A Decision Support System For Land Use Activity Changes Using Data Gained from The Intelligent Transportation Systems

Arch. Ahmed M. El-Geneidy
Department of Architecture, Faculty of Engineering, Alexandria University

Dr. Hany M. Ayad
Department of Architecture, Faculty of Engineering, Alexandria University

Dr. Nadia S. El-Baghdady
Department of Architecture, Faculty of Engineering, Alexandria University

Dr. Yousry A. Azzam
Department of Architecture, Faculty of Engineering Alexandria University

Abstract:

The majority of discussion in literature concerns the environmental impacts of Intelligent Transportation Systems (ITS) on air quality, noise and energy. Land use and social-equity environmental impacts are discussed to a limited extent in such literature. In the land use decision-making process, a frequent question, which concern a new project, are "Will it create more congestion?" and "What effect will the project have on the quality of roads?".

To answer the previously mentioned questions a proposed Decision Support System (DSS) is adopted to avoid future transportation problems that might emerge from such changes in land use activities. The DSS mainly aims at making traffic impact analysis for changes in land use activities based upon real time data.

A methodology for the interaction between data gained from ITS and changes in land use activities is proposed. This methodology can be applied for one or more land plots, and for different types of activities. Also a proposed flowchart for software that can be used in such interaction is demonstrated.

Decision-makers, landowners, planners, and investors can use the previously proposed software in making decisions towards changes in land use activities, which might affect transportation systems.

Keywords:

Land-use, Decision Support System, Transportation Planning, Intelligent Transportation Systems.

1. Introduction

The main problem in several Egyptian cities is the unplanned change and accumulation of land-use activities to the existing urban structure, which in term causes the generation of un-foreseen large capacity of vehicle trips. Due to inadequacy of the streets to accommodate such new trips and the absence of suitable parking spaces, illegal parking and traffic congestion are inevitable.

Traffic congestion is a familiar problem that seems to affect just about any place with a road and cars. Sundeen (1998) remarks that in the United States annually traffic congestion causes an estimated 10 billion US dollars loss in productivity, wastes about two billion hours and consumes an additional one billion gallons of gasoline. Traffic congestion also diminishes air quality, creates a variety of safety hazards, often discourages tourism, and can reduce business information.

The connection between land-use and transportation is a fundamental concept. Every thing that happen to land-use activity has a transportation implication. Wright and Ashford (1989) describe the land-use transportation cycle as shown in figure (1). This cycle will keep going on unless any one (the planner, decision maker ..etc) interferes in it. The interaction between transportation and land-use changes is often termed traffic impact analysis, in another term, site impact traffic evaluation (Beimborn, 1995) It is assumed that in order to forecast illegal parking and traffic jam problems, an evaluation of traffic impact should be conducted for any change in land-use activities. In turn, the traffic impact analysis usually relays on large amount of data that need to be compiled, updated in a regular basis and analyzed for decision making.

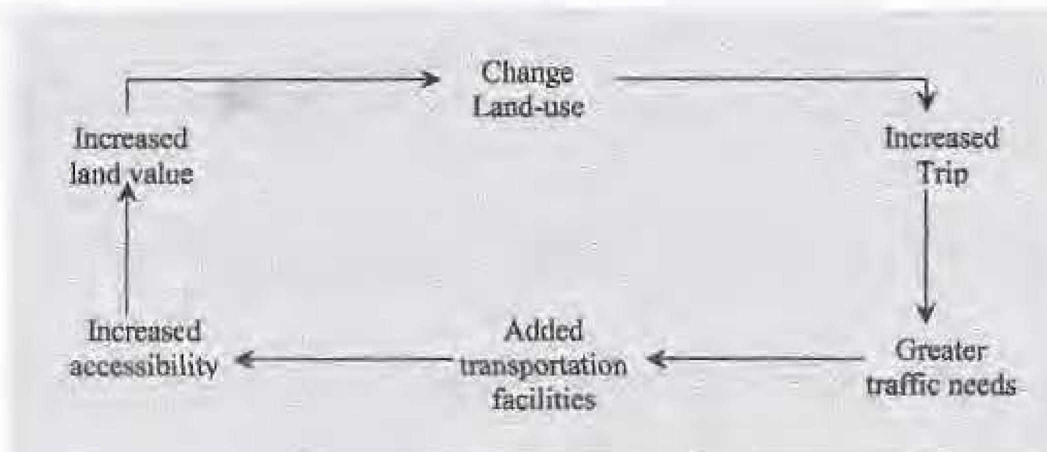

Figure (1) Land-use and transportation cycle

This paper aims at building a decision support system (DSS) applicable in the field of land-use management. More specifically, the following objectives are required to be achieved:

- Suggest a DSS framework flexible enough to provide the decision-maker a tool to evaluate the impact of land-use changes on the transportation systems based upon real time data.
- Propose a computer-based methodology that makes use of (a) data and standers related to different land-use requirements in the city and (b) Information collected through an intelligent transportation systems (ITS).
- Insure the applicability of methodology in different events that could be required by the analysts such as the changing number or size of land plot, and the different combinations of land-use types.
- Apply the proposed DSS frame work in one of the Egyptian cities (Alexandria) using real time data and existing land-use activities.

It is intended that the proposed methodology should have a friendly based computer interface in order to assist decision maker, land owners, planner, or investors in making decisions about land-use allocation and its consequences on transportation systems.

2. Intelligent transportation systems (ITS): An overview

2.1 ITS Definitions

ITS is a broad term that can refer to several definitions and applications. In planning, the term ITS refers to transportation systems which apply emerging hard and soft information systems technologies to address and alleviate transportation congestion problems. For example using advanced surveillance systems; the early stages of traffic bottleneck situation can be detected, and traffic can be directed to other routes to mitigate the congestion and to provide faster and more efficient routes for travelers. New technologies enable this type of surveillance and guidance response to occur in real time, and therefore, to allow potential congestion situations to be addressed before they develop in traffic jams (Johnson, 1999).

ITS scope and aims were studied by Mohaddes (2000), Romine (1998), Goehring (1997), and others. It can be defined as " *The application of information and communication technologies to the planning and operation of transportation systems*". When ITS first emerged on the market, community often used individual technologies to provide one particular service. Later, more advanced systems enabled technologies and applications to be linked together, so that individual systems could provide several services. The successful development of ITS depends on the capability of incorporating a vast amount of information about the location that generates travel as well as realistic representation of transportation network in which travel occurs (Golledge, 1996).

ITS are the future technologies that we deal with, sooner or later, in our transportation system (Mcqueen and Mcqueen, 1999). Using ITS technologies, quick transportation decisions can be achieved and evaluated based on huge amount of available and gained data (Ben Akiva, 2000).

2.2 ITS subsystems

Mast (1998) classified ITS into six interlocking technology subsystems:

ATIS. Advanced Traveler Information Systems; include variety of systems that provide real-time in-vehicle information to drivers.

AVCS. Advanced Vehicle Control Systems; aid the drivers in controlling their vehicle particularly in emergency situations.

CVO. Commercial Vehicle Operations; address the application of ITS technologies to the special needs of the commercial roadway vehicle.

ATMS. Advanced Traffic Management Systems; monitor, control, and manage traffic on streets and highways to reduce congestion (will be discussed late in the paper).

ARTS. Advanced Rural Transportation Systems; include systems that apply ITS technologies to the special needs of rural areas, and include emergency notification and response.

APTS. Advanced Public Transportation Systems; enhance the effectiveness, attractiveness, and economics of public transportation and include fleet management.

The previous technologies interact with each other to build up the ITS as shown in Figure (2). The ATMS work at the heart of the ITS, and transportation planners mainly deal with data gained from these systems. The Traffic Management Center (TMC) is the primary ganglion in this network of data sensing, information processing, communication, and control devices. From the Center, human operators and central computers monitor traffic conditions and carry out necessary measurements to ensure smooth traffic flow. Kelly and Folds (1998) suggest the typical advanced traffic management system shown in Figure (3).

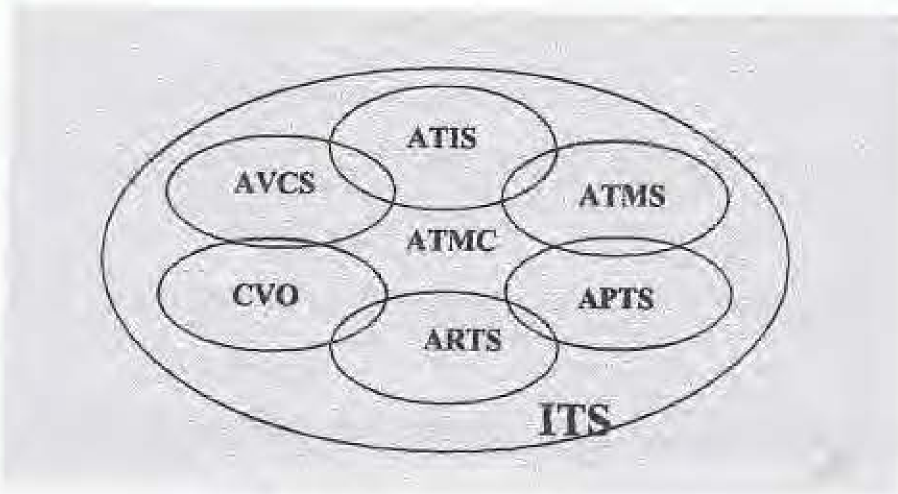

Figure (2) ITS areas of technology.

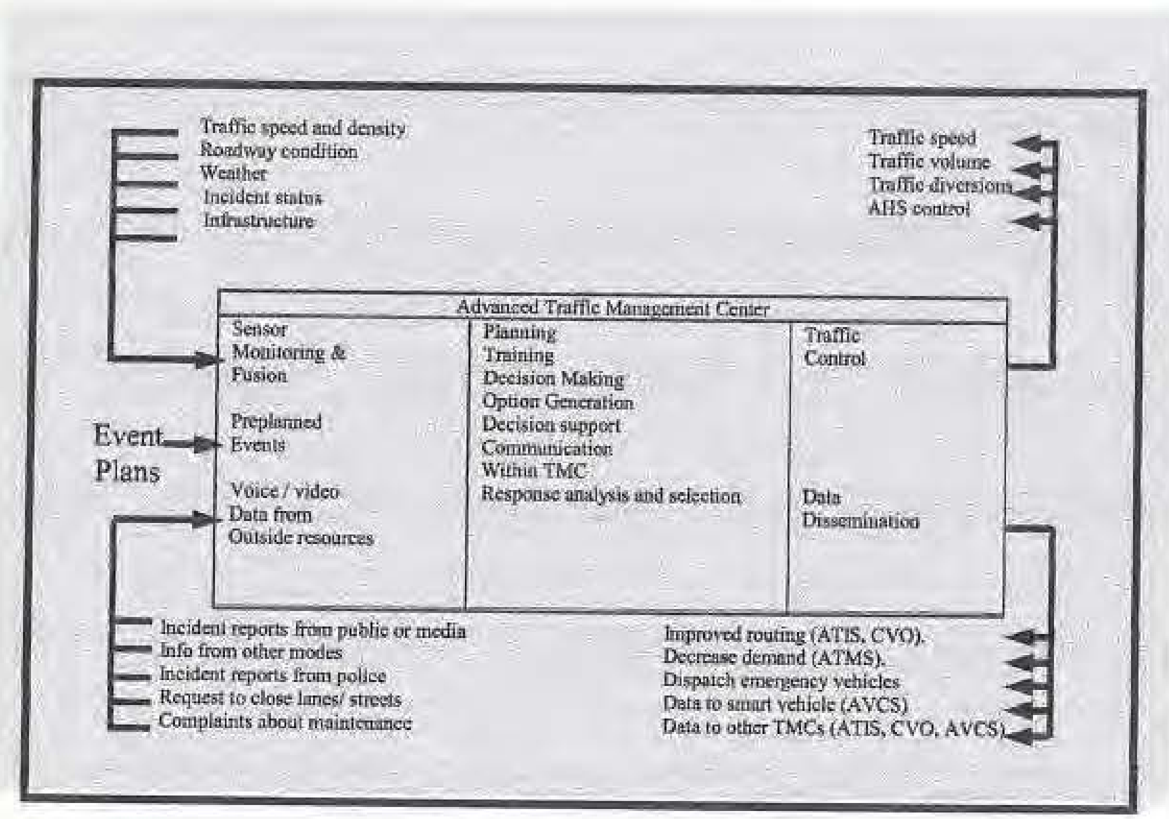

Figure (3) The typical advanced traffic management system.

The TMC is the main component of ATMS working at the heart of ITS. It links between the different components of the ITS and it also links between different ITS programs in other places so as to coordinate between them. The main functions of TMC are summarized as follows:

- Control vehicle motion, speed, and access.
- Influence vehicle routes, trip planning, and travel mode selections.
- Collect and store traffic data, incident data, and road toll data.
- Train TMC staff.
- Plan future responses and activities.

3. Intelligent transportation systems (ITS) and land-use planning: A Methodology

In land-use decision-making process a frequent question concerning a new project is "Will it create more congestion?" or "what effect will the project have on the quality of road?" and "Will the project in this location let people use non-auto travel to get their destination?" In literature review, little is known about exactly how ITS technology would function and how it would interrelate with land-use. During the preliminary investigation for the Orlando Metroplan Project, it was found that the information and researches required to analyze the interaction between the land-use and ITS was insufficient to carry out the analysis (Grovdhal and Hill, 2000). Miller (1999) comments that our understanding of transportation/land-use interaction and how it is affected by current technologies is limited.

The work presented here attempts to formulate a routine that interrelates data gained from ITS and information collected about the possible changes in land-use activities. The framework is based on data acquired from the following sources:

1. ITS data (specially data gained from TMC such as vehicle per hour per lane in each direction, average speed, and parking)
2. Changes in land-use activities, creating new trip generation and new parking demands. (any place in the world has its own standards in the trip generation, parking demands for each land-use activities)
3. Trip generation standards (any place in the world has its own standards for trip generation. For example these standards can be obtained from ITE trip generation hand book which is applied specially for the United States)

4. Parking demand standards (any land-use has its own standards for parking demands. For example these standards can be obtained from ITE parking hand book which is applied specially for the United States)

Figure (4) presents the model diagram for the proposed decision support framework, which can be summarized as follows:

1. Select the desired land plot(s) to be analyzed in a study area
2. Determine land-use activities code for the land plot(s)
3. Based on Standards, the land-use activities under examination will generate a specific amount and type of traffic that could be referred as a "trip value".
4. Determine trips generated from and to the existing land-use activities, as well as associated parking demands. Using the travel demand forecasting standards.
5. Meanwhile, an ITS will serve to monitor the existing condition in the study area and generate its own data table for the whole study area.
6. Subtract trip values generated from steps 3 and 4, from the ITS data table. The resultant ITS data table indicates the hypothetical condition of the study area without the influence of the selected land plot(s) on the transportation system.
7. Determine the proposed land-use activity that will replace the existing one on the selected land plot(s). Subsequently, a new land-use activity code is generated based on several variables such as the number of users (in case of restaurants), number of dwelling units (in case of residential uses), or gross floor area (in commercial uses). The previous variables as well as other factors are described here as the "independent variables".
8. Calculate the new trips generated from and to the selected land plot(s). Repeat the same procedure in order to calculate the parking demand.
9. Add trip values generated from step 8, to the ITS data table. The resultant ITS data table indicates the expected condition of the study area with the influence of the selected land plot(s) and proposed land-use activity on the transportation system.
10. Present the results in form of thematic maps and tables that estimate the consequences of any change in land use on the transportation system in the selected study area.

The previous framework is further explained using the proposed low-level flow chart presented in figure (5). The flow chart serves as a basis to develop the computer-based interface.

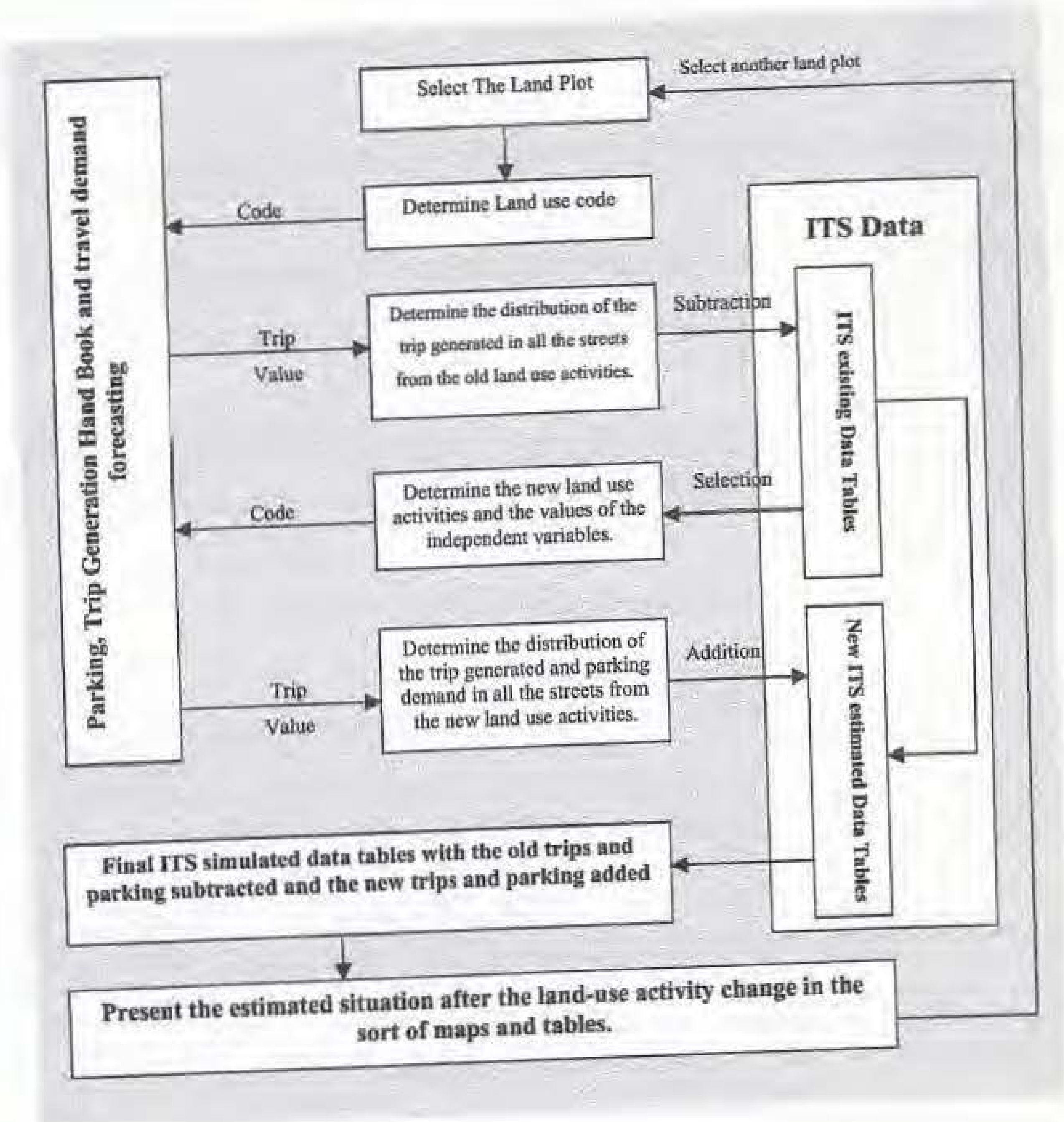

Figure (4) ITS and land-use activity model diagram

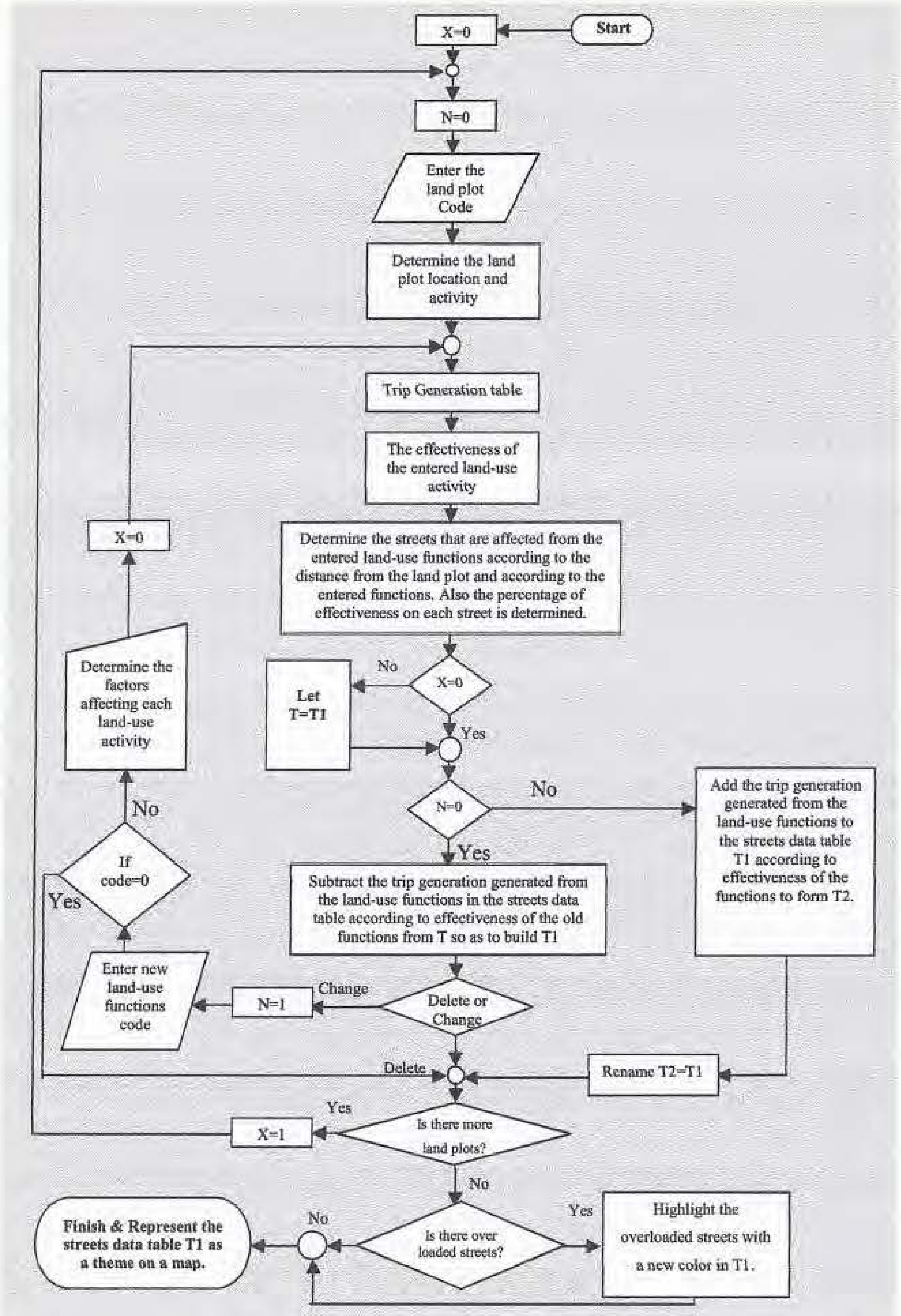

Figure (5) ITS and Land-use Model Flow Chart

4. Implementation

4.1. Alexandria Transportation System

Alexandria is the second largest city in Egypt, and it is by far the most important export-trading center of the country. Because of the presence of water bodies and valuable agricultural lands bounding the region, the city extends for more than 35 kilometers in length, and is limited to less than 5 kilometers in width (Figure 6).

Figure (6) Alexandria base map.

The Alexandria transportation system consists mainly of the road network, which supports both private and public vehicles, and the public transportation network (tramway and trains). Due to the linear composition of Alexandria and the increasing population pressures on the transportation networks, the city is undergoing serious traffic jams and parking demand problems. As a response, the General Organization for Physical Planning (1997) defined five objectives to be considered in the formulation of an action plan:

1. Improve the socioeconomic conditions by making adequate links between the major urban and suburban centers that support the expected urban growth.
2. Alleviate congestion, reduce the cost of travel, and allow for safety trips.
3. Increase the public transportation capacity to support increasing future demands.
4. Improve roadway conditions
5. Develop a strategic framework for future land-use allocation.

4.2. DSS Model Implementation

In order to carry out the study, a site that represents a prototype of Alexandria east district was selected. The site is characterized by mixed residential and other uses, as presented in the land-use activity map (figure 7). The area is approximately 320 000 square meters, and is bounded from the east and west with two main roads. From north and south, the area is penetrated by the two main arterial roads in Alexandria, El-Horia Avenue and El-Geish Avenue.

Figure (7) Selected area land-use map.

Prior to the model implementation, a site survey was conducted during the period from May to December 1999. The purpose of the survey was to: (a) update the land-use map, (b) determine the factors affecting the transportation system and ITS of the area, and (c) to simulate an ITS for the study area. The gathered data was compiled in both tabular and spatial forms using both the Arcview GIS and Microsoft Excel software. A serial number code from 1 to 375 was assigned for each land plot. Another serial number code from 1 to 56 was assigned for each street the land plot is facing. For land-use activities, a third code was assigned, consisting of four digits category. Each digit represents a different level of land-use activity.

5. Intelligent Transportation Systems (ITS) and Land-use Planning: The Computer Based Interface

The next objective to be achieved is to develop the computer-based interface. The interface is developed using the Visual Basic tools provided with the Microsoft EXCEL software and relies on its built-in tables and macros features to build the required database. The interface benefits also from the powerful ability of the ArcView GIS software in presenting and relating both spatial and tabular data, and links it with the information gained from the ITS. The Interface has two folded design levels. The high-level is the user interactive level. It is designed to be both flexible and easy to use. The calculations and coding that make the software work efficiently are executed in the low-level.

When running the software the user passes through many processes. The computer interface gives the users two options in changing the land-use activities. The first option of changing the existing land use activities is that the user can change the land-use activities using the change in the independent variables of the land-use activities without any guidance to his entries. The second is the guided change, where the user is guided through the whole process of change. In the guided change the user has the capability of following the building regulations in the study area or even setting up new building regulations. The guided method has many forms and is sophisticated in its calculations.

Figures 8,9 and 10 explain the interrelationship between the different rules in the high-level part of the interface, the guided data entry in design forms, and the method of displaying the final data results.

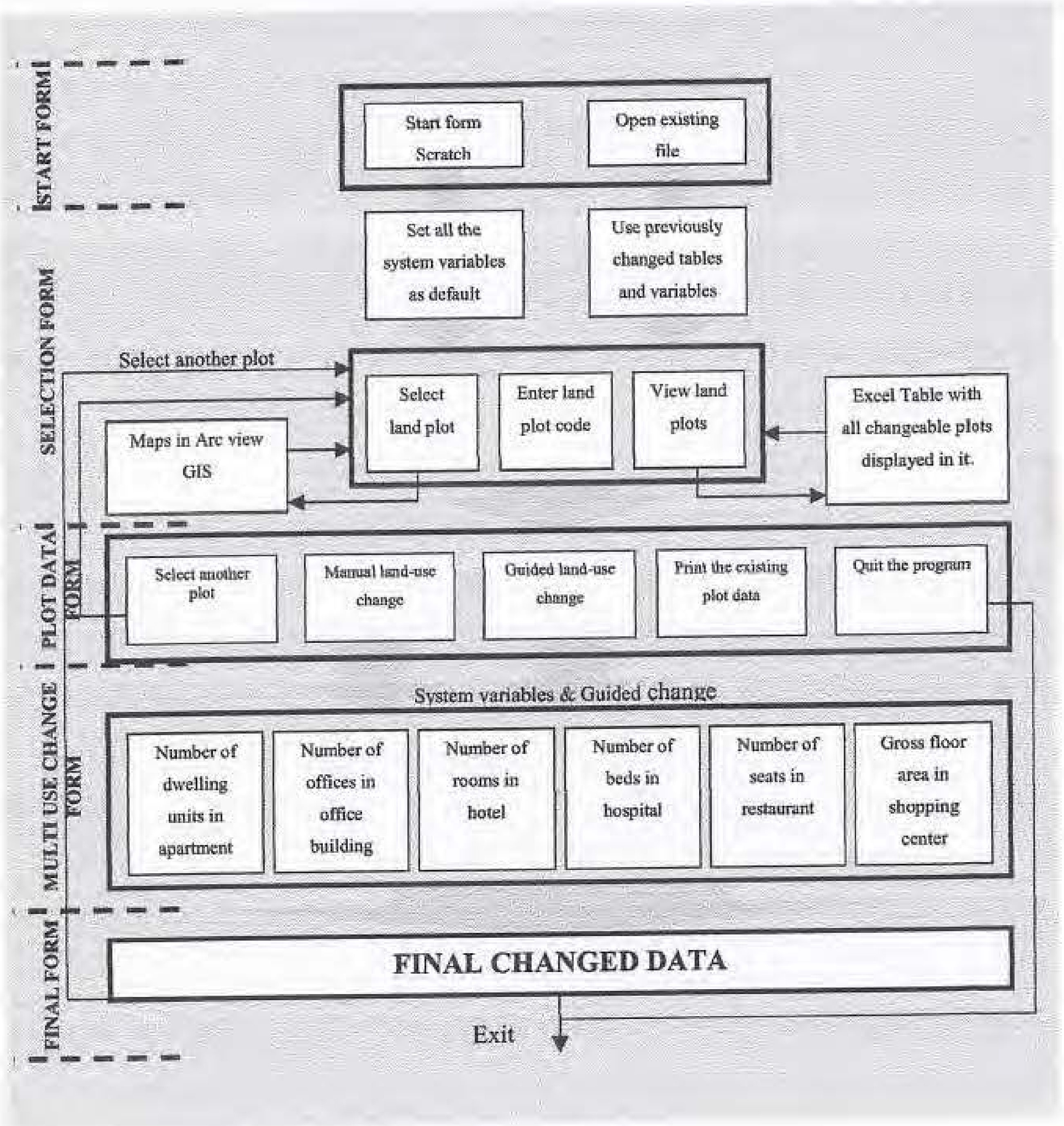

Figure (8) Computer based interface diagram.

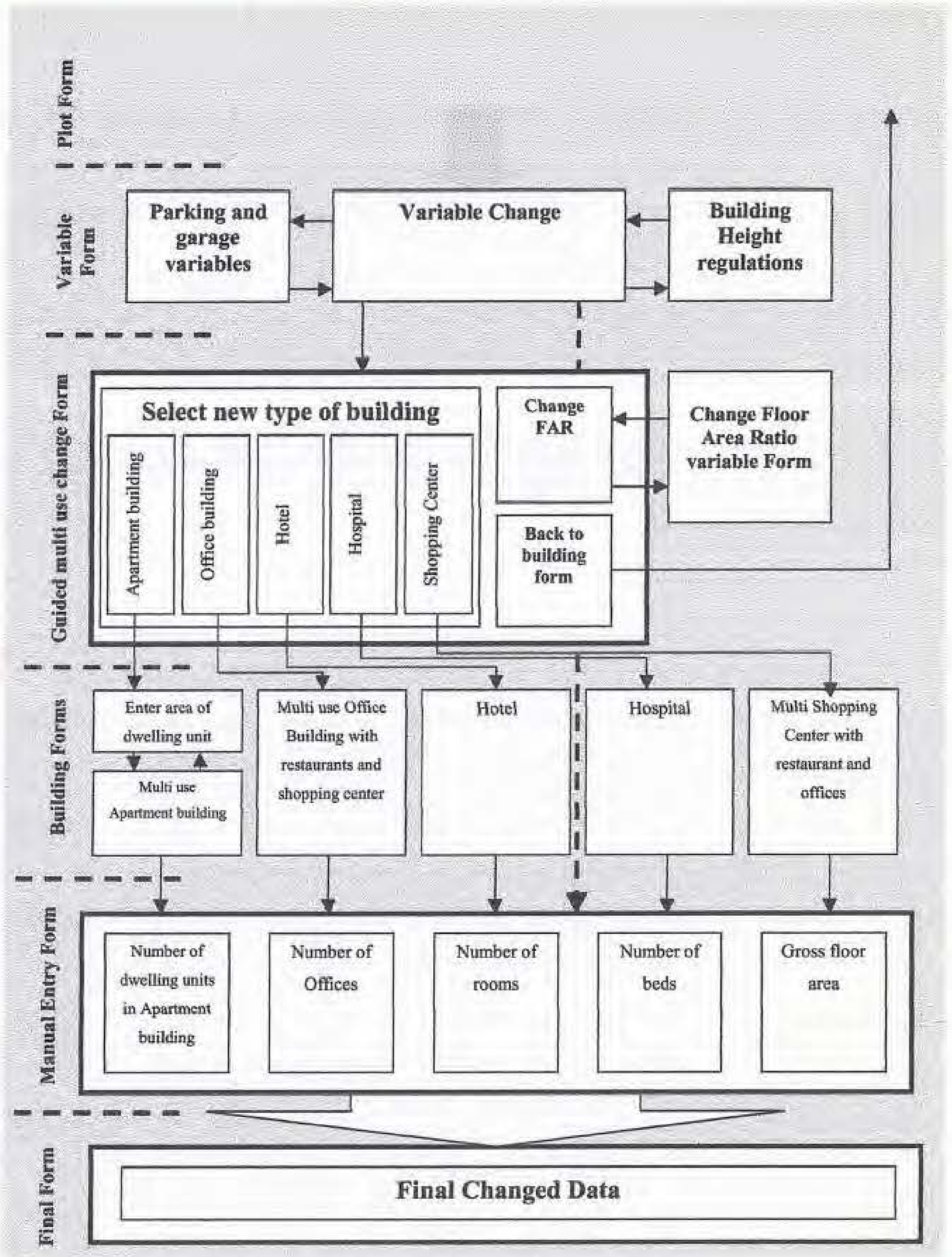

Figure (9) Guided change schematic diagram

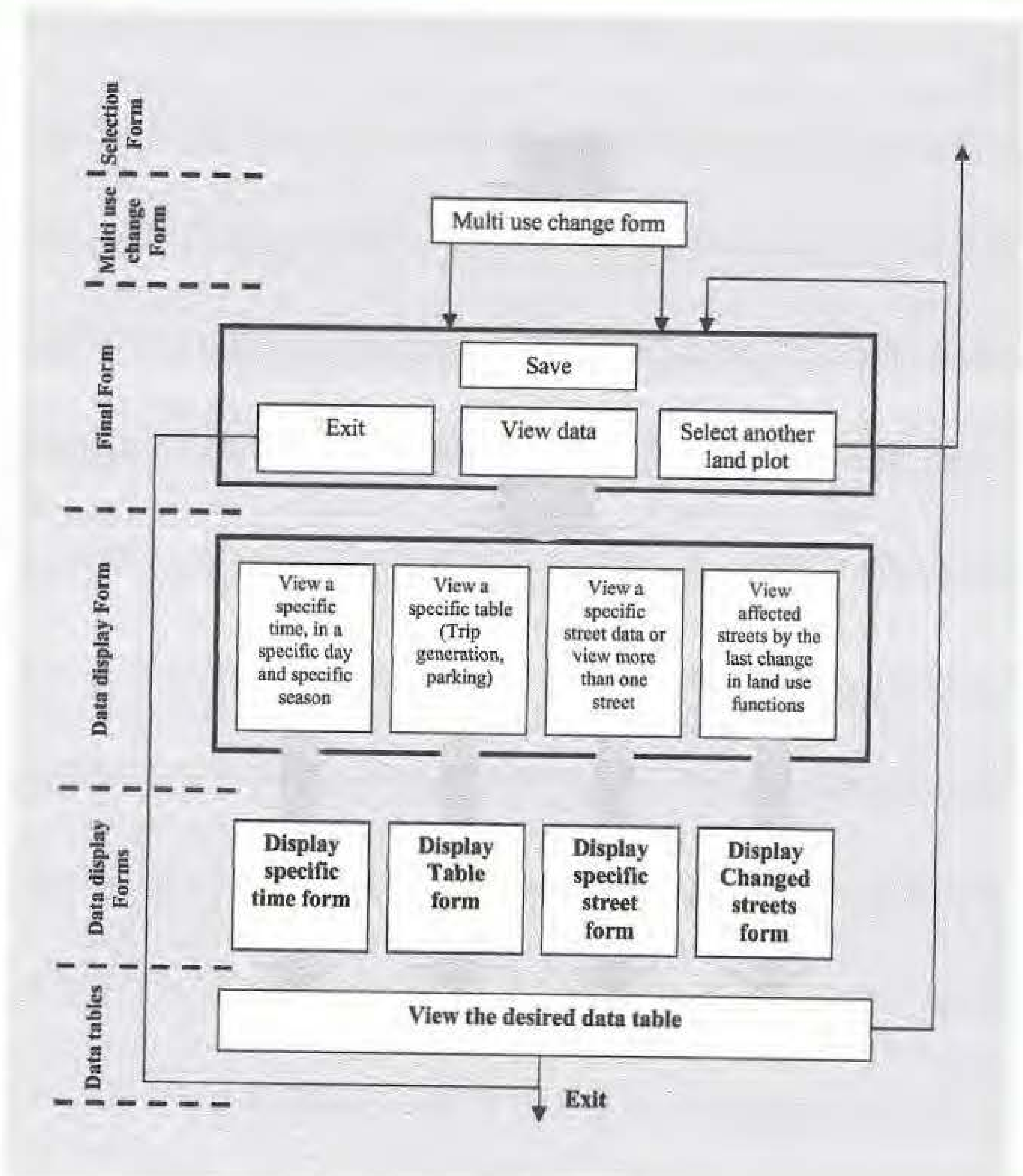

Figure (10) Data display schematic diagram

The proposed software interface was then applied to change some land-use activities on an existing land plot. An existing single-family house was proposed to be demolished and replaced by a new apartment building and a shopping center. Figure (11) represents a summary of the results achieved from the interface application. It shows the effect of land-use changes on the traffic density of an adjacent street, during different times of the day, and on selected dates. A similar graph was prepared for parking demands. It was obvious that the proposed change in land-use will considerably affect the parking demands and transportation densities during the peak hours, exceeding the carrying capacity of the selected street. Such a change will inevitably cause a traffic jam and illegal parking.

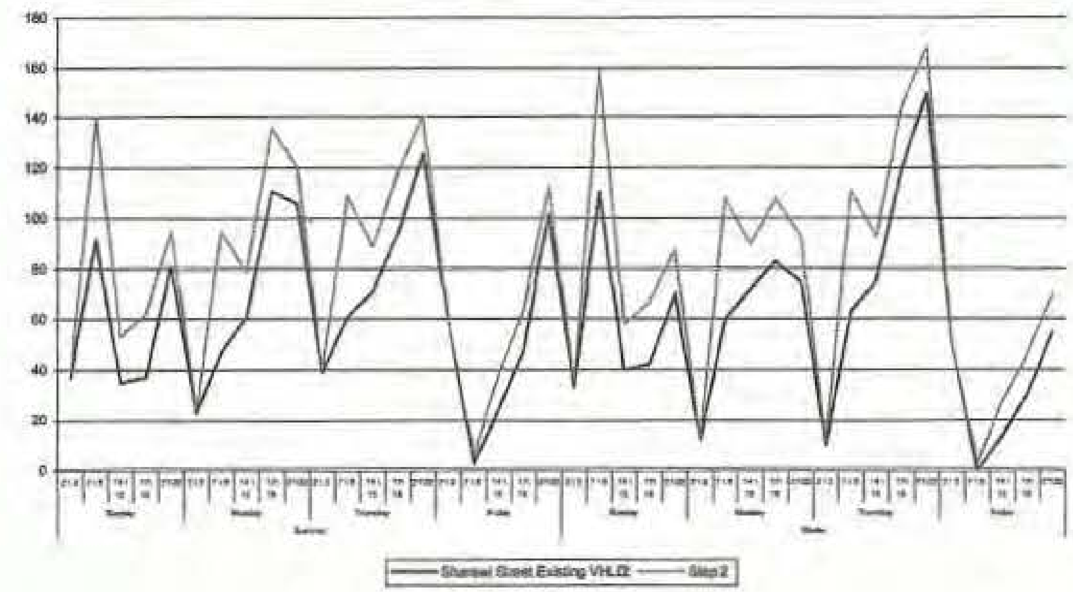

Figure (11) a study of the effect of land-use change on the traffic in a selected street within the studied area.

The proposed computer interface was then used to change land use activities in different land plots in the study area. The summary of results was presented in several sheets that may assist decision-makers about what activities in the city should be kept, replaced, or removed, in order to alleviate transportation system problems, or at least to avoid more congestion.

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6. Conclusions and Recommendations

In the present study, a DSS model framework that relies on data gained from ITS, land use information, trip generation standards, and parking demand standards is proposed and tested on a selected study area. The proposed method benefits from the data gained from ITS in the field of urban transportation planning. It provides decision-makers with a firm basis to formulate new building regulations in accordance with the future transportation system policy. Specific results can be summarized as following:

1. The proposed methodology can be used in further research in determining the different effects of land-use changes on air quality, noise pollution, social effects, and travel cost. This can be achieved through the data gained from the methodology after the changes.
2. The study demonstrates that the lack of information on transportation systems in Egypt could be accurately accomplished by the introduction of an Intelligent Transportation System that can provide fast and accurate information required for planning purpose.
3. The computer software interface developed here can be applied to different case studies, and is flexible to accept changes in trip generation and parking standards, as well as changing criteria for land-use activities.
4. It is necessary to prepare a national program of research and development for long term ITS deployment. It is also important to appreciate any change in the developing practice planning tools, policies, and theories of land development as they are related to transportation.
5. When combining ITS with other technologies it might have benefits in improving transportation in the community. It will be important to assess how those improvements can be integrated with land-use policies to better manage growth in transportation demands.

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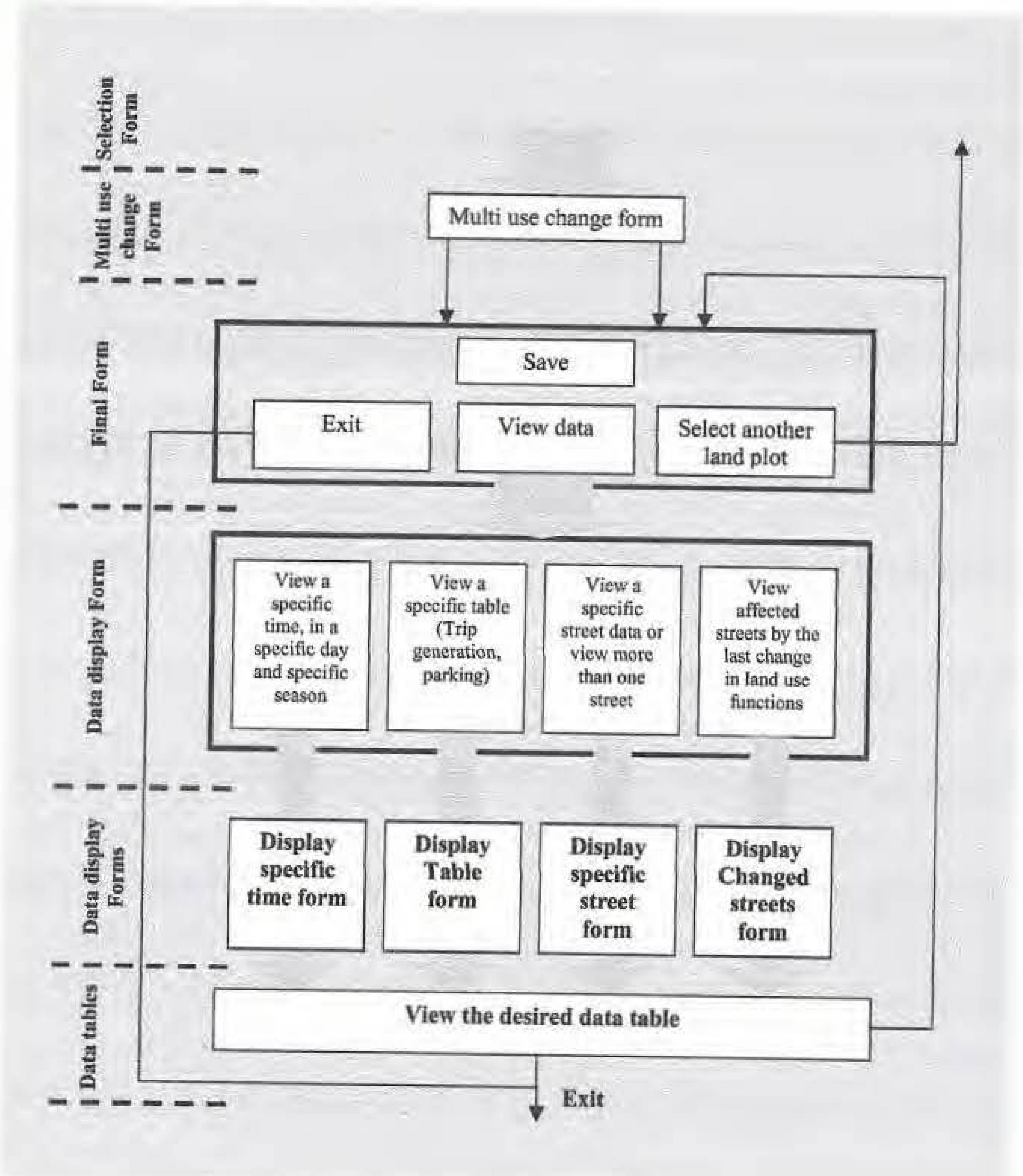

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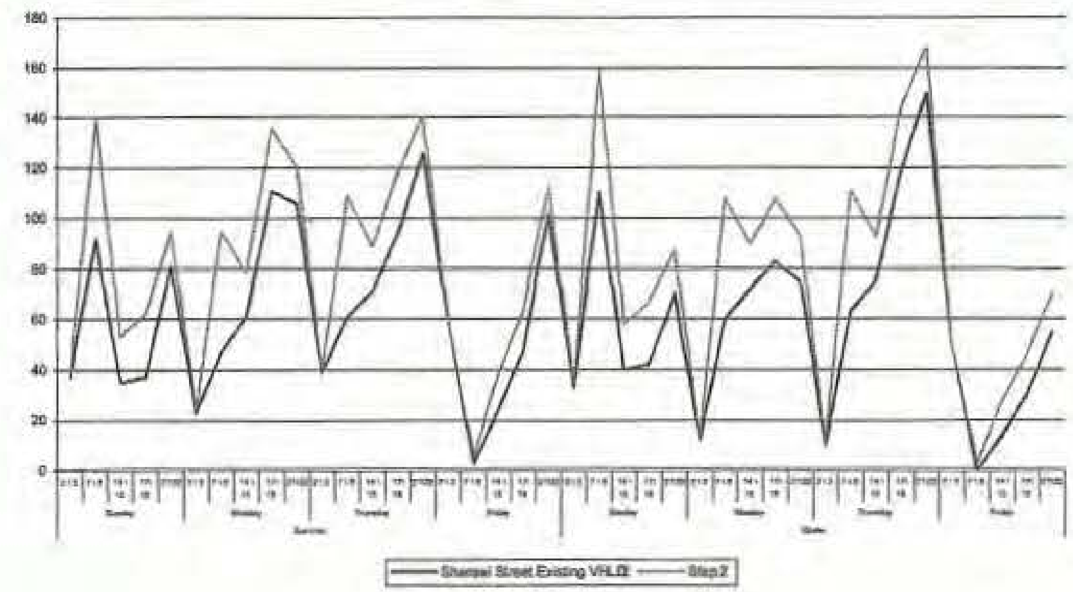

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