create their own models; database models, display models, or output models, due to the special natures, features, characters, and social appearances, and profiles. Developing countries should encourage national GIS vendors to overcome the financial, training, and linguistic problems associated with imported GIS computer software packages.

Data discovery and collection require further attention from Developed countries as well as developing countries because of the high cost, and complexity of that process.

REFERENCES

[1] L. E. Jordon III, B. Q. Rado, and S. L. Sperry, "Meeting The Needs of GIS and Image, Processing Industry in The 1990s", Photogrammetric Engineering and Remote Sensing, Vol. 58, No. 8, pp. 1249-1251, 1992.

[2] H. Archer and P.I. Croswell, "Public Access to Geographic Information Systems: An Emerging Legal Issue", Photogrammetric Engineering and Remote Sensing, Vol. 55, No. 11, pp.1575-1581, 1989.

[3] Peter L. Croswell and Stephen R. Clark. "Trends in Automated Mapping and Geographic Information System Hardware", Photogrammetric Engineering and Remote Sensing, Vol. 54, No.11, pp.13-38,1986.

[4] A. G. O. Yeh, "Strategies of GIS Development for Urban and Regional Planning in Developing Countries", Proceeding of International Conference of Computer in Urban Planning and Urban Management, 6-8 July, 1991 (United Kingdom: School of Planning Oxford Polytechnic, Oxford University) pp. 125-148, 1991.

[5] Richard Brail, "The Evolution of Decision Support and Urban Information Systems", Proceeding of International Conference of Computer in Urban Planning and Urban Management, 6-8 July, 1991 (United Kingdom: School of Planning Oxford Polytechnic, Oxford University) 19-34, 1991.

[6] Laura B. Mez, "The Knowledge; First Steps For The Preservation of The Monuments: The Contribution of New Technology", lecture held at the Department of Architecture, Alexandria University, 13 March, 1997.

[7] Editors of Computer Section, " HUD Communities", Architecture, Vol. 85, No. 1, pp. 119-121, 1996.

[8] P.F. Fisher, and R. E. Lindenberg, "On Distinctions among Cartography, Remote Sensing, and Geographic Information Systems", Photogrammetric Engineering and Remote Sensing, Vol. 55, No. 10, pp. 1430-1434, 1989.

[9] P.A. Burrough, "Principles of Geographical Information Systems for Land Resources Assessment", Oxford, Clarendon Press, pp.13-38,1986.

[10] Harvey J. Miller, "GIS and geometric representation in facility location problems", International Journal of Geographic Information Systems, Vol. 10, No. 7,pp. 791-816, 1996.

[11] William R. Gordon JR, and Nader M. Zebra, "Geographical Information Systems and Planning in the USA: Selected municipal adoption tpends and educational concerns", International Journal of Geographical Information Systems, Vol.6, No.4.pp. 267-278,1992.

[12] M. Birkin, and G. Clarke, " Model-Based GIS For Urban Planning", Proceeding of International Conference of Computer in Urban Planning and Urban Management, 6-8 July, 1991 (United Kingdom: School of Planning Oxford Polytechnic, Oxford University) pp. 3-17, 1991.

[13] Sang-Yun Han, add John Tschangho Kim, " Can Expert Systems Help with Planing?" Journal of the American Planning Vol.55, No.3, pp.296-308,1989.

[14] D. J. Maguire (ed.), Geographical Information Systems: principles and applications, London Scientific and Technical, pp. 10, 1991.

[15] E. William Huxhold, An Introduction to urban Geographic Information Systems, Oxford, Oxford University Press, pp. 64, 1991.

[16] S. H. Hallett, R. J. A. Jones, and C. A. Keay, " Environmental Information Systems Developments for Planning Sustainable Land Use", International Journal of Geographic Information Systems, Vol. 10, No. 1, pp. 47-64, 1996.

[17] Harian J.Onsrud, Jeff P. Johnson, and Xavier R. Lopez, "Protecting Personal Privacy in Using Geographic Information Systems", Photogrammetric Engineering and Remote Sensing, Vol. 60, No. 9, pp. 1083-1095, 1994.

[18] M. F. Goodchild, "Geographic Information Systems in Undergraduate Geography: A Contemporary Dilemma", The Operational Geographer, Vol. 8, pp. 34-38, 1985.

[19] J.D Cowen, "GIS Versus CAD Versus DBMS: What Are the Differences?", Photogrammetric Engineering and Remote Sensing, Vol. 54, No. 11, pp. 1551-1555, November 1988.

[20] J.K. Berry, "Computer-Assisted Map Analysis: Potential & Pitfalls", Photogrammetric Engineering and Remote Sensing, Vol. 53, No. 10, pp. 1405-1410, 1987.

[21] Stephen C. Roche, and Bruce M. Gittings, "Parallel Polygon Line Shading: The quest for More Computational Power from an Existing GIS Algorithm.", International Journal of Geographic Information Systems, Vol. 10, No. 6, pp. 731-746, 1996.

[22] E.G. Bossard, "User-Friendly GIS Modeling: Oxymoron? Or an Effective Tool for Spatial Analysis and Decision Making in The 1990S?", Proceeding of International Conference of Computer in Urban Planning and Urban Management, 6-8 July, 1991 (United Kingdom: School of Planning Oxford Polytechnic, Oxford University) pp. 19-34, 1991

[23] Michael Gould, "GIS Design: A Hermeneutic View", Photogrammetric Engineering and Remote Sensing, Vol. 60, No. 9, pp. 1105-1115, 1994.

[24] Yuemin Ding, and Paul J. Densham, "Spatial Strategies for Parallel Modelling", International Journal of Geographic Information Systems, Vol. 10, No. 6, pp. 669-698, 1996.

[25] L.s. Yapa, "Low-Cost Map Overlay Analysis Using Computer-Aided Design", Environmental and Planning B: Planning and Design, Vol.16, No. 4, pp. 367-498, 1989.

[26] B. Cheng, X. Song, and C. Lin, "The Study of Microcomputer-Based Urban Planning and Management Information System", Proceeding of International Conference of Computer in Urban Planning and Urban Management, 22-25 August, 1989 (Hong Kong: Center of Urban Studies and Urban Planning, University of Hong Kong) pp. 119-121, 1989.

[27] Jonathan Raper, and Nick Green, "Teaching the Principles of GIS: Lessons from the GISTutor Project", International Journal of Geographic Information Systems, Vol. 6, No. 4, pp. 279-290, 1992.

[28] David Medychyj-Scott, Mike Cuthbertson, and Ian Newman, "Discovering Environmental Data: Metadatabase, Network Information Resources Tools and The GENIE System", International Journal of Geographic Information Systems, Vol. 10, No. 1, 65-84, 1996.

[29] David Arbeit, "Resolving The Data Problem: A Spatial Information Infostructure for Planning Support", Proceedings of Third International Conference on Computers in Urban Planning and Urban Management, Volume One, July 23-25, 1993 (USA: Georgia Institute of Technology, Atalnta), pp. 3-26, 1993.