

# Conflict Provention in Rural Land Use Planning Using a GIS-Based System

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Wei-Ning Xiang and Owen J. Furuseth  
University of North Carolina\*

*In the practice of land use conflict handling, a relatively new but attractive strategy is conflict provention. Different from the conventional strategies of conflict management, it emphasizes the prediction and removal of sources and conditions of potential conflicts, and the promotion of an environment for co-operation. This usually requires manipulation and analysis of a large volume of geographically-referenced data. Without an efficient data handling and analysis tool, provention is a difficult task to accomplish. The GIS-based system presented in this paper is aimed to provide such a mechanism to support land use conflict provention. It integrates a GIS with a coordination model. The technical burden of data management is handled by the GIS, analysis and modeling are implemented on both GIS and other analytical tools in the coordination model. The case study demonstrates its potential as a decision support system for land use planning and decision making.*

Conflict at various scales is ubiquitous in land use planning. In rural and peri-urban areas the potential for conflict is intensified by diversity interest groups and discordant demands on the resource base. In his seminal monograph, *The Surroundings of Our Cities*, (1977), Lorne Russwurm documented the problems and land use conflicts in rural areas around North American urban centers: farmers versus residential interests, developers versus preservationists. These and other interests are often joined in confrontations over how 'best' to use rural land resources. As a consequence, a primary task for rural planners is coping with conflicts.

One strategy for dealing with this issue, which has been increasingly discussed, is conflict provention (Burton, 1990). Provention refers to a process intended to predict conflict and remove the potential causes and conditions for that conflict. Further, it is designed to create and promote an environment of cooperation. Provention differs from prevention in that it is proactive rather than reactive.

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\* Department of Geography and Earth Sciences, University of North Carolina at Charlotte, Charlotte, N.C. 28223.

Although the term is new, attempts to practice conflict prevention are not. For many years planners have worked to identify possible sources and conditions of conflict and then incorporate this knowledge into the planning and design process. Land suitability analysis devised by Ian McHarg (1969), for example, is designed to predict and avoid potential conflicts between nature and human beings as well as among different interest groups. More recently, the concept of carrying capacity has been associated with efforts to reduce or avoid conflict (Scheider, et al., 1978). Originally, carrying capacity was associated with ecosystems management (Porter, 1970; Bishop, et al., 1973). In that context, it referred to determining the maximum population density for a given species in an environment which could be supported without degradation of the environment. Planners have adopted the concept to identify critical development thresholds beyond which public health, safety, or welfare will be threatened (Held, et al., 1969; Godschalk, et al., 1974; Basile, 1977; Godschalk, 1977; Kendig, 1977; Nieswand and Pizor, 1977; Toner, 1977; Scheider, et al., 1978). The determination of carrying capacity represents a fundamental effort to avoid conflict. In real terms, community conflict is symptomatic of situations where the carrying capacity of an area has been exceeded. Unfortunately, the application of carrying capacity strategies in American land use planning has been far more widely discussed than applied.

Despite the former efforts, the avoidance of land use conflict in US planning remains an elusive goal. One might argue that without an effective conflict prediction methodology it is impossible to remove the sources of potential conflict and avoid conflicts. A fundamental problem is that conventional conflict handling tools, such as group decision making models and multilevel programming methods, fail to address this issue. This is because they take conflict between groups for granted and have no capabilities to predict conflicts. Therefore, their effectiveness in land use conflict prevention is limited.

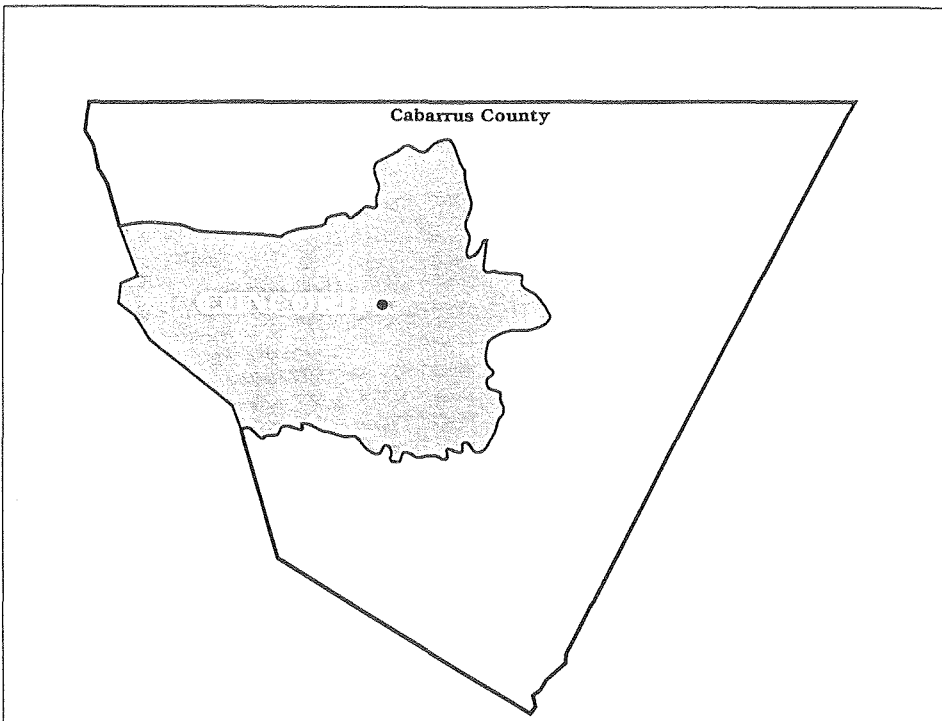
The purpose of this paper is to report on the development of computer based system to support the prevention of land use conflicts in a rural planning setting. This system uses a combination of geographic information systems (GIS) and multicriteria decision making (MCDM) models to predict sources of potential conflicts and then demonstrate strategies to remove them. This research is a cooperative effort between the Department of Geography and Earth Sciences at the University of North Carolina at Charlotte, North Carolina, USA and the nearby City of Concord to build a GIS-based planning/management support system for adoption by the community planning department (Xiang and Furuseth, 1992).

## CONCORD, NORTH CAROLINA

The study area for this project is Concord, North Carolina, USA (Fig. 1). Located in the Southern Piedmont, it is a small, rapidly growing city. The 1990

population was 29,090. Over the past ten years it has grown by 71.7 percent. Socio-economically, the community is typical of county government centers in Piedmont North Carolina. Racially, 83 percent of the population is white, and the median household income is \$25,158. The economy is mixed. Traditionally, there was an overwhelming reliance on textile manufacturing. Today, however, the economy is far more diversified with the service sector growing rapidly.

Figure 1: Study area.



Owing to North Carolina's very liberal annexation policy, the jurisdictional boundaries of Concord have expanded quite dramatically over the past decade. In 1980, the city limits encompassed 8.81 square miles; by 1990 the city limits covered 22.57 square miles. This 156 percent increase accounts for much of the population increase.

An important consequence of the territorial expansion for planners is the need for a GIS-based system to support both planning and management. Such a system cannot only handle and update huge amounts of data, but also support land carrying capacity analysis, land use allocation and development management.

## A GIS-BASED SUPPORT SYSTEM

The system which we developed consists of two parts: data management and model management. At the core of the system is a geographic information system (GIS). Few areas of research are better suited for the application of GIS technology than community based land use planning (Dangermond, 1988; Bell and Page, 1989). Not surprisingly, the planning profession in the U.S. has widely embraced the technology over the past decade.

While GIS has become a standard part of the planners lexicon, the use of the tool has been relatively unimaginative. Generally, planners have opted to employ GIS as a descriptive tool. That is to say, it is used exclusively to organize and compile information. The most common planning application of GIS is for data inventory. The system organizes and links data sets including zoning, land use permits, property ownership, physical characteristics such as water features, land cover, soil types, and elevation; political information such as electoral districts, administrative districts, and police and fire zones; demographic data such as census tract information; and infrastructure data such as transportation, recreational facilities and utilities (Santos and Lockman, 1988). The advantages of GIS over human efforts are greater accuracy and efficiency, especially on complex and large data sets. For planners, the breadth of data coverage and the specificity of data base (scale) are general bench marks of user sophistication (Lang, 1990). The products of the system are most often maps and tabular summary data.

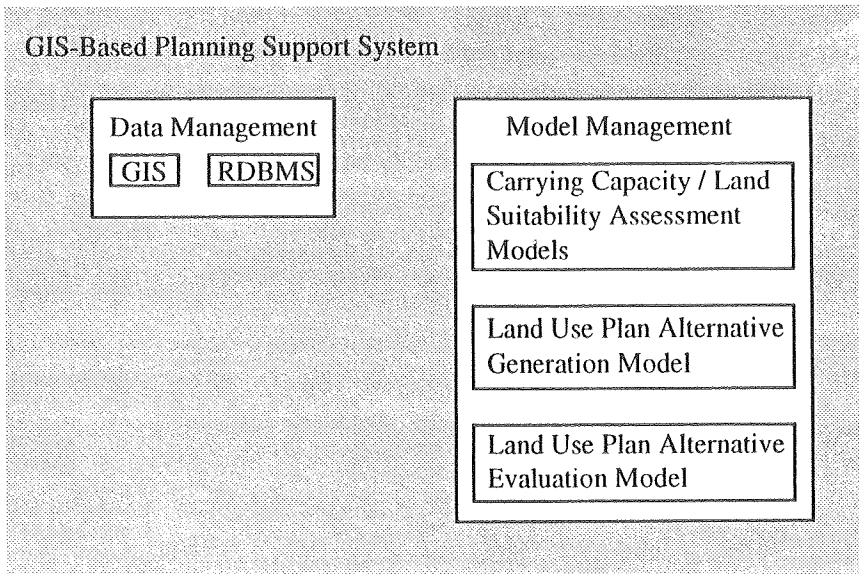
Although the value of GIS for aiding data collection and transmitting information cannot be discounted, planners have failed to utilize fully the potential of GIS as a prescriptive tool. A prescriptive application means using the system to execute analytical studies. Rather than merely mapping specified planning attributes or overlaying data sets, the GIS integrates decision making models and becomes a vehicle to problem solving.

In order to execute these analytical capabilities, GIS needs to be integrated with quantitative analytical tools. These are contained within the model management portion of the system. GIS is inherently a geographically referenced database management system with some spatial analytical capabilities. A GIS is capable of integrating information in different formats and from various sources into a common database, and manipulating spatial information through such functions as overlay and buffer. These certainly make a GIS an important part, or more appropriately, a basis of a support system for land use conflict prevention. However, the analytical capabilities of a GIS, even a most advanced one, are quite limited. This makes it critical that GIS be combined with analytical tools. Through communication channels, in this case simply a file transfer, this connection can be made quite easily.

Figure 2 outlines the components of the Concord system and their functions. At the center of the data handling part is a GIS which integrates data in different formats and from various sources into a common database. A relational database

management system (RDBMS) is added on top of the GIS to enhance its data manipulation capability. The model part of the system contains a set of analytical models. These include various carrying capacity analysis methods and land use allocation and evaluation models. They may be used to help with planning efforts at a regional scale. In particular, the system is viewed as a critical tool for bridging the long range planning goals of Concord and the surrounding Cabarrus County.

Figure 2: Components of the Concord GIS-based planning support system.



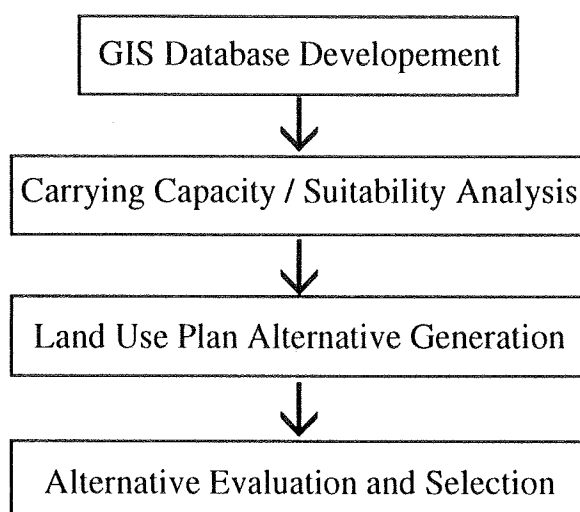
As mentioned earlier, the City of Concord has been undergoing a rapid territorial expansion. A direct impact for planners is the need to continually update their data base and modify community planning guides. For example, as each new area is annexed into the city, shifts in zoning, capital improvement programming, political data and tax records must be updated. There is continuous pressure on the staff of the Concord Planning Development to maintain accurate and up-to-date data. The GIS-based planning support system described above has a capability that allows an easy updating of the database (both cartographic and tabular).

## METHODOLOGY

This project consists of four phases (Fig. 3). The objective was to design and develop a GIS system which was adapted to the needs of the community. Specifically, we were concerned with configuring a system with capabilities to support

land use planning efforts. This objective was accomplished through the following four tasks (phases) (Xiang and Furuseth, 1992). First, building a database in a GIS system that integrates both cartographic and tabular data from various sources. Secondly, conducting a carrying capacity analysis. This analysis will serve as the fundamental principle for future land use planning. Thirdly, the development and manipulation of a GIS-based coordination model to generate land use alternatives based upon community goals and objectives. And, finally, the evaluation of these scenarios against carrying capacity results in order to develop community planning recommendations. A fuller explanation of each phase is provided below.

Figure 3: Four phases of the Concord Project.



### *GIS database development*

The GIS database developed for the project contains a total of 80 layers. They fall into five general categories of physical, ecological/environmental, socioeconomic, infrastructure, and planning. Table 1 lists some of the layers under each category.

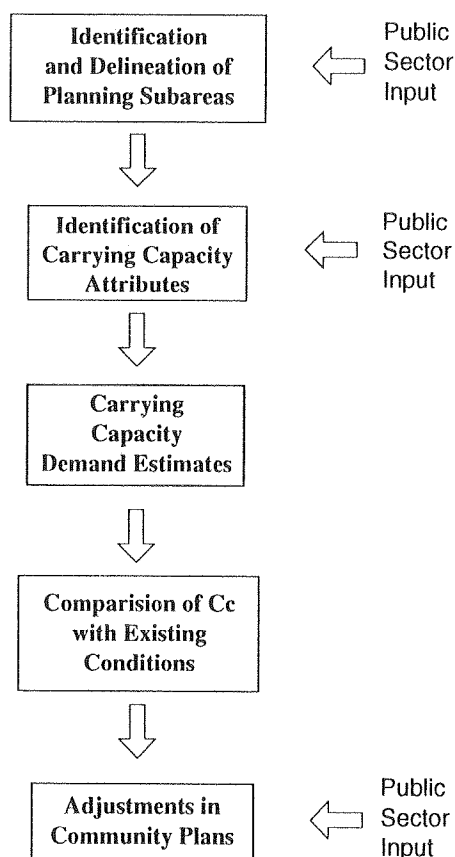
Table 1: A partial list of GIS data layers.

<i>Category of Data Layers</i>				
<i>Physical</i>	<i>Environmental</i>	<i>Ecological/ Socioeconomic</i>	<i>Infrastructure</i>	<i>Planning</i>
topography	forested land	population	water supplies	zoning
soil	water quality	income	sewage	planning
hydrology	watersheds	land use	traffic lines	districts
	wetlands		power lines	

*Carrying capacity analysis*

The process of carrying capacity analysis was executed in five steps (Fig. 4).

Figure 4: Carrying capacity analysis process.



In the first step, the City of Concord and its extraterritorial zone were subdivided into 21 planning subareas. Each subarea represents a small reasonably homogeneous unit of land. The basis for defining each unit was socio-economic, land use, and environmental complementarity. Whenever possible hydrological units were used as the primary definitional criterion, with census linked boundaries used as a secondary source.

The process of defining the subarea boundaries was executed in close cooperation with local decision-makers. While this process was based on scientifically derived concepts and information, community input refined and fine-tuned the results. This was particularly important in order for the process to be effective in conflict prevention.

In step two, land suitability analyses were carried out in order to determine the suitability of land resources for future development. As a part of these analyses, models were produced to assess the carrying capacities and existing demand on soil resources and the public sewerage system. In addition, environmentally sensitive land resources in the study area were defined for protection and preservation from increasing urbanization. Finally, trip generation was calculated based on land use types using the Institute of Transportation Engineering standards. Figure 5 lists these four components of carrying capacity analysis and GIS data layers used.

In the third step, demand estimates were developed. Demand estimates were developed for all potential categories of land uses for each carrying capacity attribute within each of the 21 planning areas. For example the demand for portable water varies significantly between different types of human activities. A typical single family household uses 300 gallons per day, while a restaurant needs 36 gallons per seat and an office or warehouse requires 15 gallons per 1,000 square feet of work space. Similar differences are evident across the remaining attributes for alternative land uses.

The aggregated demand estimates represent the carrying capacity for each planning subarea. Operationally, this carrying capacity varies marginally between attributes so that the importance of individual attributes varies. For example, traffic may be the critical constraint on carrying capacity in one area; while water and sewage capacity may be most critical in an adjoining area. The variability in carrying capacity is a function of the resource base and subarea size.

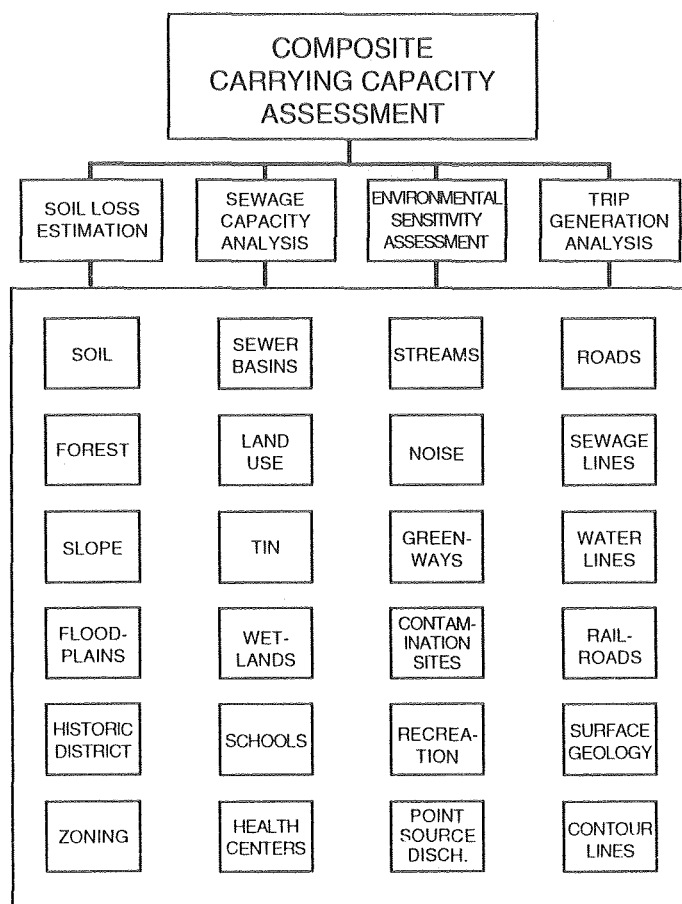
Fourth, following the carrying capacity demand estimates, these results are compared with existing conditions. The existing conditions reflect the *in situ* or in place demand on the carrying capacity attributes. Any difference between carrying capacity and existing conditions reflect potential land use conflict, and has to be resolved.

One critical feature of our strategy is the inclusion of a 'level of tolerance' surrounding carrying capacity. The tolerance zone exists on either side of the carrying capacity. The concept of a tolerance zone reflects the belief that carrying



capacity is not defined by a single line but rather by a zone that can be adjusted upward or down.

Figure 5: Four components of carrying capacity analysis and GIS data layers used.



The application of the strategy for recommending land development decisions is based on the following function:

$$| C_c - D | \leq R_i, \quad i = 1, 2$$

Where:

$C_c$  = Carrying capacity

$D$  = Current demands on the attributes

$R_i$  = Level of tolerance

$R_1$  = Lower tolerance

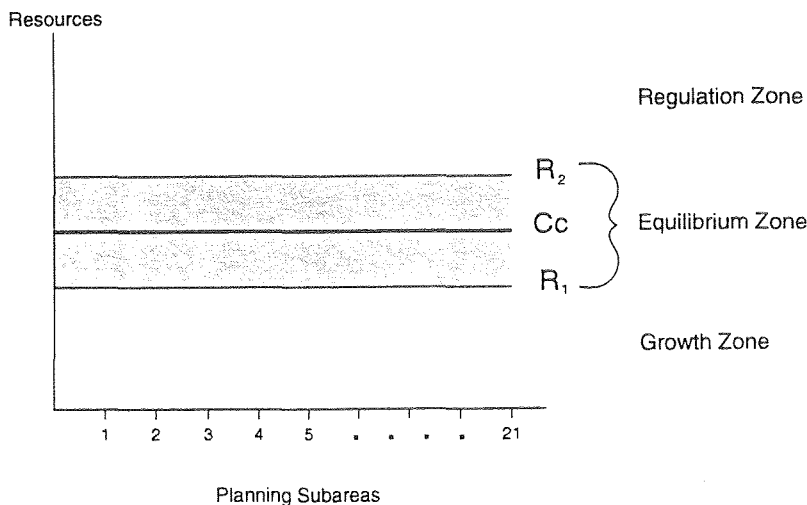
$R_2$  = Upper tolerance

Using this approach, the determination of land use strategies is derived from the following decision rules:

- IF:  $| (Cc - D) | \leq R_i, i = 1, 2$   
 THEN: No development will be encouraged.
- IF:  $(Cc - D) > R_1$ , when  $(Cc - D) > 0$   
 THEN: Certain amounts of development allowed. The total amount of growth can be calculated as:  
 $(Cc - D) / \text{Unit Demand of Specified Land Use Types}.$
- IF:  $| (Cc - D) | > R_2$ , when  $(Cc - D) < 0$   
 THEN: Absolutely no development.

The relationships outlined by these decision rules are graphically illustrated in Figure 6.

Figure 6: A carrying capacity driven land use planning model.

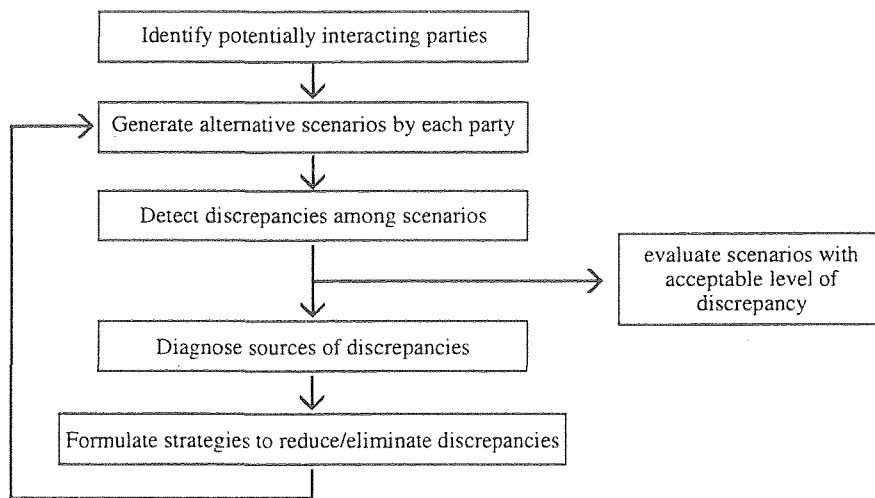


### *Land use plan alternative generation*

The final step in the analysis is preparation of alternative planning guides which reflect the carrying capacity process and findings. The generation of land use plan scenarios is a multiparticipant process. It requires coordination among the various plans and demands of different public organizations (departments) within the city and county governments. Instead of building a single planning model in an unrealistic effort to accommodate the diverse requirements of all the parties involved, a coordination model is being developed. The coordination strategy is designed to integrate the decentralized planning activities of various

city and county departments into a cooperative framework. Within such a framework, each party formulates plans to pursue its own objectives. Subsequently, individual plans are compared with other plan scenarios to detect discrepancies. If the discrepancies are acceptable to the other participants, then each party can enter the next phase to evaluate and select the least objectionable scenario. If the discrepancies are unacceptable, a diagnosis procedure will be followed to identify sources of the discrepancies. New plan scenarios are then formulated by each party to reduce or eliminate the discrepancies. Figure 7 provides an outline of the model.

Figure 7: A coordination model for land use plan scenario generation.



The theoretical design of the coordination model has been accomplished. The system development is currently underway. The model will be tested and then applied to this project.

## OUTCOMES

The direct outcome of the project is a GIS-based system that has the capabilities to support land use planning. The system provides planners with a common data base, a set of land suitability maps, a series of land annexation and land use scenarios and recommended changes in current land use regulations. Most importantly, the coordination model being developed will enable planners to avoid potential conflicts by working together and coordinating with other parties.

Conflicts are inherent to the land use planning process. Wherever there are competing demands for a resource, there is likely to be some form of conflict. A

primary task for planners is therefore to cope with conflicts. There is a wide spectrum of ways to deal with conflicts in land use planning. At one end is a defensive approach in which conflicts are regarded and treated as ordinary and negotiable features of social life. Within this framework, planning becomes conflict management. Under this approach, no action will be taken until a conflict occurs, and a measure becomes unavoidable. Conflict management techniques that are appropriate for planning include court settlement, policy intervention, mediation and negotiation. In these more direct and simple reactive processes, little, if any, attention is given to background and wider implications. At the other end of the spectrum is an offensive approach of conflict prevention. Emphasis here has been put on two aspects: (1) predict, or at least try to predict, and remove the potential causes and conditions of conflict; and (2) create and promote an environment of cooperation. Most land use planning practice is a blending, or somewhere in between, of these two approaches. The prevention strategy is, however, far more attractive to planners. With the capability to coordinate with relevant parties in detecting and eliminating discrepancies, the GIS-based system can indeed support planners' efforts of conflict prevention in land use planning and management.

## CONCLUSION

GIS as a database management system with geographic reference is extremely valuable in terms of integrating and manipulating both cartographic and tabular data in a common database. Its analytical capabilities are, however, quite limited and do not support sophisticated high level analysis and modeling. This can be overcome by integrating GIS with other analytical and reasoning tools. The system discussed in this paper is a combination of GIS, relational DBMS, and analytical models. It has the capability to support land use decision making at a planning level.

The system is being developed and applied to a real world land use planning case in Concord, North Carolina. The larger purpose of this research is to use the Concord system as a prototype. In this sense, it can be used for examining and testing the community planning applications of new ideas, e.g., conflict prevention, and new GIS-related technologies.

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