Role of geographical information as data source to the decision support system

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Abstract- The enduring development of DSS applications requires that new technologies be exploited to allow new classes of decision be supported. Urbanization prediction from planning and development point of view is the imperative requisite of time. This paper discusses the use of a Geographic Information System (GIS) as a Decision Support System (DSS) generator to create Spatial Decision Support Systems (SDSS). Many important areas of DSS application, such as routing or marketing, make use of spatial information. This paper argues that the development of such systems will allow effective support be provided for decisions which make use of spatial data.
Keywords- Decision Support Systems, Geographic Information Systems, Multcriteria decision making

Introduction

Application of any system at user level requires quality input from top level management. However the feedback from the user level through middle level manger to the top level always acts as source to enhance decision activity from time to time. Decision making is very complex and it involves both, people and information. In most organizations, when you pay people to work, they work and don't think. But when you pay people to think, they think and when you empower them to make decisions, they make good ones. The benefits of these strategies to the bottom line can be huge. You leverage the intellectual assets of your organization in ways that you might not have thought possible. Decision making is a process of choosing among alternative courses of action for the purpose of attaining a goal or goals. Management decision making is synchronous with the whole process of management [1]. Decision Support System (DSS) is well-established area of information system (IS) application. Academic research in the DSS field dates from the work of Gorry and Scott-Morton [2]. In the period since DSS came to prominence there has been considerable growth in the importance of Geographic Information Systems (GIS). This growth in GIS reflects the decreased cost of the required technology and the increasing availability of appropriate spatial data. Recent improvements in mainstream computer technologies facilitate this spread of the use of spatial data. These include inexpensive gigabyte sized hard disks, large high resolution color monitors, graphics accelerators and CD-ROM storage. This explosion in the use of computer technology can also be seen in other areas, where a virtuous circle of declining hardware costs leads to larger software sales and therefore reduced software costs. Geographic information system (GIS) is a powerful tool which can be used to create integrated geo-database, visualize scenarios, develop advanced spatial models and effective solutions, prepare hazard zonation maps, and the management plans(3,4). Within the GIS field there is increasing interest in the use of GIS software to provide decision support. A GIS can be a tremendous support to executive decision making, especially when these involve capital-investment facilities. GIS and spatial technologies are currently moving towards the web. There is need of an hour to bring openness in sharing this spatial data as the spatial data developed by commercial companies store spatial data in a proprietary format protected by copy right law. This reflects the broader trend of geographical information systems generally towards the internet platform. Spatial capability is becoming prevalent in mobile devices, starting with GPS-enabled cell phones required in many countries. The data bank of spatial information is growing exponentially through collection of multiple types of sensors, satellites, RFID readers, GPS enabled devices etc. Data storage technologies and designs have advanced into spatial object oriented and spatial database paradigm. DSS can therefore be seen as an important subset of DSS, whose potential for rapid growth has been facilitated by technical developments. The availability of appropriate inexpensive technology for manipulating spatial data enables SDSS applications to be created. The benefits of using GIS based systems for decision making are increasingly recognized. In a review of GIS, Muller (1993) identified SDSSs as a growth area in the application of GIS technology. However the value of SDSS is not determined by its innovative use of technology. Instead the contribution of these applications will be determined by how well they support the need for a spatial component in decision making.

Phases of Decision Making Process
Intelligence

a. the intelligence phase involves searching or scanning the environment for conditions calling for decisions;
b. this phase requires an exploratory analysis of the decision situation;
c. GIS can play a vital role at the initial stage of spatial decision-making;
d. the system can help in coordinating decision situation analysis through its ability to integrate and explore data and information from a wide range of sources;
e. GIS can effectively present information in a comprehensive form to the decision makers.

Design

a. the design phase involves inventing, developing, and analyzing a set of possible decision alternatives for the problem identified in the intelligence phase;
b. a formal model is typically used to support a decision maker in generating the set of alternatives;
c. while an increasing number of GI Systems are described as systems for supporting the process of designing and evaluating spatial decision alternatives, most commercially available GIS lack the kinds of spatial analysis and modeling required by decision makers;
d. the capabilities of GIS for generating a set of alternative decisions are mainly based on the spatial relationship principles of connectivity, contiguity, proximity and the overlay methods;
e. in current GIS environments, models for generating decision alternatives operate in the background, detached from users insights and qualifications.

Choice

a. the choice phase involves selecting a particular decision alternative from those available;
b. each alternative is evaluated and analyzed in relation to others in terms of a prespecified decision rule;
c. the decision rules are used to rank the alternatives under consideration;
d. the ranking depends upon the decision maker's preferences with respect to the importance of the evaluation criteria;
e. critical for use of GIS in the choice phase is the capability of incorporating the decision maker's preferences into the decision-making process;
f. in general, GI Systems do not provide a mechanism for flexible incorporation of the decision maker's preferences into the decision-making process.

Implementation

a. It is the process of developing the solution that is recommended in choice phase.
b. Implementation means putting the recommended solution to work.
c. Successful implementation results in solving the real problem.
d. Failure leads to return to an earlier phase of the process that is intelligence phase.

Feedback

a. There is flow of information from the output component to the decision-maker concerning the system's output or performance.
b. Based on the outputs, the decision-makers, who act as a control, may decide to modify the inputs, the process or both.
c. This information flow, appearing as a closed loop is called feedback.

Decision Making process and GIS

Figure 1 shows how decision making process can be related to GIS. Evaluation criteria involve a comprehensive set of objectives that reflect all concerned relevant to the decision problem, and measures for receiving those objectives. The set of evaluation criteria can be developed through; examination of relevant literature, analytical studies, and survey of options. Decision is a choice between alternatives. The alternative may represent different courses of action, different hypothesis, and different land locations and so on. Decision variables can be grouped into deterministic, random, linguistic variable. Constraints are the limitations imposed by nature or by human beings that do not permit certain action to be taken. A criterion is some basis for decision that can be measured and evaluated. The decision makes preferences with respect to evaluation criterion incorporated into decision model. The procedure by which criteria are combined are arrived at a particular evaluation are compared and acted upon. Simple adaptive weighing (SAW) are the most often technique used. These techniques are also called scoring methods since decision makers directly assign certain weights to "relative importance" attributes. Sensitivity analysis is a procedure for determining how the recommended course of action is affected by changes in the inputs of the analysis. Monte Carlo Simulation is a way for evaluating a large number of possible scenarios. In the way to integrate Multcriteria Decision Making (MCDM) and GIS there are three methods that can be proposed:

1. Loose Coupling
2. Tight Coupling
3. Interoperable

Loose coupling strategy combines the capabilities of separate models for GIS functions and MCDM by transferring files. To work in GIS MCDM model we have to switch between GIS software, database/spreadsheet software, and MCDM software very often. A tightly coupled strategy involves accessing MCDM analysis routines from within GIS software [11]. It allows the two components to run simultaneously and to share a common database; therefore, program control remains within the GIS when performing the Multcriteria decision analysis. In general, the tight coupling approach requires a high level of knowledge of the GIS in question and considerable programming skills. The user interface should support decision makers through all decision-making phases, and is the key to successful use of any decision support system [7]. It includes all I/O methods by which data are entered and results and information displayed by a MC-SDSS. It enables a dynamically interactive session in a real-time exchange of information between the user and the system [8]. Philosophies and guidelines for designing interfaces for SDSS and MC-SDSS are given in [8-12] lists a number of specific issues for consideration when designing user interfaces:

1. Accessibility: This implies that appropriate real-world metaphors are used in developing the graphical environment, and that users unfamiliar with the system can use it intuitively to infer the purpose of a particular screen or graphic object.
2. Flexibility: This allows the user to recover from unintended and adverse actions.
3. Interactiveness: This refers to the efficiency of information flow from the user to the system, and vice versa.
4. Ergonomic Layout: This stresses the effective and efficient communication between the user and the system; several strategies for dealing with the tools contained in the system should be available to the user.
5. Processing-driven: This allows users to be aware of the tasks they are carrying out; for example, different colors can be used to show active tools or animation in icons to indicate active processing. Apart from loose and tight coupling the third way to integrate GIS and MCDM is interoperability. Interoperable is the ability of two or more software components to directly cooperate/ communicate despite of their differences in programming language, interface and execution platform.

Methodology

GIS technology is a powerful tool for integration and analysis of georeferenced spatial data, and its use for predicting urbanization of Pune city. Figure 4 represents a general scheme of the methodology followed for SDSS implementation and figure 5 gives further elaboration. Two main parts are illustrated: the relational database and the user interface for spatial analysis 'Decision Support System' (DSS). The relational database contains and integrates the georeferenced information coming from remote sensing imagery, existing maps and exploration/ prospecting data, expressed as tables and maps. Existing maps and remote sensing data were digitized. The decision regarding the appropriate mix of DSS tools and the use of a generator is an important component of the process of building a DSS. However there is a very real sense in which the types of DSS design considered for a given class of problem are a function of the available DSS generators for that class of problem. In practice a small DSS project could be built, using an off-the-shelf spreadsheet or DBMS package, in less time than it would take to fully evaluate the full range of alternative methods of constructing the DSS. Therefore the DSS solutions actually constructed are strongly influenced by the perceived availability of suitable generators. Therefore the effective application of DSS technology can benefit from additional generator software becoming available. Awareness of the potential of the use of GIS based systems as DSS generators will lead to problems, currently being approached in other ways, being approached by using a SDSS. Table 1 shows the DSS generator features. In building DSS, specific generators have been designed for certain classes of problem. In other situations general purpose software such as spreadsheets or DBMS packages have been regarded as generators. In modern DBMS and spreadsheet software, the use of macro and programming languages facilitates the creation of specific applications. Various generators have strengths and weaknesses in terms of their provision of the key components of a DSS; an interface, a database, and models. In the case of a spreadsheet, modeling is the basic function of the software; various interface features such as graphs are provided, but database organization is simplistic. DBMS software, such as Access or Paradox, has good database support, provision for interface design through the use of forms, report and charts, but almost no modeling support. In this case the modeling support has to be added to the specific DSS built from such a system.

Discussion

Pune Metropolis as a case study: An emerging branch of geo-computing involves the modeling of spatial processes. A variety of techniques are being used, the most important being traditional regionalized system, change detection using land use / land cover information, dynamics approaches, multi agent systems and cellular automata. In this paper the used Simon Decision Making model for urbanization prediction of the Pune city. Here reality is examined and the problem is identified and defined. The existence of a problem can be determined by monitoring and analyzing the rate of urbanization of Pune city for last 4 decades. While generating the data, the lack of accurate information, unavailability of exact PMC boundaries, expensive satellite imageries were faced. There is wide spectrum of data as many sensors are available with the Indian Satellite IRS series. The procured satellite imageries have different datum and projection system than the Survey of India topographic sheets. The data access is banned for restricted areas like defense for Pune city. Data acquisition is time consuming, erroneous and expensive. The collection of data and the estimation of future data are among the most difficult steps in analysis. It is assumed that future data will be similar to historical data to prepare the prediction model. If not the nature of the change has to be predicted and included in the analysis. The urbanization prediction models to be developed for Pune city requires both spatial data and attribute data. In this case the nature of attribute data is demographic details of Pune city for last 4 decades. This data is partly available with census department. Based on this the growth of Pune city since last 4 decades will be simulated and urbanization prediction model will be formulated. The construction of a specific DSS from GIS software is possible however, by incorporating models that make use of the GIS database and interface. In this context low end GIS and desktop mapping products may prove more manageable for applications design than full workstation based GIS systems. While these desktop systems lack the power of a full GIS, they may be able to make effective use of data which has been prepared for a specific purpose using a full feature GIS.

Conclusion

Given the advances in computer technology in general and GIS techniques in particular, the growing subset of DSS applications in future will be those built using a GIS as a DSS generator. This class of DSS will make an important contribution, not because of its use of the latest technology, but because it will allow decision makers incorporate a spatial dimension in their decision making. This spatial dimension, which is not fully catered for in traditional DSS designs, is an important feature of many areas of DSS application. These potential areas of application including fields, such as routing or marketing, which have been important fields of DSS application in the past. The challenge for DSS builders is to achieve an appropriate synthesis of modeling techniques and interface and database approaches, drawn from the GIS domain, to provide effective decision support for these areas.

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Table 1- DSS Generator Features

DSS Component	Spreadsheets	Database Managers	GIS
Interface	Tables, forms, charts	Tables, forms, reports	Multi-layer maps, plots
Database	Independent cell entries	Linked database tables	Linked spatial and non-spatial databases
Database Tools	Rudimentary sort and selection	Comprehensive queries	Spatial query
Models	Built in mathematical functions, statistical and management science tools	Basic mathematical functions	Basic summarization and network analysis models
Model Building Tools	Recorded or programmed macros	Macro and database query languages	Macro (script) languages, programming interfaces to other programming languages

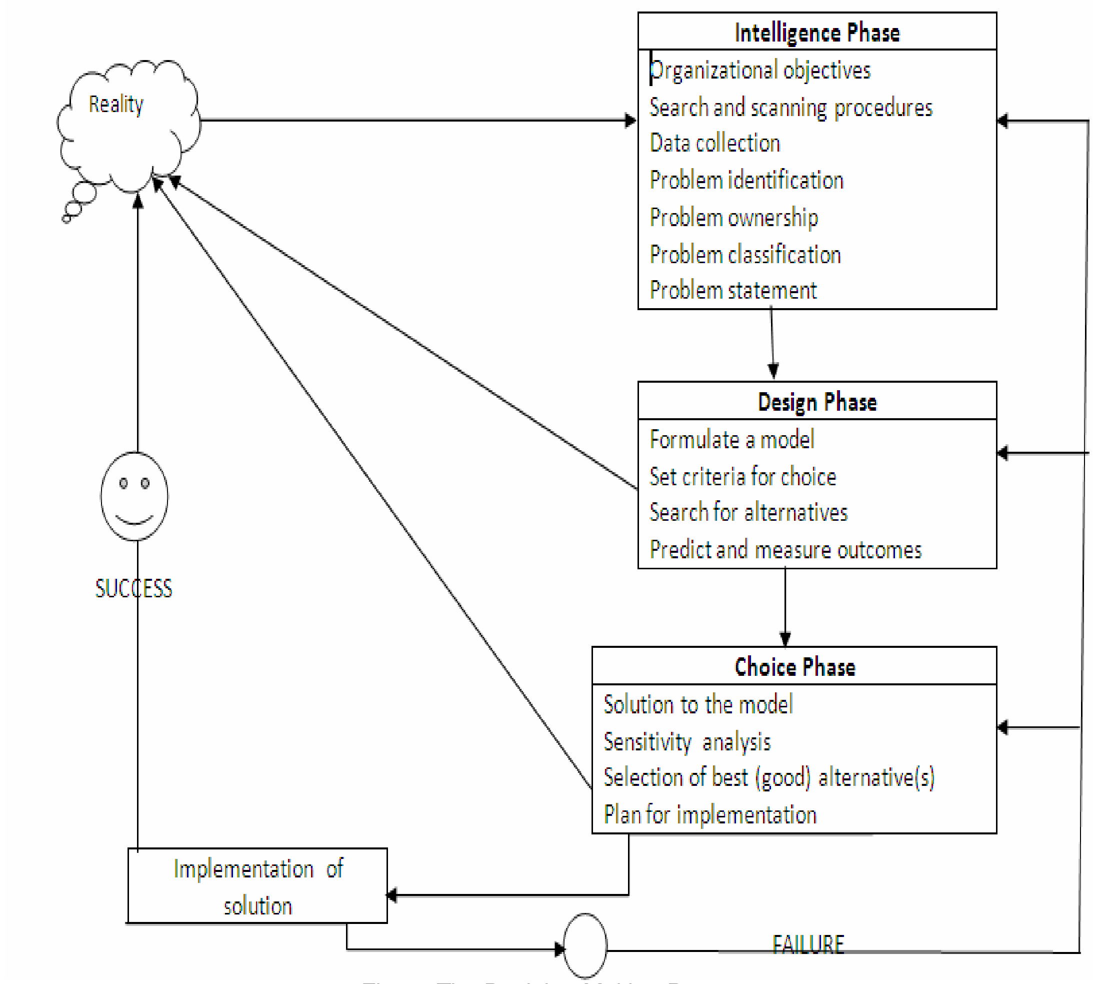

Fig. 1- The Decision Making Process

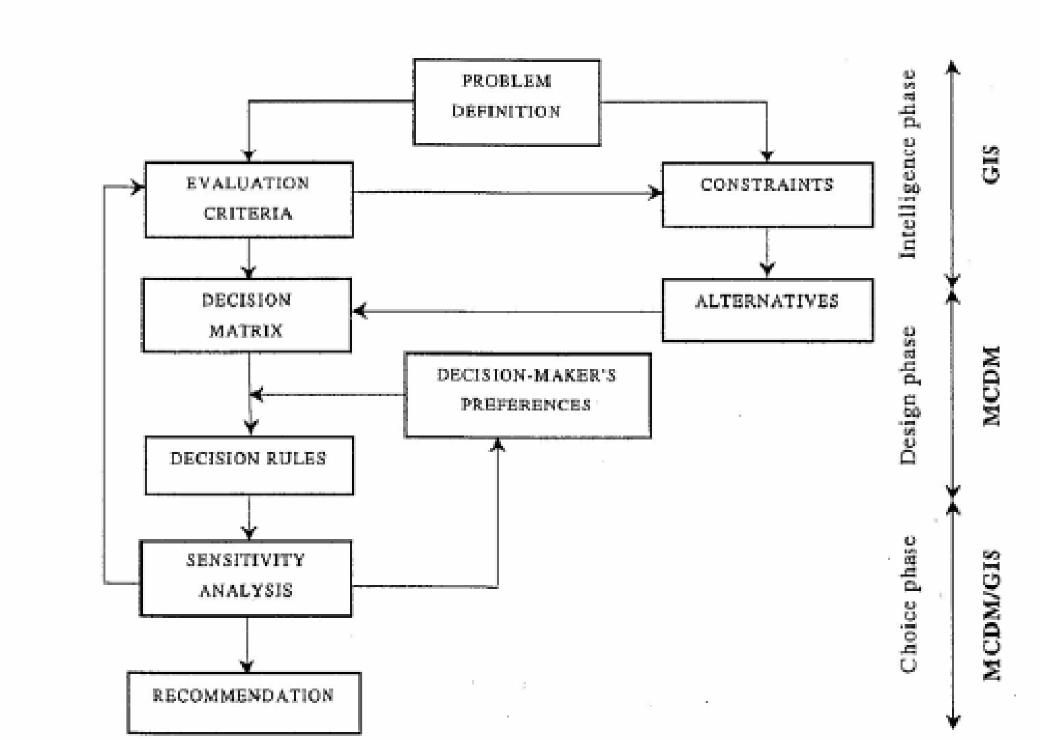

Fig. 2- Relating Decision Making Process to GIS

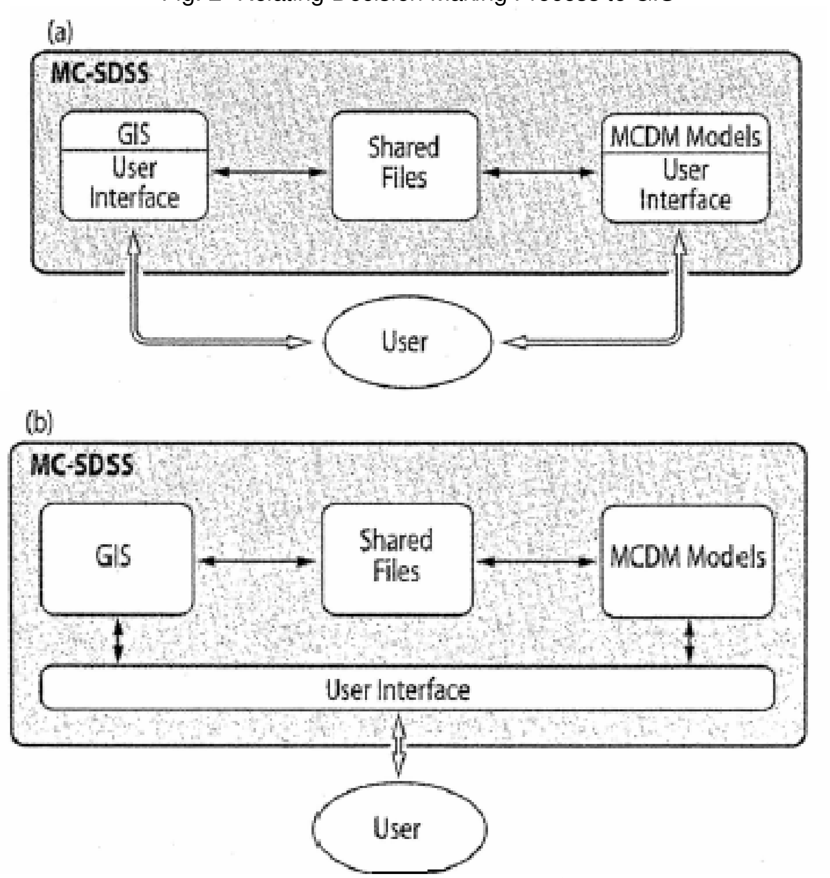

Fig. 3- a) Loose Coupling b) Tight Coupling

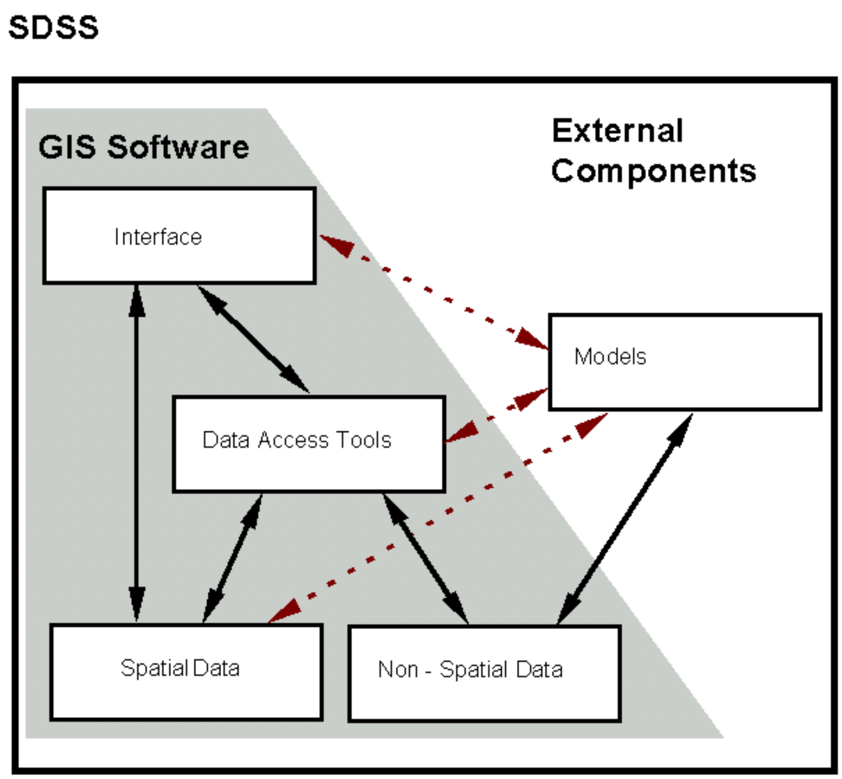

Fig. 4- Building a SDSS by integrating models with GIS

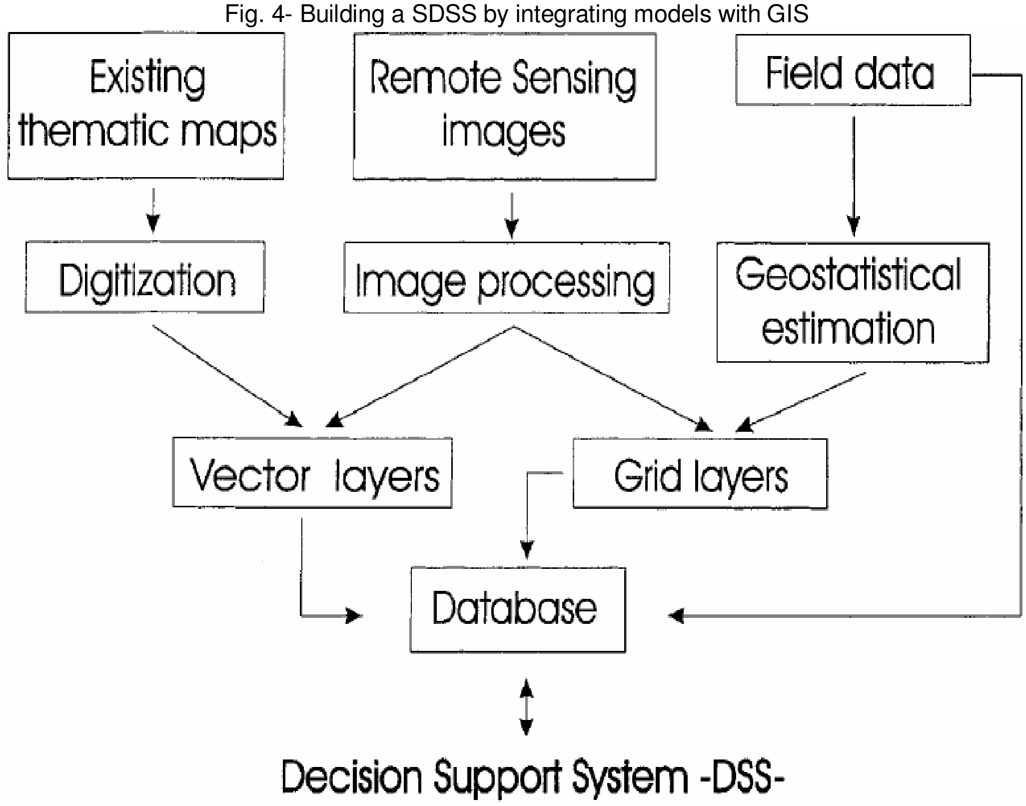

Fig. 5- Methodology observed for creating DSS for predicting urbanization of Pune City

