Interdisciplinary Themes Journal 2.1 (2010).

A CRITICAL REVIEW: IDENTIFYING THE ISSUES, CHALLENGES, AND SOLUTIONS FOR SUSTAINABLE URBAN AND RURAL DEVELOPMENT USING GEOGRAPHIC INFORMATION SYSTEM (GIS) IN DEVELOPING COUNTRIES

Shahid Kabir[1], Masoud Elbkai[2] and Ateya Beckay[2]

[1]*Sustainable Materials and Infrastructure (SMI), Collaborative µElectronic Design and Excellence Centre (CEDEC)*

[2]*School of Civil Engineering*

Universiti Sains Malaysia, Engineering Campus, Penang, Malaysia

ABSTRACT: Due to a lack of foresight in urban and rural planning, many developing countries face challenges in implementing and monitoring the development of their cities, towns, rural areas, and residential communities. Some of the challenges that they face, such as sewage, sanitation, and waste-water management, can lead to conditions that are hazardous to human life, as well as to the environment, and can result in communities that do not run efficiently. With the right tools, planners, surveyors and engineers, who possess technical expertise, political know-how, and financial insight can transform a vision of tomorrow into a strategic action plan for today. This paper provides a critical review about the issues and challenges in urban and rural planning in developing countries with high population densities, and conventional solutions that are currently being employed, including those based on GIS and remote sensing data. This study is one component of an on-going research project that is focused on the development of an enhanced model for a spatial decision-support system that will be practically applied for the development of an early-warning escape plan for natural disaster management, and for transportation network development and sustainable urban planning.

KEYWORDS: spatial decision-support systems; urban and rural land planning; early-warning escape plan; transportation network development.

1. Introduction

Due to a lack of foresight in urban and rural planning, many developing countries face challenges in implementing and monitoring the development of their cities, towns, rural areas, and residential communities. Some of the challenges that they face, such as pollution and traffic, are common to more advanced countries as well. However, due to a deficiency in management, initiative, funding, and/or equipment, developing countries sometimes have difficulty solving more simple issues, such as sewage, sanitation, and waste-water management, which can often lead to conditions that are hazardous to human life, as well as to the environment, and can result in communities that do not run efficiently. With the right tools, planners, surveyors and engineers, who possess technical expertise, political know-how, and financial insight can transform a vision of tomorrow into a strategic action plan for today.

The aim of this study is to provide a critical review about the issues and challenges in urban and rural planning in developing countries with high population densities, and conventional solutions that are currently being employed, including those based on GIS and remote sensing data. This study presents a closer look at Geographic Information Systems (GIS) and their general applications in land planning and management, as well as their role in the development of Spatial Decision Support Systems (SDSS), which are the latest approaches employed in a variety of applications. This study is one component of an on-going research project that is focused on the development of an enhanced model for a Spatial Decision Support System, which employs GIS for urban and rural land use planning and management, urban service development, and natural disaster management. This model will be practically applied for the development of an early-warning escape plan for natural disaster management in Indonesia and for transportation network development and sustainable urban planning in Bangladesh.

2. Issues in Developing Countries

There is no basic difference in the application of technology to real world problems between developed and developing countries (Ottens, 1992). However, there are some fundamental differences between developed and developing countries, which pose issues and challenges to the application of technology. These differences hinder the planning and implementation of social and physical development projects.

The main problem in applying technology in developing countries is the limitations of available financial resources. For countries that do have sufficient funding, usually from foreign aid sources, these funds are often mismanaged by those entrusted with it. Also, there is often rivalry between ministries and/or different levels of government. Political instability and corruption make the proper allocation of financial resources even more difficult.

Another problem with developing countries is their infrastructure. Some countries cover huge areas of land but the people may be concentrated in a few small areas around large cities. To cover the whole country at a reasonable scale is not only very time consuming and expensive (Burrough, 1992), but many areas are very hard to access; collecting data in such regions can sometimes be almost impossible. On the other hand, some countries have such high population densities, that keeping track of land registration and cadastral information is a difficult task. The application of technology also requires proper facilities: appropriate office space, electricity supply, computer networks, etc.

Furthermore, there is a high level of computer illiteracy in developing countries; few people know how to work with computers. This has a huge impact on the human resources of a country. Not having any language support for computer technology makes things even more difficult. Although the number of computer training institutes is rapidly increasing, the number of people that have mastered computer and IT skills is very low. This problem is usually dealt with in one of two ways: either local staff is selected and sent abroad to attend related courses, or training is conducted 'on the spot' (Teefelen et al., 1992). Both of these methods are very expensive, since the skilled people imported to conduct the training are normally paid much higher wages, and paying for seminar trips to developed countries can be quite costly.

Nevertheless, solutions are out there. As internet facilities become more and more available, online seminars are one solution to increasing computer literacy and the use of technology. Over the last few years, many new computer-based instructional products have appeared. Software companies also offer many basic modules for free, and further education is reasonably priced. Building a database of a country's resources and using that information to plan and manage the development of the country is possible within the context of collective commitment and political stability (Burrough, 1992). Although the political condition of a country cannot be controlled, organizations can work together to overcome many of the challenges faced by developing countries. GIS has a lot of potential to help solve those problems.

3. Geographic Information Systems (GIS)

GIS are powerful computer tools that are used for storing, retrieving, transforming and displaying spatial data of many kinds, and are rapidly becoming a key technology for the automated capture, management, analysis and presentation of location-referenced data all over the world (Ottens, 1992). The use of Geographic Information Systems (GIS) allows for quick and easy access to solutions for technically complicated, time-absorbing, geographical problems (Teefelen et al., 1992). This ability to store and retrieve data about special aspects of the earth and the way people live on it, and the potential to use these data in models of environmental and socioeconomic processes in order to learn more about the possible outcomes of natural trends, planning decisions, or disaster management, is not only very important for industrialised countries but also for the developing world (Burrough, 1992). There are many actual and potential applications for GIS in developing countries, such as resource inventory and monitoring, land use planning, land evaluation, irrigation and drainage, social and economic planning, disaster management, management of conservation areas and parks, as well as tourism.

While many planners have been quick to utilize these new GIS planning tools, they were not originally designed or developed for the land planning and development profession. As a result, it is highly unlikely that all computational needs of land planners will be incorporated into standard GIS packages. Instead, planners will have to adapt existing GIS tools to meet their needs. Traditional programming languages can be used to develop spatial analysis and modelling tools entirely independent of commercial packages. A combination of sophisticated GIS macro commands and traditional programming languages can also be used to develop analytical models closely linked to full-featured GIS toolkits (Klosterman, 2001).

3.1 Remote Sensing

Land use and land cover information is constantly changing as a result of an increasing human population. Due to conflicting land use demands, this type of information is very important for different applications, such as urban and rural planning and management. With the increasing pressure for better land management, there is a great need for current, detailed urban land cover and land use data (Kabir et al., 2010). To this end, remote sensing techniques, especially satellite images, have great potential to provide this information, which can then be used in GIS models.

Since information about physical and socioeconomic phenomena in developing countries is scarce, data from remote sensing sources are very important in supplying this information efficiently. Remote sensing data is not only useful for collecting information about natural resources, it is also practical in the case of informal settlements and areas that are difficult to access. Remote sensing imagery provides an extremely useful tool for both land cover and land use mapping and the collection of basic road network (Mason and Fraser, 1998). Developed countries usually collect very explicit information about the total population and its density. As field surveys take a lot of time and cost a lot of money, an easier way to get this data for developing countries is by remote sensing imagery (Majeed, 1996).

3.2 General Applications of GIS and Remote Sensing

Standardization of GIS applications is based on experience in the use of GIS and remote sensing in urban planning; the following general activities can contribute to wider adoption of GIS use:

- Preparation of existing land-use maps
- Study of urban sprawl over a given time period to understand the underlying driving forces
- Assessment of land use conversion in different areas to help understand the impact of policies pursued
- Land suitability analysis based on physical, environmental and accessibility parameters to guide the selection process for opening up land for urban development
- Accessibility analysis for proposed major development projects, such as airports, growth centres, and stadiums
- Evaluation of public suggestions and objections on draft planning proposals
- Publication of maps at various scales with relevant details

Besides the above listed primary tasks, there are many other planning jobs that can be usefully carried out using GIS. Examining net density (density computed as a ratio of population to developable area) in different areas for judicious allocation of resources, implementing Coastal Regulation Zone guidelines, and reviewing the development status of reservations, are just some of the more specific applications of GIS (Deutsch & Ruggles, 1974; Fedra & Haurie, 1999).

Geographic Information Systems have had a profound effect on hydrologic modelling and model development (Xu et al., 2001). GIS tools are now commonly used in Decision Support Systems (DSS) for hydrologic model operation and data preparation, and GIS has become an essential tool for developing watershed management Spatial Decision Support Systems (SDSS) (Tayler et al., 1999).

3.3 GIS and Decision Support Systems

Decision Support Systems (DSS) were first developed in the field of management science in the late 1970s to provide a framework for integrating database management systems, analytical models and graphics in order to improve decision-making processes. Rather than producing solutions to problems, a properly designed DSS is an interactive software-based system intended to help decision makers compile useful information from raw data, documents, personal knowledge, and/or business models to identify and solve problems and make decisions. The system presents data and predictions in a way that 'informs' the user and provides the opportunity for a participatory approach producing outputs that can be directly used by decision makers.

DSS are a specific class of computerized information systems that provide support for such activities as business and organizational decision-making. There are many advantages associated with employing DSS; it has the potential to (Stephens & Middleton, 2002):

- Improve personal efficiency
- Expedite problem solving (speed up the progress of problems solving in an organization)
- Facilitate interpersonal communication
- Promote learning or training
- Increase organizational control
- Generate new evidence in support of a decision
- Create a competitive advantage over competition
- Encourage exploration and discovery on the part of the decision maker
- Reveal new approaches to thinking about the problem space
- Help automate the managerial processes

Through the incorporation of GIS, DSS have been extended to include spatial context in the development of Spatial Decision Support Systems (SDSS), as shown in Fig. 1. Multi criteria GIS models are now integrating earth observation through remote sensing, and geo-spatial technologies with formal decision theory in an interactive visualization tool for such tasks as land management, urban and rural planning, natural resource assessment, natural disaster management, watershed development and even political decision-making in security issues (ISFEREA, 2010).

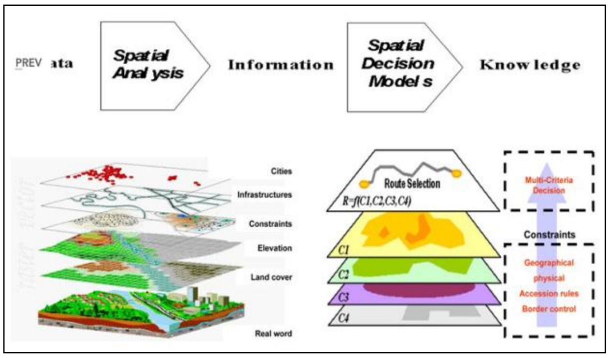

Fig. 1. Spatial Decision Support System [6]

4. Natural Disaster Management

Each year, natural disasters exert a heavy toll on human life and property. The United Nations estimated that in the past 20 years, nearly three million lives have been lost due to natural disasters, and about 800 million people have been affected (Katayama, 1994). Natural disasters leave destructive and adverse effects on human communities. Some of these disasters include floods, tsunamis, cyclones, hurricanes, as well as earthquakes. GIS and remote sensing techniques are often employed to manage these phenomena.

4.1 Flood Management

Flooding is a result of heavy or continuous rainfall exceeding the absorption capacity of soil and the flow capacity of rivers or streams. This causes a watercourse to overflow its bank onto adjacent lands. In general, floodplains, which are landforms composed primarily of adjacent depositional material derived from sediments being transported by a related stream or river (Srivastava, 2000), are most subject to flooding and are, therefore, 'flood-prone' and hazardous for the development of activities, if the vulnerability of those activities exceed an acceptable level.

Accurate flood mapping is a most essential task for flood hazard and flood damage assessment. For many legal requirements, it is necessary to map flood-prone areas from high resolution aerial photography or remote sensing data to provide initial conditions for flood forecasting, monitoring flooded areas and conducting flood damage assessments. Application of remote sensing techniques for flood study has received considerable attention, especially during the last decade. It has emerged as the most powerful tool to prepare inundation maps in real-time, which can be used effectively for flood-damage assessment and relief management (Yamagata & Akiyama, 1988). Consequently, satellite image interpretation is important in this field of research. Flood-inundation and flood-hazard maps have been prepared by many hydrologists all over the world from aircraft and satellite data, mostly from the visible and infrared bands (Deutsch & Ruggles, 1974). A few hydrologists have even used thermal infrared data to map flooded areas (Wiesnet et al., 1974).

Remote sensing technology can be much more useful and desirable when employed during the planning process. Using remote sensing data, the extent of floodplains and flood-prone areas can be approximated at small to intermediate map scales (up to 1:50 000) (Byrne et al., 1980; Colditz, 2003). Floodplains can be delineated by using remotely sensed data to infer the extent of the floodplain from vegetation changes, soils, or some other cultural features commonly associated with floodplains (Rango & Anderson, 1974).

4.2 Early-Warning Escape Plan

Warning systems are designed to alert communities of impending dangers, such as natural disasters, so that people have enough time to escape. These systems monitor certain conditions that are considered to be indicative of a specific type of danger. Sirens are an integral part of early warning system plans. In the event of impending threats, such as destructive waves or floodwaters, warnings in the form of sirens are usually sounded. Such alerts are further supported by visual indicators, such as red alert emergency warning lights and audio-recordings in various international languages (BBC News, 2005).

The Tsunami Warning and Mitigation System is a full tsunami early warning system that is based on several key components, including high-tech installations featuring quake and tidal sensors, speedy communications, alarm networks and disaster preparedness training in vulnerable regions, giving people time to flee to higher ground before the giant waves strike, as shown in Fig. 2 (BBC News, 2005).

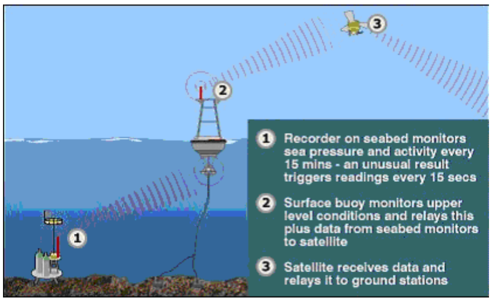

Fig. 2. Tsunami alert technology (BBC News, 25 March 2005).

One very important component of an early warning system is an early-warning escape plan. Without a comprehensive escape plan, people will be alerted to imminent danger through the warning system, but will not necessarily know how to handle the situation. A well developed plan will help prepare the community so that they will know exactly what to do, where to go, and more or less, what to expect. In this respect, GIS and remote sensing can be utilized to develop a practical, comprehensive plan, by taking into consideration the different types of data needed, such as geographical proximity to danger zones, shelter locations, possible escape routes, etc.

5. Improving Watershed Development

For large areas, such as major river valleys, time and available funds are often limited; therefore, it is usually not possible to conduct extensive detailed analysis and mapping activities during a planning study. Remote sensing technology provides an economically feasible alternative means of supplementing traditional hydrologic data sources (Sabins, 1997).

One area in which hydrologic data can be of great value to developing countries is watershed development. The conditions necessary for successful watershed development are clearly-established and include: adequately sloping topography, adequate rainfall, high contribution of land-based activities to livelihood, the willingness of landowners to allow the landless adequate access to the benefits of rehabilitation, adequate prospects for long-term ecological sustainability, including restrictions on the distribution and volume of groundwater extraction, adequate prospects for long-term institutional sustainability, including market links, and strong community commitment to joint action in resource management. Through the use of GIS and a well-developed decision support system, watershed development projects can produce positive results for the community as a whole.

6. Transportation Network Development

Social and economic development of a country depends on good transportation networks. Free and easy movement of goods and personnel are vital to the industrial development of any nation. Tourism, as an important sector of a national economy, depends heavily on a good transportation network and system. The state of transport infrastructure of any nation gives an indication as to the level of development of the nation. In most developing countries, ground transportation networks consist mostly of roads, scattered railways and a few waterways. However, road transportation remains the most prominent system of transport in these countries; movement of industrial and farm products and personnel is accomplished mostly by road network (Igbokwe, 2004).

Transportation problems are among the most pressing strategic development problems in many cities, and are often a major constraint for long-term urban development in general. These problems are very closely related to land development, economic structure, energy policies, and environmental quality. Since all citizens are either enjoying the transportation system or, and often at the same time, suffering from it, it is an important indicator of the urban quality of life. Problems often involve the inefficiency of urban transportation systems and their underlying land use patterns, which negatively affect the quality of life, economic efficiency, the environment, the high (and often hidden) costs of urban transportation in both socio-economic and environmental terms, and in particular the environmental consequences both in terms of physical aspects that include land and resource use, ecological aspects, and human health problems.

Efficient tools for comprehensive strategic analysis that are directly useful to city administrations are lacking. New strategies for sustainable mobility require well balanced combinations of measures with impacts on:

- Improved land-use/economic development planning
- Improved planning, management and use of transport infrastructures and facilities
- Incorporation of the real costs of both infrastructure and environment in investment policies and decisions and also in user costs
- Development of public transport and improvement of its competitive position
- Continued technical improvement of vehicles and fuels
- Incentives for the use of less polluting fuels
- Promotion of a more environmentally rational use of the private car, including behavioural changes

These problems can only be addressed with a consistent and comprehensive approach and planning methodology that helps to design strategies for sustainable cities. This has to include an integration of socio-economic, environmental and technological concepts including the development, integration, and demonstration of methodologies to improve forecasting, assessment and strategic policy level decision support (Fedra, 2000a, 2000b, 2000c) No single model can cover the entire range of processes, and the spatio-temporal scales characterising them, leading to a multi-tiered approach (Fedra & Haurie, 1999).

The alternative is to develop a set of models for scenario analysis, embedded in a common framework of indicators and a multi-criteria assessment methodology. The models will apply a common set of indicators for urban sustainability for a baseline analysis, ranking, and benchmarking, which ultimately feeds into a discrete multi-criteria assessment and selection mechanism. These indicators, at the same time, provide some link between the nested or cascading simulations models employed. The analytical models may include:

- Techno-economic analysis and energy system analysis using well established modelling approaches such as MARKAL; these are used to identify and evaluate cost effective transportation scenarios, consistent with the larger economic and technological framework, and estimate the market penetration of new transportation technologies
- Traffic equilibrium modelling used to evaluate alternative transportation policies, including multi-modal systems, high-occupancy vehicles, park and ride systems, and transportation telematics and their relation to land use, technological development, socio-economic development, and spatial and structural urban development (land use scenarios) in general.
- Emission modelling that translates the results of the transportation model, such as traffic frequencies, and driving conditions together with the fleet composition, into the emission used in the air quality models
- Air quality modelling used to translate emission scenarios into ambient air quality estimates, ranging from street level to the regional scale, and population exposure both for short-term events and for seasonal and annual time frames
- A fuzzy rule based system used to estimate public health impacts and the probability and costs of accidents
- Economic assessment, using classical econometric valuation methods, for estimating the full individual and external costs of the alternative development scenarios and their transportation strategies on this basis

7. Environmental Planning

Environmental planning is a field of study, which since the 1970s, has been concerned with a given society's collective stewardship over its resources, and ultimately includes those of the entire planet (Selman, 2000). The aim of environmental planning is to integrate public sector urban planning with the concerns of environmentalism to ensure sustainable development, notably of air, water, soil and rock resources (Selman, 2000). Planning seeks to include consideration for future growth of society factors other than those urban planners have traditionally factored into economic development, such as transportation, sanitation, and other services in legislator decisions, by working with environmental planners to add sustainable (social, ecological & equity) outcomes as important factors in the decision-making process.

Chief concerns among environmental planners include the encouragement of sustainable development, equity, environmental justice, green building technologies, and the preservation of environmentally sensitive areas. The primary concern of environmental planning is expressed in the assessment of three spheres of environmental impact by human economic activity and technological output (Selman, 2000):

- Biophysical environment
- Socio-economic environment
- Built environment

Integrated environmental planning assessments encompass areas such as land use, socio-economics, transportation, economic and housing characteristics, air pollution, noise pollution, wetlands, habitat of endangered species, flood zone susceptibility, coastal zone erosion, and visual studies, among others (Petts, 1999).

7.1 GIS for Development Planning and Monitoring

Development planning requires an effective planning approach to achieve the desired goals and objectives, evaluate alternatives, as well as control development programmes that are in line with current and future prospects. GIS technology has long been applied in planning activities, which essentially include plan formulation as well as development control (Johar et al., 2003). A manual published by the Federal Town and Country Planning Department in Malaysia has provided for preparing the various levels of all plans using GIS technology in the plan formulation. The different spatial level and form of the plans requires different types of support in terms of information system. Various skills are also required for preparing development plans using GIS. They include the ability to build up and manage the database, which should incorporate socio-economic attributes of the local population. Managing services at the local level would also call for contiguity and proximity analysis. On the other hand, cartographic skills are of importance if plans are to be exhibited.

It should be noted that successful implementation of GIS for sustainable urban and regional planning largely depends on four factors. The first requirement is the automation of the database. It is costly to collect, store and shift through large quantities of unnecessary data. Hence, the most cost effective approach is to collect only the data required for the specific task. Secondly, data collected either from existing records, aerial photography or field surveys need to be integrated using GIS methods; the GIS should be organized to facilitate ad-hoc query and analysis. The third factor is the ability to perform spatial modelling, so that alternative scenarios can be generated. Lastly, valid criteria must be applied to evaluate the effectiveness of possible planning strategies before the final solution is determined.

Database development for a strategic development plan basically involves gathering of data, spatial and attribute data entry, and generating of data layers based on the applications for analysis purposes. Data gathering is usually carried out based on the type of data needed and sources of data. Paper maps and remotely sensed data, including satellite data and high-resolution digital orthophotographs, are major sources for collecting digital data. Data entry is then done through interpretation of the data gathered into the required form (Yaakup et al., 2002).

7.2 Importance of GIS and Remote Sensing in Urban Planning

Spatial depiction of public amenities and infrastructural facilities can be made quite user friendly through application of GIS. This also holds true for private organizations, as they can chalk out the consumer load, the paying capacity of the consumers in different regions, and develop their organization accordingly.

Real time traffic data combined with accurate maps can be very effective in reducing the response time for emergency services. Furthermore, GIS can help determine the spatial and temporal distribution of natural resources and types of activities that are damaging to the natural wealth of a nation; with this information, the authorities can take preventive steps in specific regions to promote the cause of conservation of natural resources. Similarly, spatial demographic information combined with land use data can be used to determine the land price hike and for setting economic policies of a region. GIS can also be applied to the relatively newer concept of multilevel parking needs in developing nations. This is important because even relatively smaller urban centers are experiencing severe parking pressures in certain areas, forcing consumers to walk for kilometres, in turn hurting business and increasing pedestrian accidents. GIS and remote sensing techniques can also help in tackling problems related to traffic, encroachments, air and noise pollution, water and power supply, etc. If relevant spatial information is made available to planners, they can make much better policy decisions to solve these problems (Jain, 2009).

8. Conclusion

Geographic information systems have proven to be an invaluable tool for evaluating alternative solutions to planning problems. In combination with remote sensing data and spatial decision support systems, planning databases can be extensively interrogated to generate several alternative solutions to strategic planning problems. Various scenarios, which take into account the socioeconomic characteristic of dwellers, the constraints of physical development, availability of land and land suitability for different kinds of development can be generated. Apart from that, web-based GIS is currently one of the GIS-based innovative technologies being employed that is aimed at upgrading the quality of urban planning.

On the other hand, moving further ahead, interfacing of urban planning models with GIS should now receive due attention. Incorporation of land-use transportation models, water distribution network analysis, and simulation of urban activities to evaluate different urban development alternatives in the GIS framework needs to be explored for added advantage. Evaluation of urban policy by model-based GIS approaches provides a useful insight to guiding the development process, which is another area of application that warrants further study.

References

1. BBC News, 2005, March 25, Tsunami Warning and Mitigation System
2. BBC News World Edition, Friday, 25 March 2005, Tsunami alert technology, http://news.bbc.co.uk/2/hi/science/nature/4373333.stm
3. Burrough, P.A (1992) Possibilities and constraints of GIS applications in developing countries; Possibilities and constraints of GIS applications in developing countries; Teefelen,V.P, Gustavson,V.L. and Verkoren, O (eds), Utrecht, pp.17-25.
4. Byrne, G.F., Crapper, P.F., and Mayo, K.K., 1980, Monitoring land-cover change by principal component analysis of multi-temporal Landsat data. Remote Sensing of Environment, 10, pp. 175–184.
5. Colditz, R.R., 2003, Land cover and geomorphological floodplain mapping of the lower Panuco basin. Mexico, utilizing remote sensing and GIS-methods. Diplomarbeit, Bayerische Julius-Maimilians-Universitat Wurzburg, Germany, unpublished, p. 197.
6. Deutsch, M. and Ruggles, F.H., 1974, Optical data processing and projected applications of the ERTS-1 imagery covering the 1973 Mississippi River valley floods. Water Resources Bulletin, 10, pp. 1023–1039.
7. Fedra, K. and Haurie, H. (1999) A decision support system for air quality management combining GIS and optimization techniques. Int. J. Environment and Pollution Vol.12, Nos.1/2, 1999, 125-146.
8. Fedra, K. (2000a) Environmental Information and Decision Support Systems. Informatik/Informatique 4/2000, pp. 14-20.
9. Fedra, K. (2000b) Model-based decision support for integrated urban air quality management. In: Longhurst, J.W., Elsom, D.M. and Power, H. [eds.] Air Quality Management, pp 243-260, WIT Press, Southampton.
10. Fedra, K. (2000c) Urban environmental management: monitoring, GIS and modeling. Computers, Environment and Urban Systems 23(1999) 443-457.
11. Igbokwe, J. I. (2004). Mapping of Regional Transport Networks with Medium Resolution Satellite Imagery. (Paper No. TS 6.5), Proceedings of the 3rd Regional Conferernce of the International Federation of Surveyors (FIG), Jakarta, Indonesia. TS 6_5.
12. ISFEREA, 2010 - Geo-Spatial Information Analysis for Global Security and Stability European Union.
13. Jain, M. (2009) Remote Sensing and GIS Techniques (A Case Study of a Developing Urban Center), Himanshu Publications, New Delhi, ISBN: 978-81-7906-160-2.
14. Johar, F., Yaakup, A.B., Abu Bakar, S.Z. and Sulaiman, S. (2003). Geographical Information System for Development Planning in Malaysia, The 8 International Conference on Computers in Urban Planning and Urban Management (CUPUM'03), Sendai, Japan, May 27-29, 2003.
15. Katayama, T., 1994, International Decade for Natural Disaster Reduction: Working Against Time, UNU University Lectures (Tokyo: The United Nations University).
16. Klosterman, R.E. (2001). Planning Support System: A New Perspective on Computer Aided Planning, in Brail, R.K. and Klosterman, R.E. (eds) Planning Support System, ESRI Press, Redland, California.
17. Majeed, M. (1996): Analysis of urbanization trend in the greater Colombo area from 1956-1994 using air photos; http://www.gisdevelopment.net/aars/acrs/1996/ts12/ts12002.shtml
18. Mason,S.O. and Fraser,C.S. (1998): Image sources for informal settlement management; Photogrammetric Record 16(92); Robson,S., Dowman,I.J. (ed), pp.313-330.

19. Ottens, H.F.L. (1992) The profileration of GIS: How about the developing countries?; Possibilities and constraints of GIS applications in developing countries; Teefelen,v.P; Gustavson, V.L.;Verkoren, O (ed); Utrecht, pp.27-34.
20. Rango, A. and Anderson, A.T., 1974, Flood hazard studies in the Mississippi River basin using remote sensing. Water Resources Bulletin, 10, pp. 1060–1081.
21. Sabins, F.F., 1997, Remote Sensing: Principles and Interpretation (New York, NY: W.H. Freeman and Co.).
22. Selman, P.H., 2000, Environmental planning: The Conservation and Development of Biophysical Resources, SAGE, 2000.
23. Shahid Kabir, D-C He, M A Sanusi and W M A Wan Hussin.2010. Texture analysis of IKONOS satellite imagery for urban land use and land cover classification, Vol. 58, 2010, pp. 163-170.
24. Srivastava, S.K., 2000, High resolution remote sensing data & GIS techniques in updating of infrastructure details for flood damage assessment – a case study. In Proceedings of GIS development, ACRS, Taipei, Taiwan.
25. Stephens, W. and Middleton, T. (2002). Why has the uptake of Decision Support Systems been so poor? In: Crop-soil simulation models in developing countries. 129-148 (Eds R.B. Matthews and William Stephens). Wallingford:CABI.
26. Tayler, K., Walker, G. and Abel, D. 1999 A framewo r k for model integration in spatial decision support systems . Int. J. Geo. Inf. Sci. 13 (6), 533 – 555.
27. Teefelen, V.P, Gustavson, V.L. and Verkoren, O., (1992), Possibilities and constraints of GIS applications in developing countries; Possibilities and constraints of GIS applications in developing countries; Teefelen,v.P; Gustavson, V.L.; Verkoren, O (ed); Utrecht, pp.11-16.
28. Wiesnet, D.R., Mcginnis, D.V. and Pritchard, J.A., 1974, Mapping of the 1973 Mississippi River floods by the NOAA-2 satellite. Water Resources Bulletin, 10, pp. 1040–1049.
29. Xu, Z . X ., Ito, K., Schultz, G. A. & Li, J. Y. 2001 Integrated hydrol ogic modeling and GIS i n w ater resources manageme n t. J. Comput. Civil Engng., ASCE 15 (3), 217 – 223.
30. Yaakup, A.B., Ariffin, M.T and Ali, N.N (2002). Rekabentuk Pangkalan Data GIS Rancangan Struktur Negeri Melaka, Bengkel Pangkalan Data dan Aplikasi GIS Rancangan Struktur Negeri Melaka, Skudai, Johor, Mac 22-23.
31. Yamagata, Y. and Akiyama, T., 1988, Flood damage analysis using multi-temporal Landsat Thematic Mapper data. International Journal of Remote Sensing, 9, pp. 503–514. 2456 J. Amini