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Spatial Decision Support Systems (SDSS) and Sustainable Development of the Third World

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ABSTRACT

This paper tried to look at the various meanings given to the concept of development, all in an attempt to understand how to have a better human society. From the fallout of the focus on the concept of development is the concept of sustainable development whose focus is on how people can meet the needs of the present without compromising the ability of the future generations to meet their own needs. One of the key principles of the concept of sustainable development is to ensure social justice, particularly in the third world. It is the issue of the social justice that is the focus of this paper – how the present resources can be used in a fair and equitable manner to meet the basic needs of all.

In line with the issue of social justice, the main aim of this paper is to examine how to adopt citizen participation in the planning process and how to incorporate their views in the public facilities provision decision process. The use of a computer based decision aid called the spatial decision support system (SDSS) to resolve conflicts that may arise in the public facilities provision decision process has been discussed and recommended.

Key words: Sustainable development, social justice, citizen participation, spatial decision support system, conflict resolution, third world.

INTRODUCTION

Our concern in this study is the issue of sustainable development in the third world countries. It has been observed that it is difficult to apply the concept of sustainable development generally and that there are contradictions between the goals of sustainability and 'development'. Also one of the key principles of sustainable development is the issues of social justice. Social justice requires that fair and equitable use is made of present resources in terms of meeting the basic needs of all and extending to all the opportunity to satisfy their aspirations for a better life (Pacione, 2001). For the third world countries, the priority is attainment of basic social, economical, and political goals within a context of seeking to minimize demands on environmental capital. The aim of this study is to outline a proposed method of resolving conflicts that may arise in the course of providing these basic needs. Resolving conflicts in the process of public facilities provision decisions will ensure the sustainability of such facilities. Thus the study examined the concept of development, sustainable development, the spatial decision support system (SDSS), and the constraints and suggested solutions to such constraints in the development of SDSS in third world countries.

Definition of Development

In order to plan effectively for development, including its measurement, there is a need to define precisely what the term development means. There is no universal definition of what the term development is; some definitions are based on economic criteria, some on social conditions, while others are based on political considerations.

Most economists define development from a growth perspective. On the other hand, sociologists have emphasized the social aspects of development in their definition. Political scientists of various ideological beliefs have also defined development in different ways. For example, Nyerere (1969) has defined development as "the development of people". Contribution to the definition of development has been made by Boudeville (1966) who distinguished between the three concepts of growth, development, and progress.

All the above definitions of development are quite relevant to the urban and regional planner who is primarily concerned with the spatial aspects of development. He is interested in how economic development, social development, political development, *etc.* are reflected in space. This suggests that

his definition of development should embrace those of other disciplines. Consequently development is defined as socio-economic changes, which are drastic and which touch all layers of society. Development entails the activation of a society's socio-economic potentials in combined effort to overcome problems or indicators of under-development. It also entails human progress as measured by members of the society concerned (Omuta and Onokerhoraye, 1986).

What is Sustainable Development?

The fallout from the attempts at defining development and the consequent implementation of developmental projects around the world is the concern for the resources to be left for the future generation. This concern brought about the concept of sustainable development.

Sustainable development is development which meets the needs of the present without compromising the ability of future generations to meet their own needs. This concept is based on the following three principles:

(1) Inter-generational equity- which requires that natural capital assets of at least equal value to those of the present are passed on to future generations;

(2) Social justice – which requires that fair and equitable use is made of present resources, in terms of meeting the basic needs of all and extending to all the opportunity to satisfy their aspirations for a better life; and

(3) Transfrontier responsibility – which requires recognition and control of cross-border pollution. Ideally the impacts of human activity should not involve an uncompensated geographical displacement of environmental problems (Pacione, 2001).

The ideal world envisaged at the Rio Earth Summit in 1992 was one in which the objectives of sustainable development would be fulfilled at all levels of spatial organization. Given the diversity of countries in terms of size, population growth rates and their economic, social, political, cultural, and ecological settings, it is difficult to apply the concept of sustainable development generally. As Nwaka (1996) stated, "for us in the developing world, the 'ecological debt' to future generation is not nearly as urgent as the 'social debt' for the future if today's young people lack the standard of health, education and skills to cope with tomorrow's world."

Even in the West, sustainable development is not accepted universally as a key goal of growth, particularly if it involves constraints on personal patterns of consumption. Ideally, for richer cities with high levels of resource use, a priority should be reduction of fossil fuel use and waste generation, while maintaining a productive economy and achieving a more equitable distribution of the benefits of urban living.

For the third world countries the priority is attainment of basic social, economical, and political goals within a context of seeking to minimize demands on environmental capital. We do not, of course, live in an ideal world, and the goals of sustainable urban development are often difficult, if not impossible, to realize (Pacione, 2001). In line with the above stated objective of sustainable development in the third world countries, this study is to examine the issue of basic public facilities provision and how conflicts that may arise from the distribution could be addressed through the use of a computer based SDSS.

To plan for development or sustainable development at that, the planning process is adopted which simply consists of stages from the identification of problem, to post implementation and review of the plan. The next section of this study will then examine the decision process and the different decision models and their characteristics.

THE DECISION PROCESS

Planning methodology has changed over the years as emphasis has shifted from situations in which planners think, plan, and design for the people, to one which both people and planners have become important actors in the planning process. The arguments have been that planners do not necessarily have knowledge and the ability to perform planning tasks 'alone', and consequently should interact more with the people for whom the plan is being made. Indeed, the people consist of two groups: the decision-makers who eventually consider and approve plans, and the common people for whom the plans are being made. It is probably true to say that, for a long time, both groups of people have looked upon the planner as a technocrat whose main interest lies in imposing rules, laws, and regulations without much consideration for the views of the people. The need to involve not only planners but also policy-makers in the planning process calls for the introduction of new planning approaches that integrate these three groups of people.

One way to integrate the actors in the planning process is through the use of "spatial group decision support systems", which in turn depends to a considerable extent on the development of user-friendly mathematical models through the use of expert systems (Ayeni, 1997; Ademiluyi and Otun, 2007).

Decision Theory/Models

Following from the above outline of the expected role of the planners and the people in the decision process, this section will look at some theories and concepts that are relevant to the study of decision making, particularly those concepts and models that aid the understanding of how multiple views are accommodated in the decision process of providing public facilities.

Decision theory is the formal study of the making of decisions. Real-life studies, which use surveys and experimentation, are called descriptive decision theory; studies of rational decision making, which employ logic and statistics, are called prescriptive decision theory. Such studies grow progressively more complex when more than one person is involved, when outcomes of various options are not known with certainty, and when even the probabilities of outcomes are unknown (Microsoft Encarta, 2008).

The Planning Process and Spatial Decision Support

Planning and management are based on a generic problems solving process which begins with problem definition and description, involves various forms of analysis, which might include simulation and modeling, moves to prediction and thence to prescription or design which often involves the evaluation of alternative solutions to the problem. Decision characterizes every stage of this process, while the process of implementation of the chosen plan or policy involves this sequence once again. The process takes place across many scales and is clearly 'iterative' or 'cyclic' in form. Processes may be nested within one another while the extent to which different professionals, managers, and other decision-making interests are involved through the various stages, depends upon the nature of specific applications and their context. In practice, the process is often partial and much diluted from this more formal characterization. The typical process illustrated in Figure 1, however, remains a basis for action (Batty and Densham, 1996).

Figure 1 shows how Geographic Information System (GIS) and related modeling technologies fit within this process indeed, this is the kind of structure that Harris (1989, 1991) refers to as a planning support

system (PSS), which links a variety of computer-based software supporting decisions at different stages of the planning process (Batty and Densham, 1996). This kind of process is rarely executed in a comprehensive fashion and usually, only a few elements of it exist, often to the exclusion of others. For example, many involved in public planning have access to GIS, but few are involved in linking GIS to modeling and forecasting (Manheim, 1986). In fact, a major research program involves the use and adaptation of GIS through embedding and linking various types of predictive and prescriptive models in formal terms. Strategies for such linking range from weak to strong coupling (Batty and Densham, 1996). Models can be linked to GIS simply through the import and export of data-weak coupling, while much stronger coupling exists where models are embedded within GIS or GIS functions within models.

Advocacy Planning /Citizen Participation in Planning

In other to ensure that the people that are the recipients of the benefits of planning have a say in the planning process, the use of the advocacy planner can be introduced as discussed below. This will likely be more beneficial in the third world countries where the voice of few well placed people in the society are likely to be dominant.

The advocacy model is an adaptation from the legal profession where it is more articulately developed (Piven, 1970). Generally, the advocate is defined as one who pleads the cause of another, or one who is in support of something.

The advocacy planning model as developed by Davidoff (1965), is the strategy whereby the professional services of the planner are made available to those segments of society whose interests are at stake in the planning issue. The advocacy model may, therefore, be seen as a rejection of unitary approaches to planning, where issues, policies and decisions are made from the point of view of one group, which is usually the interest of government.

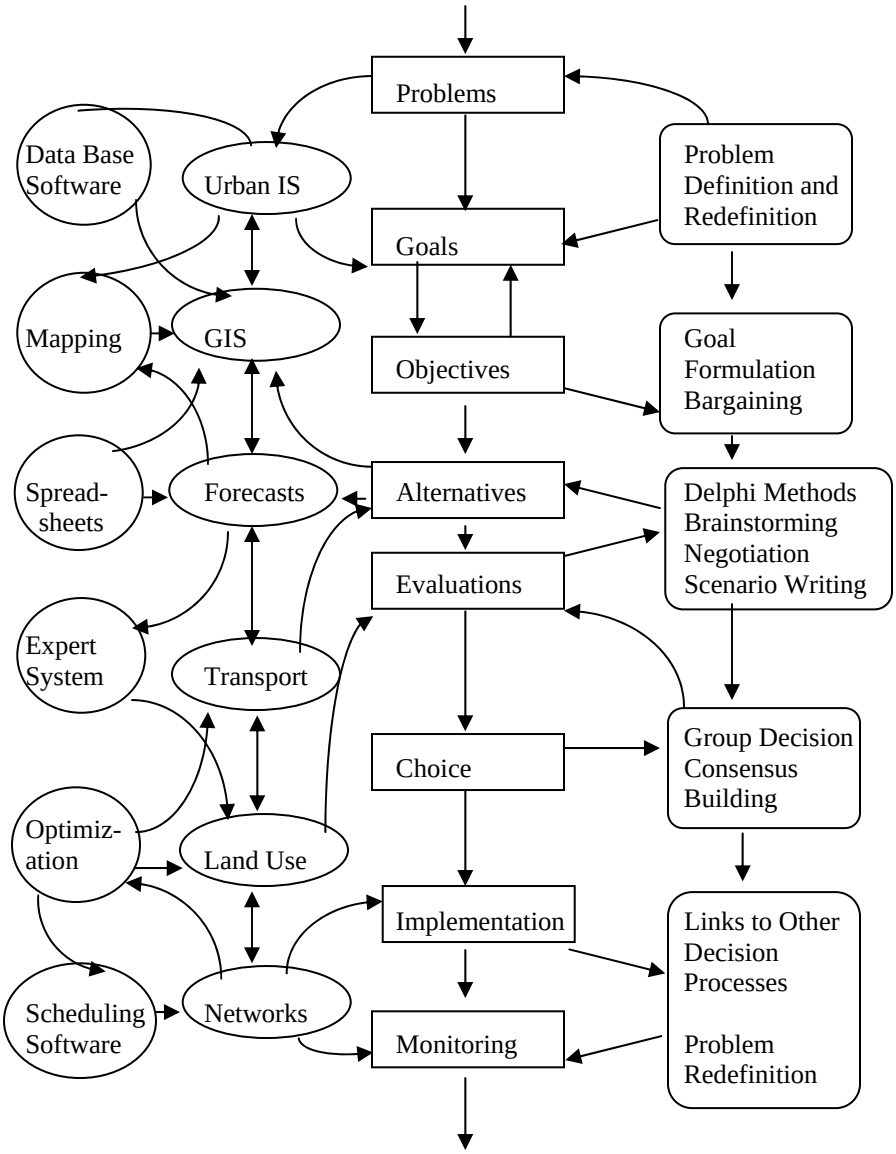

Figure 1: The Planning Process as a Sequence of Computable Methods Enabling Decision Support.
Source: Batty and Densham (1996) *Decision Support, GIS and Urban Planning*

Citizen Participation in Planning

The advocacy planning, as described above, is a form of citizen participation in planning which is out to ensure that the citizens are involved in the planning process. However, it should be noted that the level of citizen participation in the planning process varies in accordance with the stage of the planning

process, the planning issue involved, and the type of political process and planning environment. The table below shows the categories of citizen participation.

Steps		
1	Manipulation	Non-Participation
2	Therapy	
3	Information	High level of
4	Consultation	Tokenism
5	Placation	
6	Partnerships	
7	Delegated power	Citizen participation
8	Citizen control	

Source: Sherry Arnestein, 'Ladder of citizen participation' July, (1969)

The last step in the citizen participation ladder (shown above) will involve the 'Radicalists' – humanistic planning model. This model sees democracy in planning as the total involvement of the citizen in the planning process and resolve to break the legal tyranny that has suppressed the majority of mankind to perpetual authority. However, according to Onorkerhoraye and Omuta (1986), the model is utopian in nature.

Service Development Planning

As mentioned earlier, the focus of this study is on the equity aspect of sustainable development, which requires that fair and equitable use is made of present resources in terms of meeting the basic needs of all. The focus in this study is how to ensure equitable distribution of public facilities during the process of planning and provision of these facilities. Hence, in this section we looked at the concept of service development planning and the notion of equity as a locational objective in public service provision.

Public services have been defined as "the service received from that portion of the gross national product spent by government at all levels" (Lonsdale and Enyedi, 1984). The objectives in the provision of public services are to ensure equal accessibility to the services and to maximize societal welfare but not necessarily to maximize profit. On the other hand, private services are made available to consumers to maximize the profit margin of the providers.

Locational Objectives in Public Facilities Provision

The properties of public services, enumerated above, provide points of reference for the identification and explanation of what societal norms are set for their provision and location. The normative questions of public facility location focus on the objectives of the principal actors (the government and the consumers) who make decisions on facility provision and consumption, respectively. The key issues identified are optimality, equality, and accessibility (Owoola, 1996). The issue of equity, as a locational objective in public facility provision, is examined below.

The Notion of Equity

The notion of equity is less clearly articulated in locational studies. Nonetheless, the notion of equity evolved from the need to protect that segment of the society less able to compete in the national/regional space economy. Thus, Harvey (1973) interpreted equity in terms of social justice with respect to location. An equitable system is, therefore, conceived as one that ensures a fair access to the resource of a system by all competing groups, regardless of their spatial location. The incorporation of equity in locational decision-making is an attempt to reinforce the argument that in the spatial world, the uncertainties confronting the decision-maker and the complexity of the environment makes global rationality impossible. Thus, the decision-maker tries to satisfy by specifying aspiration levels. An approach by which the decision-maker can incorporate his aspiration levels into an operational model of search for a satisfying solution is considered below.

Multi-Criteria Modeling

Gradually geographers have recognized that many problems of resource planning involve not a single optimization but multiple, conflicting and possibly incommensurate objectives. This has led to dissatisfaction with the objective of maximizing some aggregate measure of economic efficiency as in the traditional models that tend to have a lack of operationality. So there has been work replacing this objective with a concern for *multi-objective optimization.*

The theory of multi-criteria decision-making deals with situations in which a single decision maker is faced with a multiplicity of usually incompatible criteria, performance indices or *pay-offs*, in which a

number of decision-makers or game players must consider criteria each of which depends on the decisions of all the decision-makers.

In a multiplicity situation involving a decision maker, two main approaches by which the decision-maker incorporates his aspiration levels into an operational model are discussed below. In the first approach, the decision-making problem is solved using pre-specified aspiration levels by means of goal programming. In the second approach, the decision-maker's aspiration levels are progressively revealed during the problem solving process using interactive programming methods (Malczewski, 1997). When there is more than one decision-maker, both co-operation and non-co-operation between players is possible and such a situation can be examined using the game theory discussed below.

Game Theory

The society is often fragmented and pluralistic along economic, ethnic, religious, social, and political lines; and multiple interests and value positions are involved and reflected in typical planning issues. To be able to accommodate the multiplicity of views in the spatial decision process, serious research efforts are going on in one branch of mathematics called 'game theory'. The 1994 Nobel Prize for Economics has actually been given to three of the proponents of game theory to appreciate their contributions in this area of research.Game theory is the mathematical analysis of any situation involving a conflict of interest, with the intent of indicating the optimal choices that, under given conditions, will lead to a desired outcome.

Decision Support Systems

Decision support systems, which are our concern in this study, is an interactive, computer-based system designed to support a user or group of users in achieving a higher effectiveness of decision-making, while solving a semi-structured spatial decision problem (Sprague and Carlson, 1982; Wikipeadia Encyclopedia, 2008).

The decision support system as a tool can be deployed in the planning process to ensure the equity aspect of sustainable development. Due to the proposition of allowing inputs from different groups that are stakeholders in the provision of public facilities (the people, the politicians, and the planners), the

decision problem is usually semi-structured in nature. As a result, the SDSS is being suggested as a way of resolving conflicts that may arise from the decision process.

Decision making involves selecting the correct action from a series of alternatives choices. Three types of decisions are usually recognized: operational decisions, tactical decisions, and strategic decisions. The relationship of the decision types to different types of system is shown schematically in Figure 2 below.

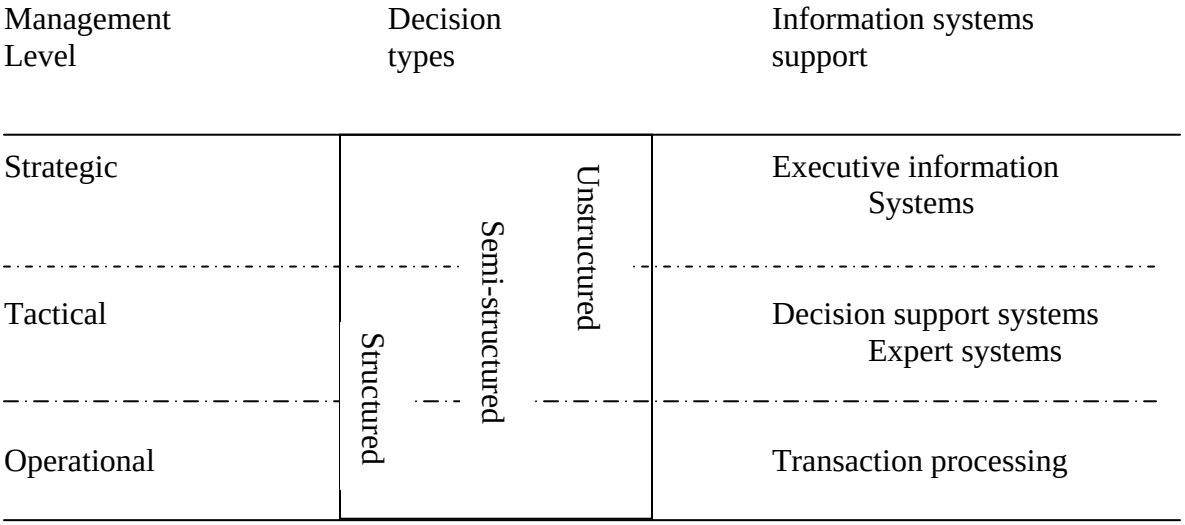

Figure 2: Classifications of Decisions by Decision Type and Their Relation to Different Types
Source: Bocij P., *et al* (1999) *Business Information Systems: Technology, Development and Management*, London: Pitman Publishing.

Decision Support System Components

Decision support systems are often built around the "*DDM paradigm*", i.e. the technology for a DSS must consist of three sets of capabilities in the areas of *dialog*, *data*, and *modeling* (Sprague and Watson, 1996). A well-designed DSS should have balance among the three capabilities.

Sprague and Watson (1996) identify three main-components in a decision support system: (i) the Data Base Management System (DBMS), (ii) the Model Base Management System (MBMS), and the Dialog Generation and Management System (DGMS). Figure 3 (below) presents the architecture of a SDSS (Lolonis, 1990).

Types of Decision Support System

There is a bewildering array of terms used to describe software developed to help solve semi-structured problems, including artificial intelligence, expert systems, neural networks, fuzzy logic, data mining, and intelligent knowledge-based systems.

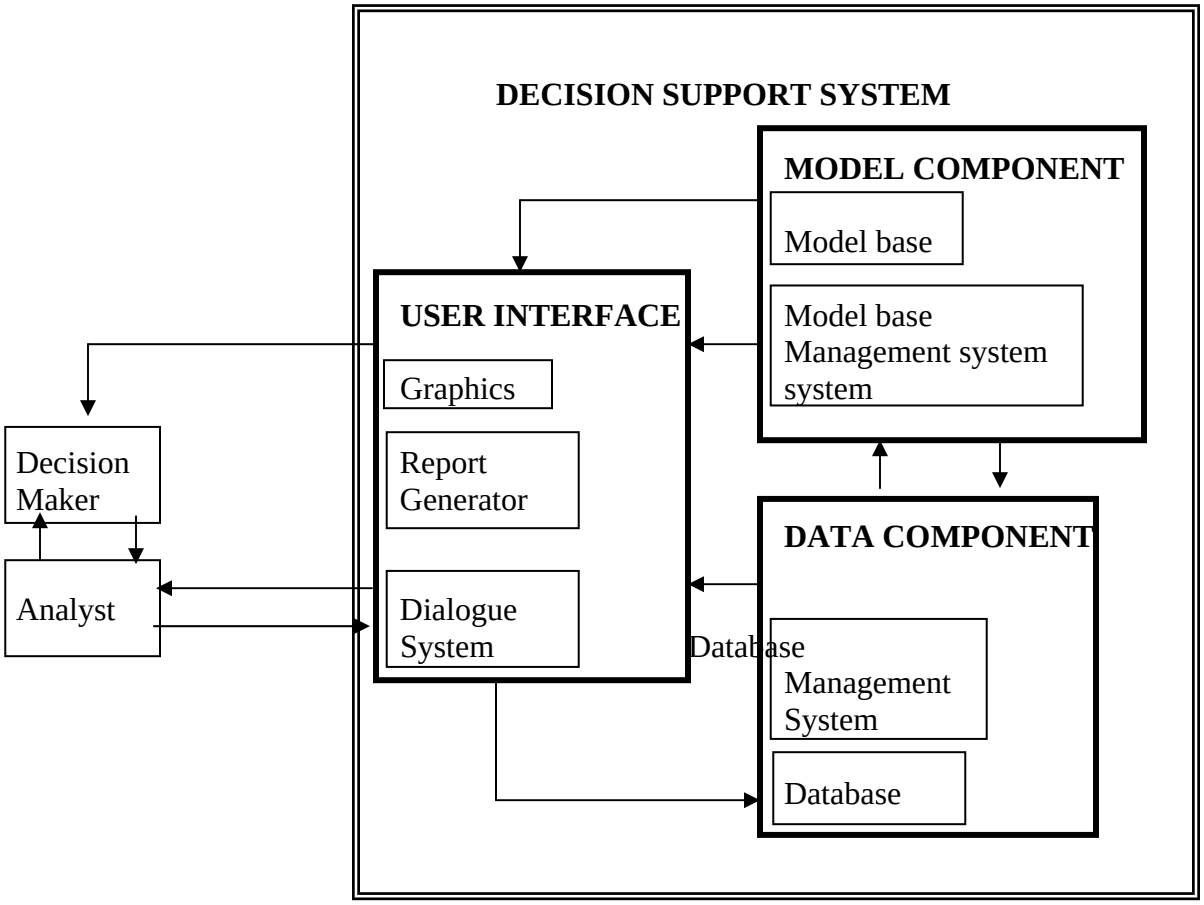

Figure 3: A Decision Support System (Lolonis, 1990)

All of these types of software have the same broad aim – to assist decision making by using software to mimic the way decisions are made by experts in their own field. However, the system of interest here is the type called 'SDSS' which is discussed below.

SPATIAL DECISION SUPPORT SYSTEMS (SDSSS)

SDSSs are decision support developed for use with a domain database that has a spatial dimension or for situations where the solution space of a problem has a spatial dimension (Wright and Buehler, 1993). SDSSs integrate a geographical information system with a computer-based spatial analysis module, map analysis, and display modules. Such systems typically employ a personal computer in such a way that planning scenarios can be determined, analyzed, and adopted according to the planning standards that are set up by planners and decision makers. The use of these support systems is highly desirable when professional planners, politicians, and decision-makers act to effect certain decisions.

Characteristics of Spatial Decision Support System (SDSS)

As computer-based systems, decision support systems assist decision-makers in semi-structured tasks, support rather than replace judgment, and improve the effectiveness of decision-makers rather than its efficiency. A SDSS assumes that there is no single solution or answer to a problem, but allows users to bring their expertise to the solution of the problem. In this way, users are able to use intuition and expert judgment about '*unmodellable*' aspects of the problem. That is how decision support systems are used to solve ill- or semi-structured problems, i.e. where objectives cannot be fully or precisely defined in a way that the computer can be programmed to solve on its own (i.e. without the expert's input). Furthermore, since only one formulation of the problem is evaluated at any stage, the process allows groups to evaluate solutions and revise specifications of the problem (Ayeni, 1997).

The Future of Spatial Decision Support Systems (SDSS)

According to Batty and Densham (1996), the development in computing and GIS is likely to affect urban planning in the nearest future. This will involve the ways integration between spatial representation, modeling, and optimization design will be implemented in the coming years. Increasingly these will take place in a *digital environment* which itself will be integrated through networking. According to Batty and Densham (1996), we will soon see the development of whole groups of non-technical users in planning being directly involved in the integration of data and models across distributed networks. A distributed system allows for processing to be carried out at several locations and for computer files to be dispersed amongst those locations (Eyitayo *et. al*., 1999). Tasks to be performed by individuals or groups on the network can then be shipped to the appropriate computers

for processing across very high bandwidth communications channels. In this way, both individual users and groups working together to solve complex spatial problems can be supported in this way. The current growth of the internet and the World Wide Web is clear evidence of the potential for this kind of integration.

Spatial Decision Support System (SDSS) and Sustainable Development

From the foregoing discussion, it has been established that planning the provision of basic facilities requires inputs from the technocrats/planners, as well as from the people (the users and the politicians). It is suggested that advocacy planners should be particularly used in the third word countries to ensure representation in the provision of public facilities decision process. This study has also shown that the SDSS (SDSS) can incorporate the views of these groups of people in the decision process to provide basic facilities. The advantages of this computerized decision aid include the ability to make use of vast amounts of stored data and the ability to use both analytical models and the large stored set of rules that constitute the knowledge base. Current efforts are going on to improve this computerized decision aid to be able to resolve conflicts that may arise from group's disagreement on the issue of public facilities location.

It is also shown that the decision tool can benefit from the current improvements in information and communication technologies by designing SDSS that can solve spatial problems using hardware, software, and human resources of computers that are located in different geographic areas. It is hoped that when the SDSS is fully developed it will be able to resolve more conflicting views particularly with respect to equity in the provision of public facilities better and, thus, ensure a more sustainable distribution and use of such facilities.

Constraints to the Use of the Spatial Decision Support System (SDSS) for Sustainable Development in the Third World Countries

There are aspects of urban and regional planning where the development of decision support systems has attained important dimensions. The use of the expert system is likely to improve the development of urban infrastructure models. However, an expert system will provide advice that is as good as the knowledge base. Consequently, the role of the human designer comes into focus and also his or her ability to resolve conflicting knowledge and validate expert systems (Ayeni, 1997).

It is in line with the above role of knowledge-base that researches in areas of game theory identified by the 1994 Nobel Prize for Economics should be intensified. The highlighted areas for possible future enquiry by geographers and regional planners are:

(1) Further variants on the *prisoners' dilemma* in the form of games reaching an equilibrium; and

(2) Multi-stage games where the credibility of a particular player's threatened move is important (Guy, 1998).

Apart from the areas for future research in the development of SDSS, mentioned above, countries of the third world need to improve their research capability especially in the area of computing and its application to decision support systems.

As mentioned earlier, the future development of the SDSS is towards geographically distributed processing and solving of spatial problems to be supported by the information super highway. To benefit from the new improvements to the SDSS, it is imperative for governments in different third world countries to ensure that telecommunication facilities are upgraded to the level that will allow the necessary and adequate exchange of information within and among various countries and institutions at reasonable costs to the user.

CONCLUSION

To ensure equity and sustainable development, especially in the area of provision of basic facilities for the people, third world countries need a political and social re-structuring that will allow for advocacy planning and citizen participation in the planning process. This is to strengthen the voice of common people in decisions that has to do with their lives. However, to accommodate their view in the decision process, third world countries need the political will at each national level to make the integration of research and development of tools like the SDSS into national plans of action within the context of a long-term objective of attaining sustainability development.

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